INTERNATIONAL JOURNAL OF CONSERVATION SCIENCE

ISSN: 2067-533X Volume 11, Issue 2, April-June 2020: 463-484 www.ijcs.ro

CONSERVATION OF THE HEINZ AND GEORGES LEICHTER DRY PLATE COLLECTION, EGYPT: CASE STUDY

Mervat ABDALLAH[1], Mona ALI[2], Ahmed BELAL[1], Filippo STANCO[3], Francis MOHAREB[4], Maha ALI[2,*]

[1] Faculty of Applied Arts, Helwan University, Giza, Egypt.
[2] Conservation Department, Faculty of Archaeology, Cairo University, Giza, Egypt.
[3] Department of Mathematics and Computer Sciences, University of Catania, Catania, Italy.
[4] Faculty of Tourism and Hotels, Luxor University, Luxor, Egypt.

Abstract

The Heinz and Georges Leichter collection of gelatin dry plate negatives, located in Egypt, includes approximately 1000 negatives, 500 of which are gelatin dry plate negatives. The negatives were found to depict different subjects (i.e. archaeological sites, portraits, landscapes and others). Different formats and sizes were noted. Similar to other photographic materials, gelatin dry plate negatives consist of a layered structure which can be divided into three components: the primary support, glass; the binder layer, gelatin; and the final image material, silver grains. With regard to the state of preservation, the majority of the negatives were found to suffer from mechanical damage due to poor handling and improper housing, as well as chemical damage due to storage in unfavorable environmental conditions. This paper mainly aimed at studying the collection in terms of historical background, structure and state of preservation. It also evaluated several mirroring reduction/removal treatments for possible use with mirrored dry plate negatives prior to digitization for producing an enhanced copy of the original, which is a significant measure for safeguarding the context of these valuable records. Finally, it also aimed at preserving the collection for future generations through performing several conservation treatments. Several examination and analytical techniques were utilized to study five representative gelatin dry plates selected from the Leichter collection such as: visual inspection, USB digital microscope, stereomicroscope, and SEM-EDX. Fungal testing was also carried out to identify fungal growths.

Keywords*: Heinz and Georges Leichter; Gelatin dry plates; Mirroring; SEM-EDX; Fungal testing; Conservation.*

Introduction

The art of photography reached Egypt in the same year of its invention in 1839. It was greatly encouraged by its Ottoman ruler Muhammad Ali Pasha who gave it special attention and care as he always did with all new inventions. He introduced photography in the activities of his army, and practiced it himself, with his Pashas and relatives [1]. At that time, particularly after the inauguration of Suez Canal in 1896, Egypt flourished as a touristic destination; and as result, professionals and amateur photographers produced thousands of negatives representing archaeological sites, tourist steamers, landscapes and portraits of Egyptian natives. After 1852, many studios were opened around the Azbakya garden, the new downtown Ataba, then

* Corresponding author: maha.ahmed@hotmail.com

Alexandria and Luxor. This form of art became extremely popular, now millions of photographs held by photographical museums, associations, special and private archives around the world bear testimony to the presence of Egypt as a metropolitan of the east, and a leader country in the universal history of photography. In this research paper, we have selected a collection of two great photographers, Heinz Leichter (also known as Henry Leichter in Luxor) and his son Georges Leichter. Heinz worked as a photographer for nearly 40 years. He was one of the master photographers who worked on Egyptian archeophotography between 1910 till his death in 1940. His collection includes around 1000 negatives, 500 of which are gelatin dry plate negatives.

Glass plate negatives were introduced around 1851. The first glass plate negatives, known as wet plate negatives used collodion. In 1880, wet plate negatives were replaced by dry plate negatives, which used a silver gelatin emulsion [2]. In 1871, Richard Leach Maddox developed a workable gelatin dry plate negative in 1871. However, this process was slow compared to the wet plate process [3]. Many significant steps were made to improve Maddox's process [4]. However, it was not until 1878 that Charles Bennett produced gelatin dry plates with his ripening process [5]. These were about ten times as sensitive as the collodion wet plates and gave images of great clarity [4]. Gelatin dry plates were the most common negative process in the years between 1880s and the 1920s when they were gradually replaced by cellulose acetate and cellulose nitrate negatives [6]. The dry plate process is based on the light sensitivity of silver halides, in most cases silver bromide, which are suspended in a gelatin binder on a glass support [7, 8]. They have glass plates of different dimensions and of thickness of the order of 1-2 mm as a support. The gelatin emulsion is of thickness of the order of 50 micrometers [6]. During exposure, a latent image is formed, which is chemically developed to produce a visible image. The image is then fixed and washed to obtain a permanent image [7].

Leichter photographs are published in many publications like the large work of epigraphic survey on Medinet Habou in western Thebes, and in many travelers' books. Nevertheless, there is no detailed study dedicated to the work of Leichter. Gerard Reveillac attempted in one of his publications, Les collections photographiques Beato, Gaddis & Seif, Adly Leichter, in Cfeetk to collect information on the collection; and after talking with Abd El Samie El Adly, the heir of the studio and the collection, we were told that he did some contact prints of the collection, approximately around 350 glass plates and cellulose negatives [9]. During 2000, we did multiple visits to the studio, situated in Karnak Street since 1929. After the catastrophic inundation of the Nile that year, Heinz Leichter moved his old studio existing near the Karnak Hotel on the shores of the Nile, to the new studio, which was a small shop about 55 square meters in the building of the Hotel Des Familles. We have been buying items from the collection since 2009. In 2015, we acquired the entire collection, including around 1000 negatives and 300 prints, five wooden cameras used by Leichter, enlargements, contact print machines, lenses, books, heaters, etc.

A detailed research conducted by photograph researchers Claudio Busi and Francis Amin Mohareb, is dedicated to the reconstruction of the history of Heinz Leichter (1882-1940) and his son Georges (1913 -1974), who were born in Bolzano in Northern Italy (then under the Austrian empire). Heinz arrived in Cairo in 1910, where he collaborated with some photographers such as Studio Horus, and Leichtenstern and Harari. Later, he opened his own small studio in down-town of which we know only some photographic reproductions. During World War I (1914-1919), Heinz was held captive as war prisoner in Malta, in Saint Clement's camp with other Italian and Austrian photographers such as Theodore Kofler, Bauer, Shroder, etc. In 1920, he returned to Cairo and then he moved to Luxor, where he worked as a photographer with Chicago University (i.e. Chicago house) from 1929 until his death in1940. Georges his only son worked with him, and left Egypt in 1937 and never returned, and he died in Yugoslavia in 1974 [10]. In a letter sent to A. Abouzeid from Leichter, Heinz declares that he opened another studio in Luxor Hotel in partnership with A. Abboudi. We believe that many negatives have been transferred to this new studio; however, we have no clue where it is currently located. A long life of a photographer like Leichter produced at least some 10,000 negatives, Abdelsamie, son of El-Adly, who is Leichter's assistant, told us that many negatives, especially portraits, were sold for silver extraction, some plates for the manufacture of frames and for the fabrication of Ramadan lanterns.

In this paper, we give a detailed description of the Leichter collection. Upon purchasing the collection, Abdelsamie, the official heir of the collection, handed the Amins a certificate declaring their ownership of the collection and copyright. Many historians of photography claim that the use of gelatin dry plate negatives, ended around 1925. However, our study proves otherwise since we have found glass plates dating up to 1940, the date of Heinz's death. A number of 20 glass plates commemorating the inauguration of the mosque of Ayad in Luxor, in approximately 1936, have been found. We also possess glass plate negatives of another photographer, Abouzeid and most of them date back to the period between 1956 and 1965.

Similar to most photographic materials, gelatin dry plate negatives consist of a layered structure. This structure can be divided into three components: the primary support, glass; the binder layer, gelatin; and the final image material, metallic silver grains [11]. As a result, dry plate negatives have a complex physical and chemical nature that must be taken into consideration if they are to be preserved for future generations [7]. The threats affecting the permanence of dry plate negatives are many, including: improper temperature and relative humidity levels, light, air pollution, improper handling and misuse, poor storage and display materials, biological threats and disasters [12, 13].

One common preservation issue presenting a true challenge to photograph conservators is the treatment of silver mirroring, which in many cases disfigures the image side of dry plates, complicating the production of enhanced digitized copies. Nearly 50% of the Heinz and Georges Leichter dry plate collection suffer from silver mirroring, a common image silver decay. Image silver is found as microscopic grains embedded in the binder layer, gelatin [14]. Silver is reactive towards a number of chemical reagents than one would expect for its classification as a noble metal [12]. The first stage of image silver decay is the oxidation of the silver particles; the metallic particles (AgO) are stripped of electrons and converted to invisible silver ions (Ag^{+}). These silver ions may migrate away from their parent silver grain in all directions within the gelatin binder. Silver mirroring occurs when the mobile silver ions migrates to the surface [15, 16]. On the surface, it is assumed that silver ions are reduced back to metallic silver [17]. However, X-ray photoelectron spectroscopy (XPS) results allows us to conclude that silver mirroring is mainly formed of a surface layer of silver sulfide (Ag_2S), a result of the reaction between silver ions and an environmental sulfur-based compound [18]. Nearly most 19th and 20th century silver gelatin photographs are affected by this type of image decay [19]. Silver mirroring appears as a bluish metallic sheen giving the shadow areas an iridescent appearance [20-22]. When very severe, it can appear green, violet or bronze in color [6]. Silver mirroring can occur locally or overall depending on the source of pollutant attacking the image silver [15].

