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Conservation and Characterization of Arabic Papyrus in Egyptian National Library and Archives, Egypt

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Abstract: An Arabic Papyrus sheet stored at the Egyptian National Library and Archives was previously placed on unknown secondary support, and interleaved between two glass sheets enclosed with adhesive tape. This papyrus has various deterioration issues especially in the upper section where there is a large embedded stain causing the papyrus to stick to the secondary support and the glass sheet. Conservation treatments conducted involved cleaning, fibre alignment and rehousing, scientific investigations including visible light microscopy, Fourier transform infrared spectroscopy with attenuated total reflectance (FTIR-ATR), and Scanning Electron Microscopy with Energy Dispersive Spectrometry (SEM-EDS) were conducted to identify materials involved. A lack of information in the historical records about the excavation and previous conservation treatments increase the importance of the research. The analysis showed that the secondary support is gelatine and Arabic text was written in carbon ink. The gelatine support was successfully removed from the papyrus and the papyrus document was re-housed.

Keywords: Arabic papyrus, Conservation, Analysis, Mounting, Gelatine, Ink, FTIR, SEM

1. Introduction:

Papyrus was the main writing support in Egypt since 3,000 BCE and was adopted by Arab Muslims in the 7th century until it was gradually superseded by paper in the 10th CE. The Egyptian National Library and Archives in Cairo contains significant Arabic papyri from the Islamic era. The selected papyrus sheet (card numbers 4583 recto &4584 verso) represents a personal letter dating to 8th, 9th CE. Measuring (21 H×12W) cm, it was written in Arabic script on the recto (13 lines) and verso (11 lines). The papyrus was found in critical state which needs urgent interaction to solve its problems; the main problem represented in using unknown secondary support adhered with the papyrus verso which caused a big dark stain in the upper part. This stain might be occurred as a result of exposure to direct contact with water during previous treatment or poor conditions storing (figure 1). The papyrus and its support eventually became as one burnet layer. It can be seen that the ink layer in the place of stain has a complete deformation in the text due to dissolving the binder of the ink and the degradation of the surface fibres.

Some mounting technique have a devastating effect on papyrus, for instance, papyri may suffer from (staining, degradation, pressure, difficult removing) [1].

Fig.1. Shows (a) the verso side and (b) the recto side of the selected papyrus before treatment

Research has found the following types of secondary supports to be applied to papyri: Cardboard and paper support [2-4]; gelatine [2, 5]; goldbeater`s skin [2]; celluloid film [4, 5]; plexiglass [6, 7]; glass support [1, 4, 8, 9].

Various methods have been used to remove papyrus from poor quality supports .An important technique used at the British museum [10] involved applying a temporary facing on the papyrus surface in order to guarantee safe removal of the secondary support using Japanese tissue and Paraloid B72 .The backing support was put under damping blotting paper for several hours under weights and poultice from Laponite R D also was applied. Facing can be removed by placed the papyrus between acetone-soaked blotting paper under glass and after that lifted strip by strip [2].

According to Leach 2006, [11] most of the Ramesseum Papyri at the British Museum were attached to a gelatin film in the first part of the twentieth century and warm water was used to attach papyri with gelatine film to avoid using adhesive but using water to attach the gelatin film caused swelling and distortion ,So Cellulose nitrate adhesive was used instead of water. However, cellulose nitrate become insoluble over time and causes many problems [12].

In the Grand Egyptian Museum, cardboard backing was removed from papyrus after facing the papyrus surface with spider paper and Klucel G. Gore-Tex a moisture-permeable material allows water vapour to reach the papyrus without wetting it to facilitate removing cardboard layer by layer. Facings were removed by placing fragments between sheets of blotting paper soaked in alcohol [13].

At Louvre museum, Menei 2006 [14] introduced new technique to remove cardboard secondary support from the papyrus backing included facing the surface with Gampi paper and Funori (Japanese seaweed glue) and peeling mechanically after damping with water.

In the Egyptian Museum, Cairo, another method of removing cardboard from Greek papyrus was applied involved protect the papyrus surface using rectangular pieces from Gampi paper 19gm/m2 and Hydroxy propyl cellulose (KG) 4% .The cardboard was humidified with a mixture from ethanol and distilled water and peeled it off with tweezers After removing the backing, the facing lining was dampened with a brush impregnated with acetone and tweezers were used to remove [15].

The aim of this research was to find a safe method to remove the papyrus from unsuitable mounting and undertake the needed conservation procedures for the selected Arabic papyrus, at the end store papyrus in new housing. A secondary aim was to characterize the type of secondary support and black ink using various analytical investigations.

2. Methodology:

2.1. Samples:
During the conservation of the papyrus process, some traces detached and did not affect in the structure of the text on papyrus; so it was a great opportunity to investigate it to identify the compatibility between the scientific investigation and the experience of the conservator.

2.2. Non-invasive investigation

2.2.1. Visual assessment and photography:

The papyrus was visually investigated with the assistance of a 10x magnifier lens .Observations were documented using a DSLR camera (Canon EOS 1000D) before, during and after conservation processes.

2.2.2. Visible light microscopy:

Small samples were investigated using a microscope (Olympus BX51 with the camera (DP70) and computer (DELL OptiPlex GX280) imaging system under 40x magnification reflected light.

2.2.3. Scanning Electron Microscopy Energy Dispersive Spectrometry (SEM-EDS):

Scanning electron microscope PHILIPS (FEI) XL30 ESEM TMP, in Earth Sciences department, Melbourne University, has been used for study the surface morphology of two samples and also to identify the elemental composition of the ink and papyrus surface. The EDS system is an OXFORD INCA and uses a liquid-nitrogen cooled Si-Li detector with an area of 10 sq. mm and an ATW2 thin detector window which allows collection of x-rays between B and U. The system operates under Windows 2000 via a graphical user interface.

2.2.4. Fourier transform infrared spectroscopy with attenuated total reflectance (FTIR-ATR):

In order to identify the type of the secondary support used in mounting the papyrus, FTIR was used. IR spectra were collected using a portable Bruker Alpha- P FTIR spectrophotometer equipped with a diamond ATR window (Bruker Optik GmbH, Ettlingen, Germany) and OPUS v 6.5 software. Prior to the spectral collection of each sample. All spectra were recorded in the spectral range of 4000–375 cm−1 with 32 co-added scans at a spectral resolution of 4 cm-1.

2.3. Conservation treatments:
The treatment of the papyrus involved many steps such as removal of the unsuitable secondary support, cleaning, fibers' alignment, and rehousing

3. Results and discussion:

3.1. Investigation and analysis:

3.1.1. Visual assessment : Both sides (recto and verso) of the papyrus were investigated; which had various deterioration features as follow: Accretions attached to the surface most likely from the dig site, that appear to be clay, based on their light brown color and lack of coherence (see circled region in figure 2b); big dark stain in the upper section (see circled region in figure 2c); a secondary film based support (concluded to be gelatine based on its smell, feel, color and response to moisture) has been applied in the past most likely to stabilize and support the papyrus(indicated by arrow in figure 2c); delamination of the fibre (