The treatment of silver mirroring is a controversial issue among conservators. Some conservators argue that mirroring should not be removed as it is a sign of authenticity and should be valued as a patina. Others suggest that it should only be removed if it disfigures the image rather than enhance it. However, while this damage form can be appealing now, one should consider that the continuation of the same decay process will result in undesirable appearance in the future.

Since it is not possible to return the silver particles in the surface mirror to its original location in the binder layer, methods of reduction or removal have been performed and several have been investigated [23]. Chemical restoration has been used to convert mirrored silver salts to black elemental image silver. However, attempt to carry them out may cause serious damage, and even when successful can alter the tone of the photograph changing the integrity of the object [24]. One of the previously investigated treatments involved immersion of the damaged photographic print in a solution of iodine/alcohol for a short time. This treatment was introduced by Edith Weyde in 1972 [25]. Another treatment involving the use of Thiourea and ammonium thiosulfate was performed to remove mirroring from aged negative material [26]. Two types of PVC erasers were examined and their effects on both silver gelatin and albumen prints were evaluated [27]. The author recommended more studies to be carried out. PVC erasers, ethanol/water solution and iodine/ethanol solution, methyl cellulose and coating microcrystalline wax coating were evaluated and the results show that they have affected the surface characteristics of the tested images [28].

The main aims of this paper is to thoroughly study the Heinz and Georges Leichter dry plate collection in terms of historical background, structure and state of preservation; and to evaluate several treatments for possible use with mirrored dry plate negatives with the purpose of improving the visual appearance of the disfigured negatives so as to obtain a digitized copy with as much details as possible; thus preserving the information it holds. It further aims at preserving this unique collection for future generations through applying several conservation procedures. It further aims at preserving this unique collection for future generations through applying several conservation procedures.

Materials and methods

Materials

Collection description

The Heinz and Georges Leichter's gelatin dry plate collection has been stored in the old studio since 1910. It was 2010 when the collection was transferred to El-Adly's household in bad state of preservation. It was later moved again to the Amins' property between 2005 and 2015. After surveying the collection, we found that it comprises around 500 gelatin dry plates produced during the period between 1910 and 1940.

The negatives depict different subjects (i.e. archaeological sites, portraits, landscapes and others). Different formats and sizes were noted. The collection items were classified according to their size (i.e. 11 × 8, 11 × 9, 12 × 10, 15 × 10, 16 × 12, 17 × 12, 18 × 13, and 24 × 18cm^2) (Fig. 1A). Some large plates were cut in two by the photographer himself and this was recognized by their uneven edges (Fig. 1B). The photographer also applied different types of retouching on both the image and glass sides to enhance the visual appearance of the final images. In some cases, he applied black paper in the form of a frame around all edges; while in others, he applied masking or red opaque paint (Fig. 1C and D). Some negatives were also varnished.

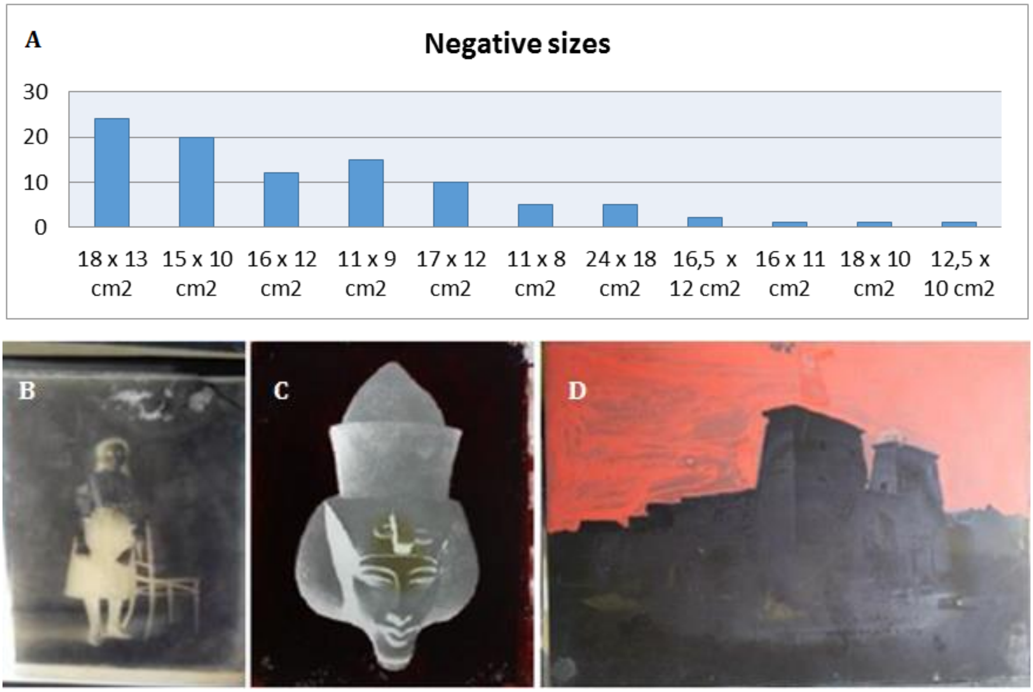


Fig. 1. Classification of the dry plate negatives according to their size and the percentage of each size within the collection (A). Irregular edges of a dry plate cut originally from a 13 × 18 cm^2 plate (B), and retouches found on some negatives for visual enhancement (C, D). (Courtesy of the Amin family)

With regard to the state of preservation, the majority of the negatives were found to suffer from mechanical damage due to poor handling and improper housing, as well as chemical damage due to storage in unfavorable environmental conditions (Fig. 2A and B). Past storage conditions were generally inappropriate (i.e. improper temperature and relative humidity levels, poor air quality, improper light levels, poor-quality enclosures), with plates of different types and sizes stacked in piles. Consequently, these conditions have resulted in many damage forms such as surface dirt, fingerprint stains, scratches, accretions, breakage, silver mirroring, image discoloration, binder flaking, binder peeling, mold stains, adhesive residues, poor-quality labels and many others (Fig. 2C-H). The dry plate negatives were categorized according to their state of preservation into the following four categories: good, fair, poor and very poor (i.e. broken glass plates) (Fig. 2I).

Precise knowledge of the materials involved in the making of the negatives and correct diagnosis of the present damage forms greatly assist in the development of an appropriate approach for better conservation and protection of the collection for future generations. In this paper, we are considering the importance of the scientific analysis in understanding the material composition, the manufacturing methods, the integrity of the material, and the environmental impact.on the collection. Five representative dry plate negatives were selected showing signs of common damage forms such as: surface dust, mold infection, silver mirroring, breakage, etc… (Fig. 3)

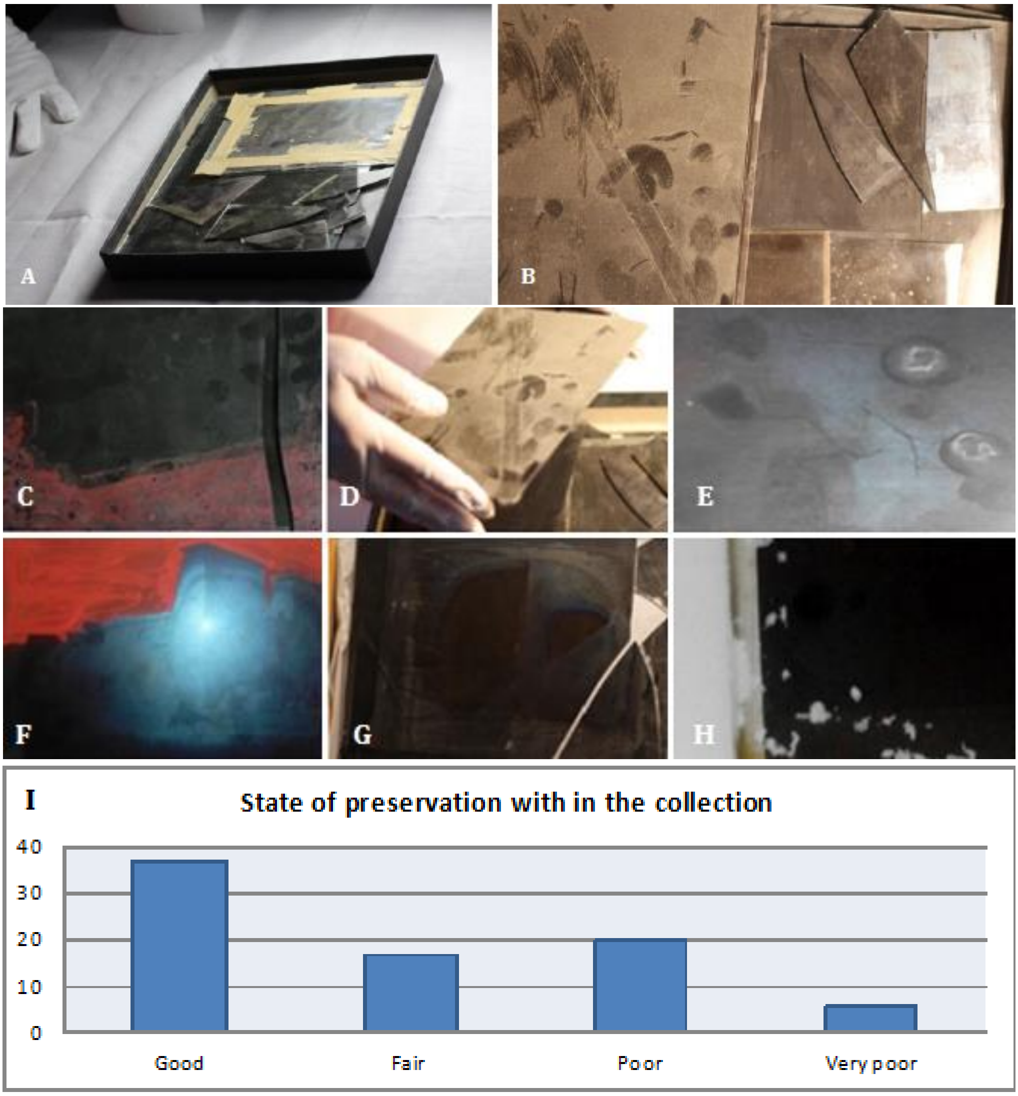


Fig. 2. Absence of dividers has caused the negatives to break (A); while improper housing and poor collection management has lead to the accumulation of dust inside the enclosures (B). Several damage forms were found such as broken glass negative (C), surface dirt (D), accretions (E), silver mirroring (F), broken glass negative and mirroring (G) and losses in binder layer (H). (Courtesy of the Amin family). This chart represents the percentage of each preservation status within the collection (I)

Photographic samples for treatment testing

A heavily mirrored gelatin dry plate negative from the Heinz and Georges Leichter collection was selected for testing silver mirroring removal treatments. The plate has a size of 16 x 12cm^2 and a thickness of 1.6 mm (Fig. 3A and B).

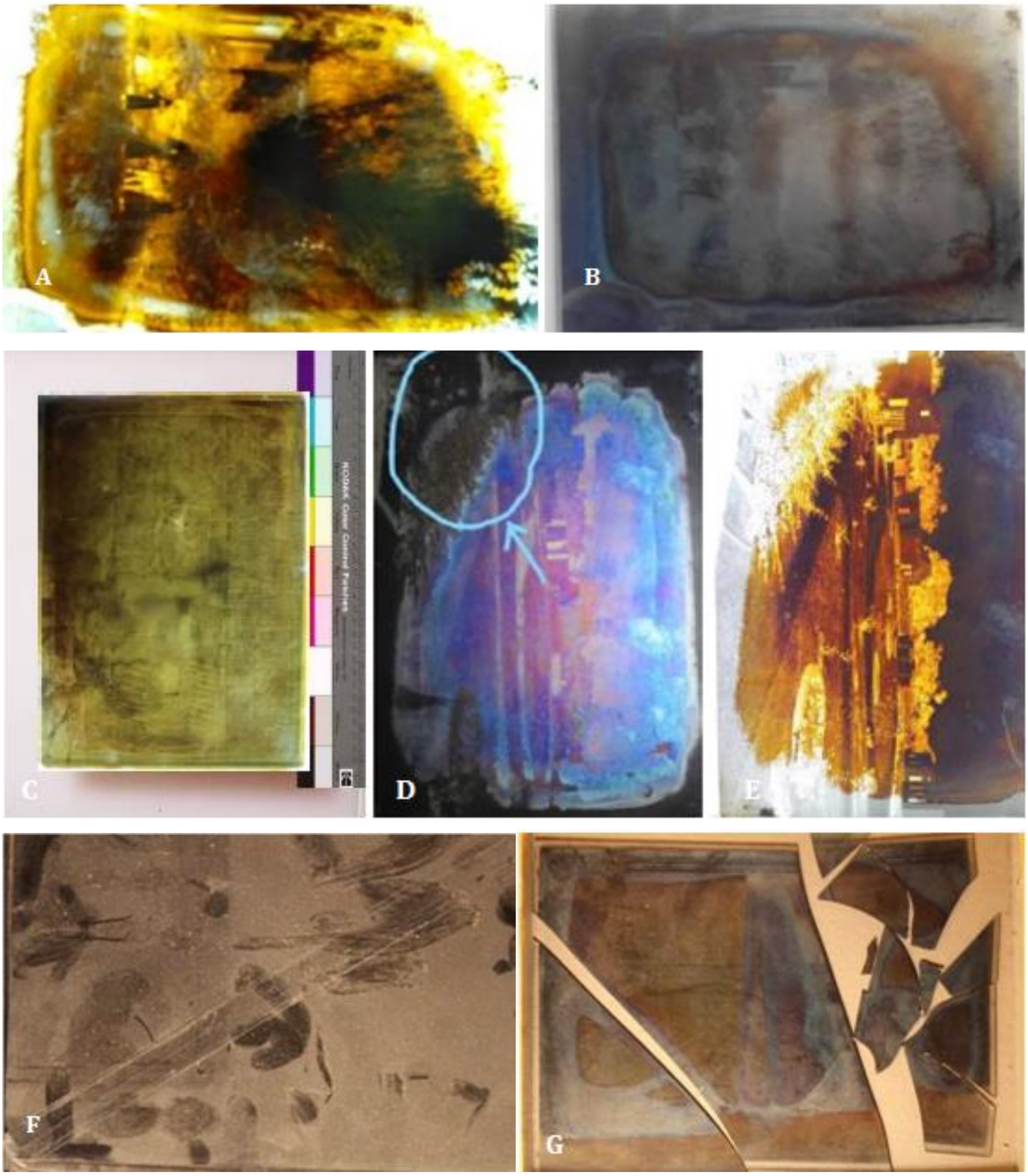


Fig. 3. Shows the first glass plate negative suffering from image degradation apparent as yellow orange discoloration in transmitted light (A) and mirroring in reflected light (B). The second glass plate negative suffering from severe damage (C), and the third glass plate negative in reflected light (D) and in transmitted light (E). The fourth glass plate negative covered heavily with dust and repaired using adhesive tape (F). The broken fifth glass plate negative (G) (Courtesy of the Amin family)

Removal/reduction materials

Three different types of erasers were tested for silver mirroring removal/reduction: Faber Castell PVC free eraser, Staedtler Mars eraser and a commercial eraser known as Softy (Fig. 4).

Methods

Treatment application method

Erasing was carried out by gently rubbing the mirrored area in a circular motion. Eraser residues were removed by brushing and an air blower (Fig. 4).

Fig. 4. Erasers tested for mirroring removal/reduction (top). Application method (bottom)

Visual inspection

Complete photo-documentation for the purpose of documenting visible forms of damage was carried out using a CANON, EOS 700D digital camera. Images were shot in both reflection and transmittance lighting conditions.

USB digital microscope

A SUPEREYES USB digital microscope was used to detect damage forms found in the selected dry glass plates which are not visible to the naked eyes, as well as document visual changes post treatments, with enlargements from 20× up to 500×.

Stereo microscope

An Olympus SZ-STU2 Stereo microscope utilizing an Olympus ring light illuminator lamp, with a magnification of 20X and 40X, was used to examine the condition of the plates.

Scanning electron microscope with energy dispersive X-ray spectroscopy (SEM-EDX)

The analysis was carried out on the selected dry plates and the photographic samples before and after treatment using a SEM Model Quanta 250 FEG (Field Emission Gun) attached with EDX unit, with accelerating voltage of 30 K.V., magnification 14× up to 1000000× and resolutions for the Gun of 1n. Samples were gold-coated using an EMITECH K550×, sputter coater (England). The process was performed at the SEM Laboratory of the Ministry of Petroleum, the Egyptian Mineral Resources Authority Central Laboratories Sector.

Fungal testing

The swab sampling technique was used to collect samples since it is considered a non-invasive sample prelevation method [29]. Sterile cotton swabs were used to gently wipe the infected areas of the image layer and glass surface of each plate then transferred to the lab in sterile tubes to be used for fungal culturing and identification [30]. The cultural media chosen for this test are listed in Table 1. Inoculation was conducted by directly wiping swabs on the surface of potato dextrose agar (PDA) and Sabouraud Dox Agar (SBA) Petri dishes containing chloramphenicol. The plates were then sealed with Parafilm and incubated at 28±2°C for a period of 7 days. The identification of fungal isolate was carried out at the Microbiology Laboratory of the Research Centre at the Ministry of Antiquities in Cairo, Egypt.

Table 1. Cultural media used for fungal testing

PDA		SBA	
Ingredients	**Quantity**	**Ingredients**	**Quantity**
Filtrates of boiled potato slices in one liter of distilled water	200g	Dextrose	40g
Dextrose	20g	Peptone	10g
Agar	20g	Agar	20g
Distilled water	1000 mL	Distilled water	1000 mL

Ninhydrin test

Ninhydrin is a common reagent for detecting proteins. When ninhydrin reacts with an amino acid, one of the products is a deep violet, resonance-stabilized anion called Ruhemann's purple. Ninhydrin produces this purple dye regardless of the structure of the original amino acid [31]. The ninhydrin reagent was prepared by dissolving 1.25g of ninhydrin crystals in 200mL of acetone [32]. To perform the ninhydrin test, one drop of the reagent was placed on the swabs, and allowed to rest several minutes before heating on a taking iron. The swaps had to be heated for several minutes before a color appeared [33]. The test was performed to understand whether or not the binder layer was disturbed during cleaning. The same test was performed on a blank to ensure that the test was being conducted correctly. Gloves must be worn during the test, as the resulting stains are difficult to remove.

Results and discussion

Collection condition assessment

Visual inspection

The first glass plate negative depicts a landscape. It has the dimension of 12×16cm^2 and the thickness of 2mm. In transmitted light, the plate shows yellow-orange discoloration; however, in reflected light, silver mirroring is apparent (Fig. 3A and B). Second glass plate negative has the dimension of 13×18cm^2 and the thickness of 2mm. The plate is in severe bad state of preservation making the glass opaque. As for the third glass negative, it also carries a landscape image. It has the dimension of 13×18cm^2 and the thickness of 2mm. The image surface is severely damaged showing a reddish purple discoloration in reflected light and an orange brown discoloration in transmitted light. The binder layer shows the presence of fingerprints, scratches and losses (Fig. 3C-E). The fourth glass plate negative has a size of 13×18cm^2 and the thickness of 2mm. The plate is in very poor condition and is heavily covered with dust. It also shows a previous restoration using adhesive tape to reassemble the broken plate (Fig. 3F). The fifth and last plate depicts an archaeological site (i.e. an inscription of a tomb). It has a dimension of 18×24cm^2 and the thickness of 2mm. It is broken into 12 fragments and suffers from losses. It also suffers from mirroring (Fig. 3G).

USB digital microscope

Microscopic examination revealed the presence of biodeterioration on the plates, apparent as losses in the gelatin binder layer due to fungal infection (Fig. 5).

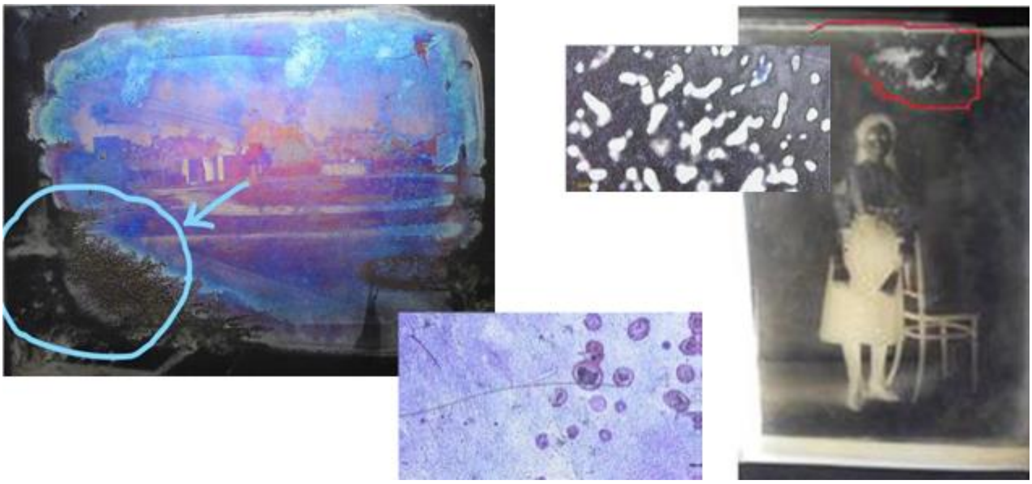


Fig. 5. Two glass negatives showing signs of biodeterioration under microscopic inspection (300× magnification). (Courtesy of the Amin family)

Stereo microscope

Microscopic inspection showed the presence of various physical and chemical forms of damage. Fingerprints were obvious in all selected glass plates, which is clear evidence of poor handling. Mirroring, scratches and lifted binder and surface dirt were also evident (Fig. 6).

Fig. 6. Examples of damage found during microscopic inspection using a stereo microscope. Fingerprints (A), scratches, mirroring and binder lifting (B) and dirt (C). (Courtesy of the Amin family)

Scanning electron microscope with energy dispersive X-ray spectroscopy (SEM-EDX)

Examination and analysis were carried out on multiple locations on a small fragment. Elemental mapping of the glass side of the plate showed the presence of silicon, sodium, calcium and low concentration of aluminum (Fig. 7A and B). This is consistent with the fact that early glasses were almost all soda–lime–silica compositions (soda lime glass) that varied depending upon the availability of raw materials [34]. However, the basic ingredients are: amorphous silicon dioxide (SiO_2), soda (sodium carbonate, Na_2CO_3) or potash, a compound or flux to lower the melting point, and a stabilizer such as lime (calcium oxide, CaO) to restore insolubility [35]. Studies have also pointed out several modifications of the properties of silica glass induced by aluminum present as an impurity [36].

The red colorant has been identified as Vermilion, mercury sulfide, HgS (Fig. 7C and D) [37]. Vermilion red was one of the most important reds in art and its use as a pigment dates back to Antiquity [38]. It was the primary red pigment used by European painters from the Renaissance until the 20th century. Mercuric sulfide yields a range of warm hues.

Analysis of the image side revealed the presence of silver (Ag) as the final image material. Sulfur may be associated with image silver decay (silver mirroring) or as indication of the presence of residual fixer, sodium thiosulfate, $Na_2S_2O_3$ [39]. Chloride (Cl) was also found which may indicate the presence of residual light-sensitive material, it may also be from the water baths used during processing or it may come from glass [36]. The presence of iron (Fe) may be related to the coloring agents used by photographers to enhance the visual appearance of image (Fig. 7E and F). In this context, many photographers used various types of coloring agents to modify images such as Red lead (Pb_3O_4), Natural red earth (Fe_2O_3 + kaolin), Venetian red (Fe_2O_3 + gypsum), Pompei red (Fe_2O_3 + kaolin), Caput Mortuum reddish (Fe_2O_3 + some silicates) and Vermilion, also known as Cinnabar (HgS).

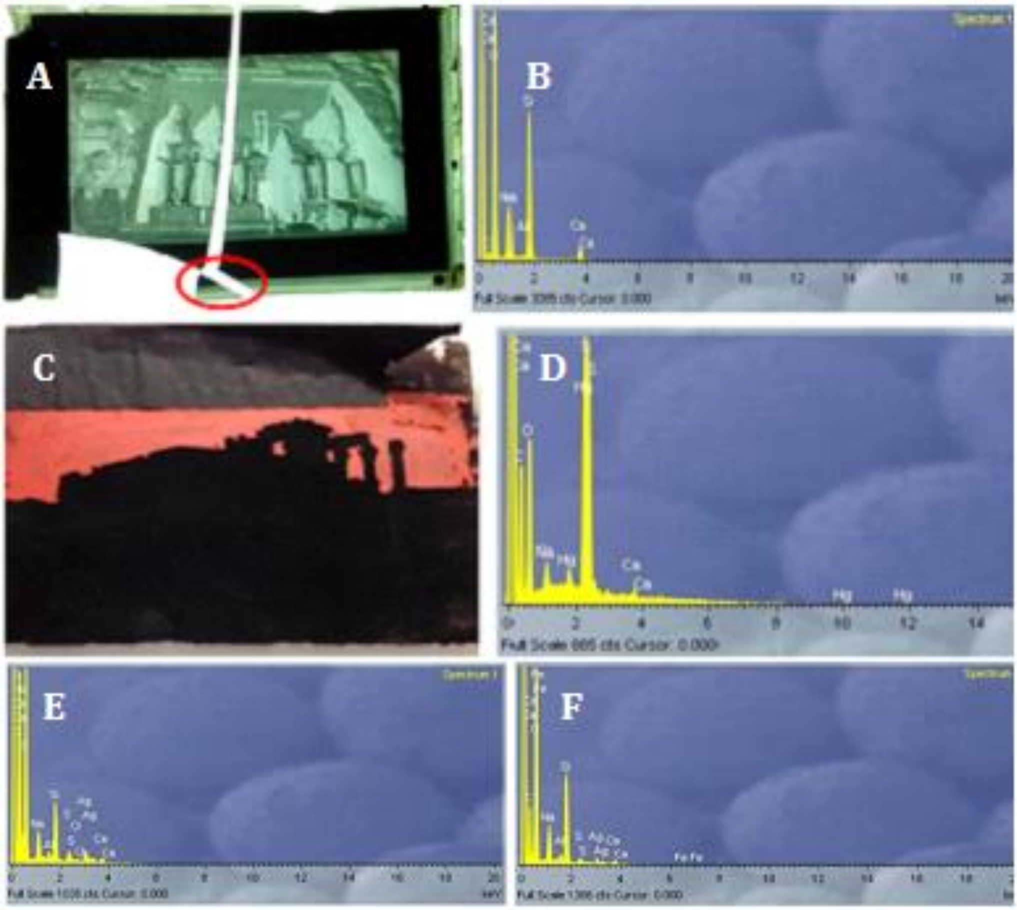


Fig. 7. Broken fragment used for SEM-EDX analysis (A). X-ray spectrum revealing the elemental composition of the glass support (B). Analysis of the red retouching medium found on one of the plates (C). X-ray spectrum reveals the elemental composition of the red coloring agent as Vermilion, HgS (D). X-ray spectrum revealing the elemental composition of the image side revealing the presence of silver as the final image material. Sulfur was also detected as a possible sign of image decay (E). Iron was also found which may be related to the coloring agents used by photographers to enhance the appearance of their images (F)

Taxa identification

Fungi could be considered the principal microbial contaminants of photographs, since they are exclusively heterotrophic and can be active at lower water availabilities [40]. After one week, circles of mold spread and formed distinguishable patterns in the Petri dishes (Fig. 8). For identification, the isolates were studied under the light microscope and identified according to the morphological characteristics of the fungal colonies. The isolates were transferred to sterilized plates for purification and identification. The grown fungi were mounted n a slide and stained to detect fungal structure [41]. Different species were isolated from the glass negatives and the results of their frequent occurrence are listed in Table 2 and Table 3.

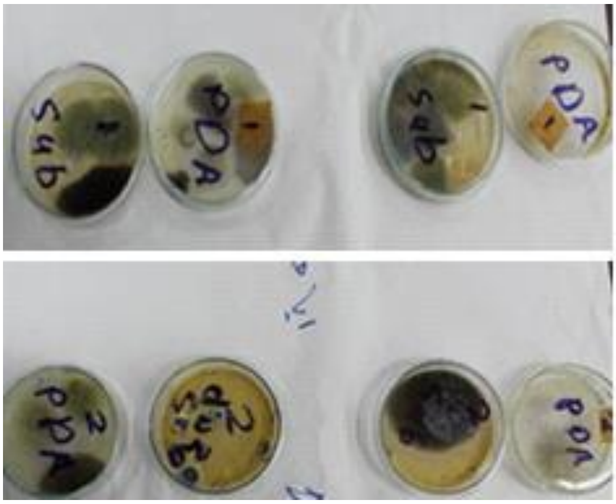


Fig. 8. Inoculated plates showing fungal growth after one week of incubation at 28°C

Table 2. The isolated fungi from plate 1 and the frequency of their occurrence

Frequency of occurremce	PDA				SBA			
	R1	**%**	**R2**	**%**	**R1**	**%**	**R2**	**%**
Alternaria teniuus	1	100	1	10				
Alternaria flavus			4	40	3	75	2	66.6
Aspergillus nidulans			2	20				
Aspergillus niger			3	30			1	33.3
Aspergillus sydowi								
Cladosporium					1	25		
Gliocladwim spp								
Mycelia strelia								
Total	1		10		4		3	

Table 3. The isolated fungi from plate 2 and the frequency of their occurrence

Frequency of occurremce	PDA				SBA			
	R1	**%**	**R2**	**%**	**R1**	**%**	**R2**	**%**
Alternaria teniuus								
Alternaria flavus					5	50		
Aspergillus nidulans								
Aspergillus niger					2	20		
Aspergillus sydowi					2	20		
Cladosporium								
Gliocladwim spp	1	50						
Mycelia strelia	1	50						
Total	2				9			

Assessment of silver mirroring treatments

USB digital microscope

Unsatisfactory results were observed post treatment with Staedtler Mars and Softy erasers. In both cases, treated surfaces showed varying degrees of scratches. On the other hand, Faber Castell's PVC free eraser yielded good resulting reducing the mirroring to a notable degree without producing any visible scratches (Fig. 9).

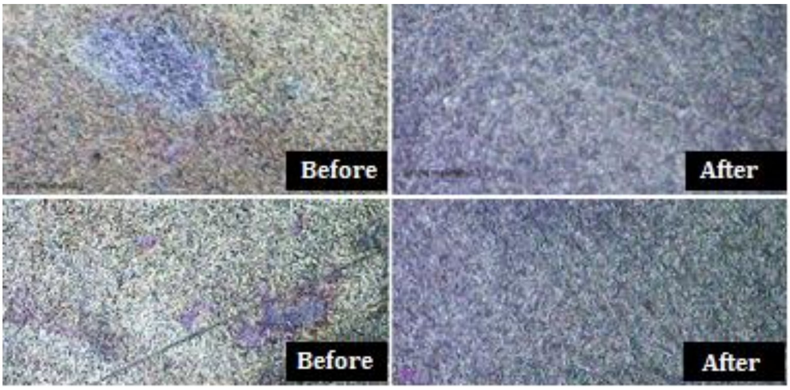
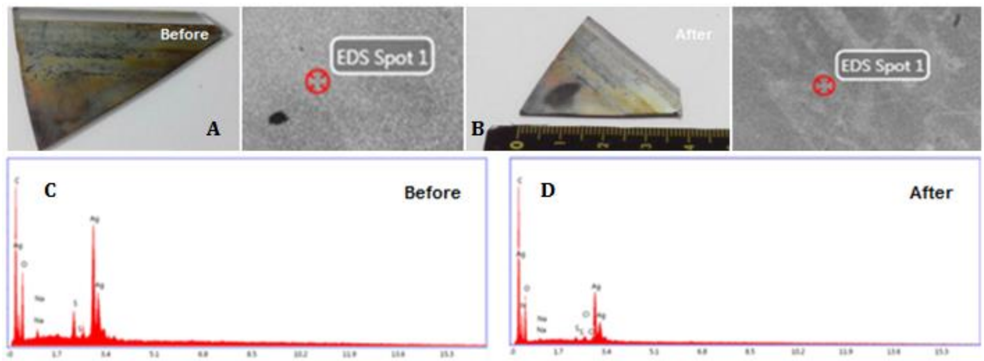


Fig. 9. Surface before and after treatment with Staedtler Mars eraser showing minor scratches (top). Surface before and after treatment with Faber Castell eraser showing a mirrored free surface with no scratches (bottom)

Scanning electron microscope with energy dispersive X-ray spectroscopy (SEM-EDX)

Surface treated with Faber Castell PVC free eraser was examined and analyzed before and after treatment using a broken fragment from the plate. SEM-EDX analysis showed a decrease in the amount of silver and sulfur post treatment with Faber Castell PVC free eraser (Fig. 10), a result that is consistent with observation documented during digital microscopic inspection.



Element	Weight %	Atomic %	Net Int.	Error %	Kratio	Z	R	A	F
C K	28.79	35.78	246.31	7.71	0.1421	1.1073	0.9170	0.4457	1.0000
O K	36.75	43.86	197.50	10.80	0.0536	1.0677	0.9403	0.1366	1.0000
NaK	5.04	4.19	51.15	12.65	0.0114	0.9778	0.9690	0.2311	1.0026
S K	2.31	1.38	91.10	7.49	0.0189	0.9681	1.0075	0.8176	1.0308
AgL	27.10	4.80	501.48	4.14	0.2380	0.7569	1.2216	1.1431	1.0152

Element	Weight %	Atomic %	Net Int.	Error %	Kratio	Z	R	A	F
C K	31.72	41.28	501.61	6.27	0.1640	1.0548	0.9581	0.5496	1.0000
N K	21.96	24.39	114.09	11.58	0.0316	1.0333	0.9694	0.1400	1.0000
O K	31.92	31.18	209.63	11.01	0.0362	1.0145	0.9795	0.1117	1.0000
NaK	1.63	1.11	27.33	14.40	0.0039	0.9296	1.0055	0.2567	1.0023
S K	0.25	0.12	15.75	23.87	0.0021	0.9143	1.0395	0.8875	1.0279
ClK	0.33	0.14	19.85	18.09	0.0028	0.8798	1.0453	0.9417	1.0418
AgL	12.29	1.78	360.80	5.57	0.1089	0.7140	1.2572	1.2169	1.0195

Fig. 10. Test sample before (A) and after treatment (B) and analysis locations. X-ray spectra revealing the success of Faber Castell eraser in reducing mirroring decay (C, D)

Ninhydrin test

Results for the Ninhydrin test carried out on the residues of the Faber Castell eraser showed no change in color indicating that the gelatin binder has not been affected (Fig. 11).

To test previous findings, a mirrored plate was half cleaned to reduce the mirroring appearance and was then contact printed on Ilford black and white photographic paper RC Deluxe 3, glossy. We have observed that the mirrored half required more exposure time to obtain an image with visible details to some extent (Fig. 12).

Fig. 11. Ninhydrin test results showed no change for the Faber Castell eraser residues

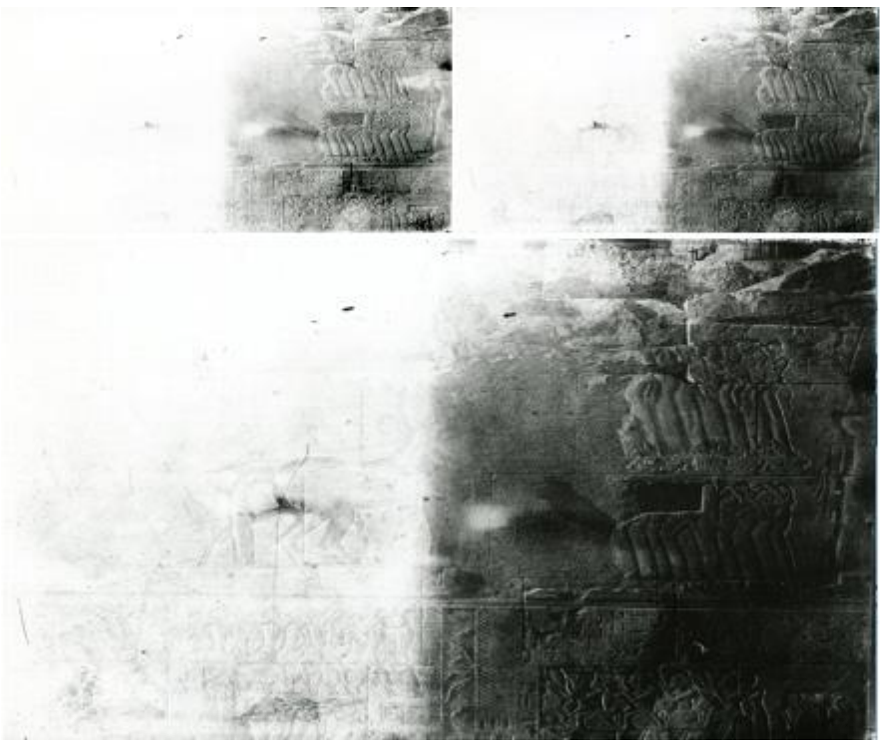


Fig. 12. Contact prints produced from a gelatin dry plate negative half cleaned to remove mirroring, with the bottom print being expose to a longer time period in order to obtain a visible image. (Courtesy of the Amin family)

Conservation of selected dry plate negatives from the Leichter Collection, Egypt

Based on the obtained results, it was decided that the conservation treatments would involve: disinfection, surface cleaning, removal of previous repairs, digitization, and rehousing.

Disinfection

Chemical fungicides have been widely used to disinfect contaminated historic objects such as thymol, formaldehyde, ethylene oxide and many others [42-44]. However, the use of such toxic chemicals is becoming increasingly restricted due to their damaging impact on the environment and human health [45]. Accordingly, the use of natural alternatives such as essential oils is definitely a safer and more appropriate approach. In recent years, essential oils have been proven to have antibacterial and antifungal properties. Essential oils are volatile aromatic concentrated hydrophobic oily liquids which are obtained from various plant parts [46]. The biocide activity of extracts of sweet basil, clove, cumin, cinnamon, lavender, thyme and many other essential oils has been addressed in many publications [47-50].

Thyme essential oil was selected since it is readily available in Egypt. Chemical analysis of the thyme essential oil showed that thymol (68.91%), para-cymene (13.61%), g-terpinene (7.60%), ocimene (2.11%) and carvacrol (1.55%) were present at the highest fractions. Lower amounts of following compounds were measured: 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% [50]. The essential oil used in this study was provided by the National Research Center (NRC) in Cairo, Egypt. Three concentrations of thyme essential oils were prepared in pure ethyl alcohol (0.25%, 0.5% and 1%) for testing their efficiency. Table 4 represents the inhibition zone diameters (cm) for the three tested concentrations. Results show that the use of thyme oil in ethyl alcohol (0.5%) gave very good results. The essential oil was applied in vapour phase for higher efficiency [51].

Table 4. Inhibition zone diameter for thyme essential oil in ethyl alcohol

		Thyme essential oil concentration in ethyl alcohol		
		0.25%	**0.5%**	**1%**
Aspergillus Niger	Inhibition zone diameter (cm)	0.3	1.6	1.2
Aspergillus flavus		1.4	1.4	2.0
Aspergillus fumigatus		0	1.3	2.5
Aspergillus sulphoreus		1.2	1.3	2.2
Fuzarium sp.		1.5	1.6	2.2
Penicillium sp.		1.1	1.2	3.1

Surface cleaning

Surface dirt was removed following the conventional methods using a soft brush, more preferably a bristled squirrel hair brush (Fig. 13A). Silver mirroring was reduced using Faber Castell's PVC free eraser (Fig. 13B).

Removal of previous repairs

The tape carrier was carefully removed using a solution of ethyl alcohol in distilled water (80:20%) (Fig. 13C). The remaining adhesive was removed by gently rolling a cotton swab dampened with the previous organic solvent over it to avoid damaging the binder layer (Fig. 13D).

Digitization

A CANON, EOS 700D digital camera with aperture of F/5.6, exposure time of 1/1000 seconds and ISO of 200 was used to digitize the plates and a positive digital reproduction of each plate was produced and enhanced using Adobe Photoshop (Fig. 13E, F).

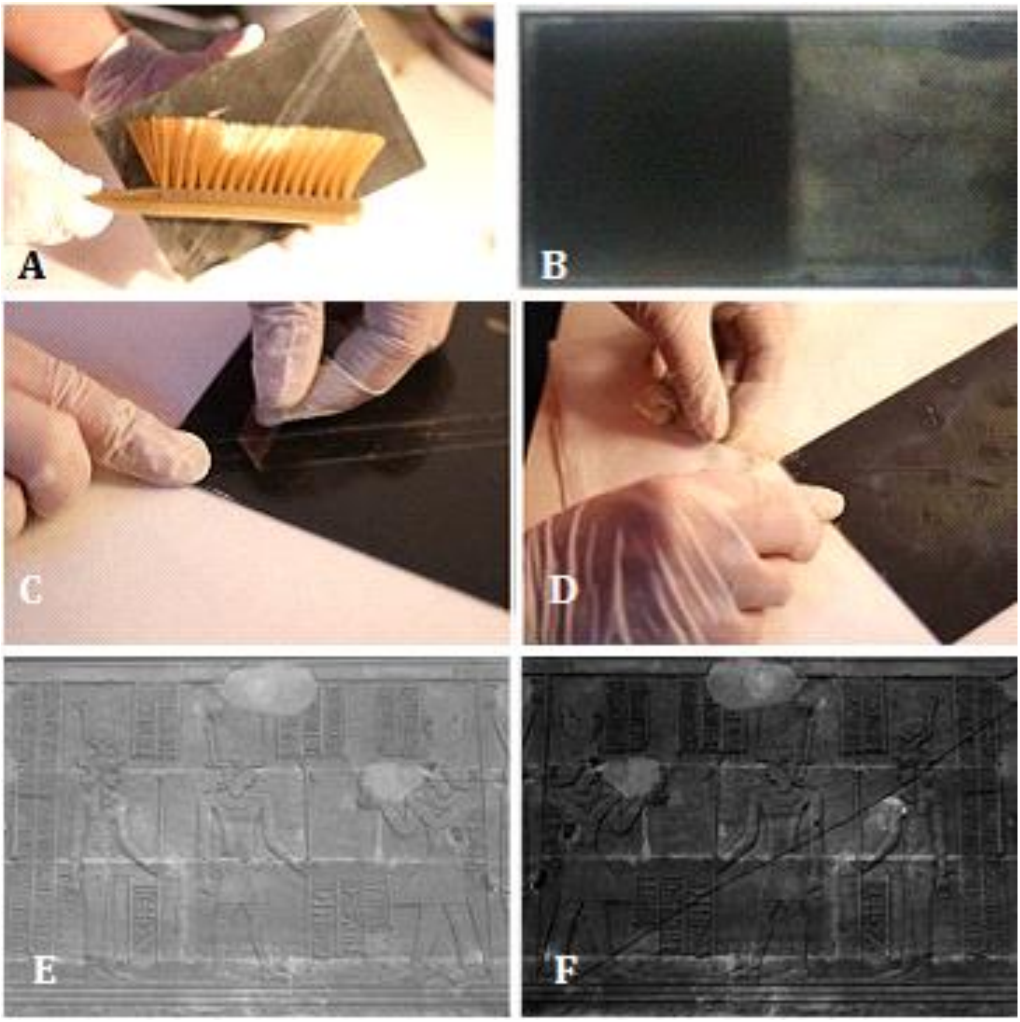


Fig. 13. Surface cleaning using a soft brush (A) and mirroring reduction (B). Removal of previous repairs (C, D). A positive enhance reproduction of a gelatin dry plate form the Heinz and Georges Leichter collection (E, F)

Rehousing

For the broken glass negatives, there are two different approaches for assembling broken glass negative: by preparation of a non-adhesive housing mat [52, 53] or by using an adhesive such as Paraloid B72, which has been used in several cases [54, 55] and epoxies [56].

The authors found it more convenient to prepare a non-adhesive housing mat (i.e. sink mat) that serves both as a non-invasive method of assembling broken glass negative as well as a proper housing method. Being transparent, it permits the viewing of the negative from both sides. A 4-ply acid-free board was used for making the enclosures.

As for broken glass negatives with missing fragments, they were placed in an acid-free cardboard frame and sandwiched between two pieces of glass cut 0.5cm larger than the image plate on each side. A small opening was intentionally made in each corner for ventilation. This structure was then placed in a custom made four flap enclosures (Fig. 14).

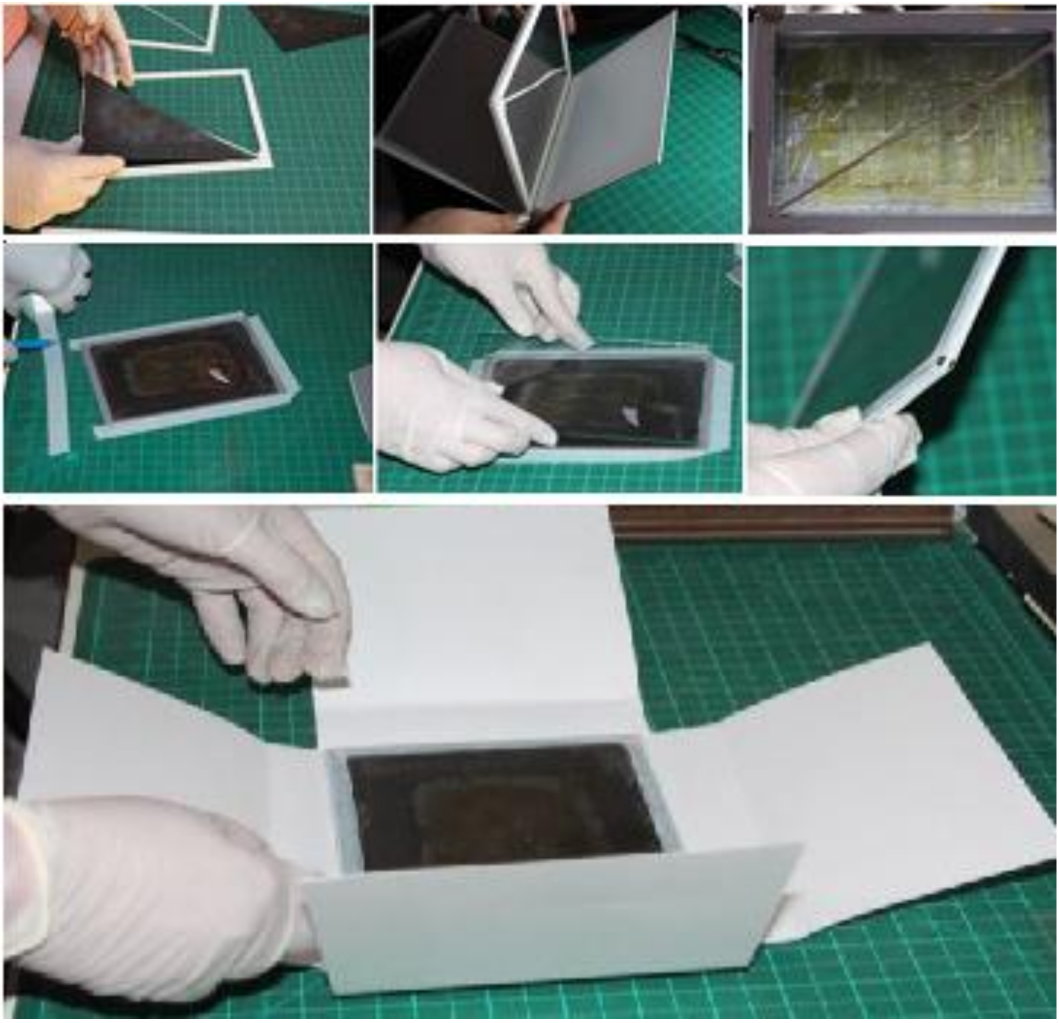


Fig. 14. Preparation of a sink mat for housing broken glass negatives (top). Preparation of a sink mat for housing broken glass negatives with missing parts (center). Four flap enclosure (bottom)

Finally, oversized storage boxes were made from acid-free cardboard to house large gelatin dry plates (i.e. size of 13×18cm^2). Flip top storage boxes were made for small plates. Aluminum pins were used to hold the box together (Fig. 15).

Fig. 15. Oversized storage boxes for horizontally housing large negatives (top). Storage boxes for vertically housing small negatives (bottom)

Conclusions

Photography reached Egypt in 1839, the same year it was invented in France. After 1852, many studios were opened around the Azbakya garden, the new downtown Ataba, then Alexandria and Luxor. Among these was the studio of Leichter. Heinz Leichter is one of the master photographers who worked on Egyptian archeophotography between 1910 till his death in 1940. Georges his only son worked with him till 1937. The Leichter collection owned by the Amin's family includes around 1000 negatives, 500 of which are gelatin dry plate negatives. Many historians of photography claim that the use of gelatin dry plate negatives, ended around 1925. However, our study proves otherwise since we have found glass plates dating up to 1940, the date of Heinz's death.

The negatives were found to depict different subjects (i.e. archaeological sites, portraits, landscapes and others). Different formats and different sizes were noted. The collection items were classified according to their size (11×8, 11×9, 12×10, 15×10, 16×12, 17×12, 18×13, and 24×18cm^2). In some cases large plates were cut in two by the photographer himself. The photographer also applied different types of retouching on both the image and glass sides to enhance the visual appearance of the final images.

Several examination and analytical techniques were utilized to study five gelatin dry plated selected from the Leichter collection such as: visual inspection, USB digital microscope, stereo microscope, and SEM-EDX. Fungal testing was also carried out to identify fungal growths.

Visual and microscopic inspection showed that the majority of the negatives were found to suffer from different forms of damage (surface dirt, fingerprint stains, scratches, accretions, breakage, silver mirroring, image discoloration, binder flaking, binder peeling, mold stains, adhesive residues, poor labels, and many others) due to poor handling and storage in unfavorable environmental conditions.

SEM-EDX analysis identified the glass support used as soda–lime–silica as indicated by the presence of silicon, sodium, calcium and low concentration of aluminum. One of the selected plates had a red retouching medium which has been identified as vermilion, HgS. Analysis of the image side revealed the presence of silver (Ag) as the final image material. Sulfur was also detected; this finding may be associated with image silver decay (silver mirroring) or as indication of the presence of residual fixer, sodium thiosulfate, $Na_2S_2O_3$. Chloride (Cl) was also found which may indicate the presence of residual light-sensitive material, it may be also from the water baths used during processing or one of the impurities of glass. The presence of iron (Fe) may be related to the coloring agents used by photographers to enhance the visual appearance of image.

With regard to fungal testing, different species were isolated from the glass negatives: *Alternaria teniuus, Alternaria flavus, Aspergillus nidulans, Aspergillus niger, Aspergillus sydowi, Cladosporium, Gliocladwim spp* and *Mycelia strelia.*

Nearly 50% of the Heinz and Georges Leichter dry plate collection suffer from advanced form of silver mirroring, an image decay form that appears as a bluish metallic sheen. The treatment of silver mirroring is a controversial issue among conservators. However, methods of reduction or removal have been performed and several have been investigated. In this study we have tested three types of erasers (Faber Castell PVC free eraser, Staedtler Mars eraser and a commercial eraser known as Softy) with the aim of improving the visual appearance of the disfigured negatives so as to obtain a digitized copy with as much details as possible rather than enhancing the image appearance for aesthetic reasons. Treatments were evaluated using USB digital microscope, SEM-EDX and ninhydrin test. Microscopic inspection showed unsatisfactory results post treatment with Staedtler Mars and Softy erasers. In both cases, treated surfaces showed varying degrees of scratches. On the other hand, Faber Castell's PVC free eraser yielded good results reducing the mirroring to a notable degree without producing any visible scratches. SEM-EDX analysis showed a decrease in the amount of silver and sulfur post treatment with Faber Castell PVC free eraser. Results for the Ninhydrin test carried out on the residues of the Faber Castell eraser showed no change in color indicating that the gelatin binder has not been affected.

Based on the obtained results, it was decided that the conservation treatments would involve: disinfection, cleaning, removal of previous repairs, digitization and rehousing. Thyme oil in pure ethyl alcohol (0.5%) was used for the disinfection of the collection. Surface dirt was mechanically removed using a soft brush, while silver mirroring was reduced using Faber Castell's PVC free eraser. The self-adhesive tapes previously used to repair broken negatives were removed using a solution of ethyl alcohol in distilled water (80:20%). A CANON, EOS 700D digital camera with aperture of F/5.6, exposure time of 1/1000 seconds and ISO of 200 was used to digitize the plates and a positive digital reproduction of each plate was produced and enhanced using Adobe Photoshop. For rehousing the collection, different enclosures were prepared from acid-free cardboard and paper (i.e. sink mats, four flap enclosures, and storage boxes).

References

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

[2] R. Herskovitz, *Storage of Glass Plate Negatives, Minnesota History Interpreter*, **Minnesota Historical Society**, July 1999, pp. 3-6.

[3] C. Wills, D. Wills, **History of Photography: Techniques and Equipment**, The Hamlyn Publishing Group, London, 1980.

[4] C. Mees, **Photography**, G. Bell and Sons LTD, London, 1936.

[5] * * *, **The Graphic Atlas**, **Dry Glass Plate, Process Identification**, from the Image Permanence Institute, Rochester, http://www.graphicsatlas.org/identification/?process_id=303 [accessed on 20.1.2017].
[6] G. Di Pietro, *Silver Mirroring on Silver Gelatin Glass Negatives*, **PhD Thesis**, University of Basel, 2002.
[7] M. Valverde, **Photographic Negatives: Nature and Evolution of Processes**, 2nd edition, Advanced Residency Program in Photograph Conservation, 2005.
[8] E. Larew, *Not Just the Paris Portrait: Preserving Berenice Abbott's Glass Plate Negatives*, **Master's Thesis**, Ryerson University, 2015.
[9] G. Réveillac, **Les Collections Photographiques Beato, Gaddis-Seif, Adly-Leichter**. Centre Franco-Égyptien d'étude Des Temples De Karnak Louqsor (Égypte) usr 3172 du cnrs, Extrait des Cahiers de Karnak 11, 2003.
[10] C. Busi, F. Mohareb**, Fotografi in egitto, Immagini di Heinz e Giorgio Leichter dal 1910 -1940**, Ananke Torino, 2002.
[11] P. Mustardo, N. Kennedy, *Photograph Preservation: Basic Methods of Safeguarding Your Collections*, **Technical Leaflet Series,** No. 9, Mid-Atlantic Regional Archives Conference, 1997.
[12] K. Hendriks, K. **The Preservation and Restoration of Photographic Materials in Archives and Libraries: A Ramp Study with Guidelines**, UNESCO, 1984.
[13] H. Creasy, **Caring for Photographic Collections in Museums**, Factsheet, Museums Council, 2001.
[14] M. Ali, *Study of Forms of Chemical Degradation "Discoloration, Fading and Stains" of Black and White Fiber-Based Photographic Prints due to the Deterioration of the Silver Gelatin Emulsion Layer Applied on Selected Objects*, **Master's Thesis**, Cairo University, 2010.
[15] G. Weaver, **A Guide to Fiber-Base Gelatin Silver Print Condition and Deterioration**, Adobe Calson, Pro, Catriel, and Tandelle, 2008.
[16] N. Code, **Forms of Photograph Degradation: Silver Mirroring**; from the Archives and Special Collections Blog, University Libraries, University of South Dakota, https://archivesandspecialcollections.wordpress.com/2012/01/17/forms-of-photographic-degradation-silver-mirroring/ [accessed on 18.6.2016].
[17] D. Burge, J. Reilly, D. Nishimura, *Effects of Enclosure Papers and Paperboards Containing Lignins on Photographic Image Stability*, **Journal of the American Institute for Conservation**, **41**(3), 2002, pp. 279-290.
[18] C. Grzywacz, **Monitoring for Gaseous Pollutants in Museum Environments: Tools for Conservation**, Getty Publications, 2006.
[19] * * *, Recollections: Caring for Collections across Australia, **Caring for Cultural Materials 1: Photograph 1**; from Heritage Collections Council, http://archive.amol.org.au/recollections/1/3/08.htm [accessed on 20.6.2016].
[20] P. Banks, *What Makes Records Deteriorate: Practical Guide*, **ASHRAE Journal**, **41**(4), 1999.
[21] B. Lavédrine, J. Gandolfo, S. Monod, **A Guide to the Preventive Conservation of Photograph Collections**, Getty Conservation Institute, 2003.
[22] J. Gruneir, *Urban Decay: A Case Study of the Negatives in the Toronto Telegram Fonds, Clara Thomas Archives and Special Collections*, **Master's Thesis**, Ryerson University, 2007.
[23] S. Bisi, G. Smith, G. Albright, *Purple Haze: The Development and Analysis of Vapor Iodine Treatment for the Reduction of Silver Mirroring*, **Topics in Photographic Preservation**, **13**(25), 2009, pp. 182-197.
[24] R.A. Weinstein, L. Booth, **Collection, Use and Care of Historical Photographs**, American Association of State and Local History, Oak Knollo, 1977.

[25] J. Johnsen, *Chemical Treatment of Black and White Negatives*, **The International Congress of Restorers of Graphic Art**, Sweden. August 1991.
[26] S. Barger, T. Hill, *Thiourea and Ammonium Thiosulfate Treatments for the Removal of Silvering from Aged Negative Materials*, **Journal of Imaging Technology**, **14**(2), 1988, pp. 43- 46.
[27] B. Bernier, *A Study of Poly (Vinyl Chloride) Erasers used in the Surface Cleaning of Photographs*, **Topics in Photographic Preservation**, **7**, 1997, pp. 10 – 18.
[28] T. Luzeckyj, I. Brückle, *Immediate and Long-Term Effects of the Treatment of Silver Mirroring on the Surface of Photographs*, **Topics in Photographic Preservation**, **8**, 1991, pp. 31 – 43.
[29] O. Baldasici, L. Barbu-Tudoran, L., *Structural and Elemental Analysis of Biodegraded Artifacts*, **Annals of RSCB**, **17**(2), 1984, pp. 213 – 219.
[30] M. Montanari, V. Mellomi, F. Pinzari, G. Innocenti, *Fungal Biodeterioration of Historical Library Materials Stored in Compactus*, **International Biodeterioration and Biodegradation**, **75,** 2012, pp. 83 – 88.
[31] L. Wade,**Organic Chemistry**, 7th edition, Prentice Hall, 2010.
[32] * * *, **Technical Procedure for Ninhydrin**, The North Carolina State Crime Lab and Forensic Laboratories, North Carolina Department of Justice, Version 1, 2013, http://www.ncdoj.gov/getdoc/29907b44-a482-4cb5-9777-d690a64c04dc/Ninhydrin-10-31-2013.aspx [accessed 20.8.2016].
[33] M.S. Adams, C.A. Baker, S. Zachary, *Sizing in Nineteenth-Century Book Papers*, **The Book and Paper Group Annual**, **28**, 2009, pp. 1-6.
[34] C. Kurkjian, W. Prindle, *Perspectives on the History of Glass Composition*, **Journal of American Ceramic Society**, **81**(4), 1998, pp. 795 – 813.
[35] K. Whitman, **Photographic Materials Conservation Catalog**, American Institute for Conservation of Historic and Artistic Works (AIC) Photographic Materials Specialty Group (PMG), http://www.conservation-wiki.com/wiki/PMG_Preservation_of_Glass_in_Photographic_Materials [accessed on 29.6.2016].
[36] R. Le Parc, C. Levelut, J. Pelous, V. Martinez, B. Champagnon, *Influence of Fictive Temperature and Composition of Silica Glass on Anomalous Elastic Behaviour*, **Journal of Physics: Condensed Matter**, **21**(7), 2006, pp. 7507 – 7527.
[37] M. Radepont, Y. Coquinot, K. Janssens, J. Ezrati, W. Nolfa, M. Cottebce, *Thermodynamic and Experimental Study of the Degradation of the Red Pigment Mercury Sulfide*, **Journal of Analytical Atomic Spectrometry**, **30**, 2015, pp. 599 – 612.
[38] C. Miguel, J. Pinto, M. Clarke, M. Melo, *The Alchemy of Red Mercury Sulphide: The Production of Vermilion for Medieval Art*, **Dyes and Pigments**, **102**, 2014, pp. 210 – 217.
[39] M. Ali, M. Ali, S. Darwish, U. Saker, E. Ciliberto, E. Greco, E. Viscuzo, *Investigation and Conservation of Elshenawy Palace Photographic Collection in Mansora Egypt*, **Mediterranean Archaeology and Archaeometry**, **15**(3), 2015, pp. 165 – 185.
[40] M. Lourenco and J. Sampaio, *Microbial Deterioration of Gelatin Emulsion Photographs: A Case Study*, **Topics in Photographic Preservation**, **12**, 2007, pp. 19 – 34.
[41] F. Toma, N. Abdulla, *Isolation and Identification of Fungi from Spices and Medicinal Plants*, **Journal of Environmental and Earth Sciences**, **5**(3), 2013, pp. 131 – 138.
[42] T. Velikova, E. Trepova, T. Rozen, *The Use of Biocides for the Protection of Library Documents: Before and Now*, in **Science Against Microbial Pathogens: Communication Current Research and Technological Advances**, ed, Méndez-Vilas A, Formatex, Badajoz, 2011, pp. 152 – 159.
[43] S. Sequeira, E. Cabrita and M. Macedo, *Antifungals on paper conservation: An overview*, **International Biodeterioration and Biodegradation**, **74,** 2012, pp. 67 – 86.

[44] C. Roman, R. Diaconescu, L. Scripcariu, A. Grigoriu, *Biocides Used in Preservation, Restoration and Conservation of the Paper*, **European Journal of Science and Theology**, **9**(4), 2013, pp. 263 – 271.

[45] S. Bonzi, I. Somda, E. Zida, P. Sérémé, *In Vitro Antifungal Activity of Various Local Plant Extracts in the Control of Phoma Sorghina (Sacc.) Boerema et al. and Collectotrichum graminicola (Ces.) Wilson, as Sorghum Seed Mold Pathogen in Burkina Faso*, **Tropicultura, 30**(2), 2012, pp. 103 – 106.

[46] N. Tabassum, M. Vidyasagar, *Antifungal Investigations on Plant Essential Oils: A Review*, **International Journal of Pharmacy and Pharmaceutical Sciences**, **5**(2), 2015, pp. 19 – 28.

[47] H. Srivastava, P. Shukla, S. Tripathi, B. Shanker, *Antioxidant and Antimicrobial Activities of Sweet Basil Oils*, **International Journal of Pharnaceutical Sciences and Research**, **5**(2), 2014, pp. 279 – 285.

[48] T. Anjum, N. Akhtar, *Antifungal Activity of Essential Oils Extracted from Clove, Cumin and Cinnamon Against Blue Mold Disease on Citrus Fruit*, **International Conference on Applied Life Sciences**, Turkey, September 10 -12, 2012, pp. 321 – 326.

[49] M. Zuzarte, M. Goncalves, C. Cavaleiro, J. Canhoto, L. Vale-Silva, M. Silva, E. Pinto, L. Salgueiro, *Chemical Composition and Antifungal Activity of the Essential Oils of Lavandula viridis L'He´r*, **Journal of Medical Microbiology**, **60,** 2011, pp. 612 – 618.

[50] S. Anžlovar, D. Baričevič, J. Avguštin, J. Koce, *Essential Oil of Common Thyme as a Natural Antimicrobial Food Additive*, **Food Technology and Biotechnology**, **52**(2), 2014, pp. 263–268.

[51] A. Puškárová, M. Bučková, L. Kraková, D. Pangallo, K. Kozics, *The Antibacterial and Antifungal Activity of Six Essential Oils and Their Cyto/Genotoxicity to Human HEL 12469 Cells*, **Scientific Reports**, **7**(1), 2017, Article Number: 8211.

[52] I. Ali, *A Novel Non-Adhesive Housing Mat for Display and Storage of Broken Glass Plates*, **Topics in Photographic Preservation**, **15,** 2013, pp. 107 – 111.

[53] S. Wagner, *Approaches to Moving Glass Plate Negatives*, **Topics in Photographic Preservation**, **6**, 1995, pp. 130 – 133.

[54] K. Whitman, R. Wiegandt, *Case Study: Repair of a Broken Glass Plate Negative*, **Topics in Photographic Preservation**, **12**, 2007, pp. 175 – 181.

[55] J. Tay, *The Glass Plate Negative Project at the Heritage Conservation Centre*, **Topics in Photographic Preservation**, **15**, 2013, pp. 94 – 106.

[56] K. Whitman, *Conservation of an American Icon: the Reconstruction of the Lincoln*, **Topics in Photographic Preservation**, **15**, 2013, pp. 15 – 24.

Received: July 12, 2018
Accepted: May 24, 2020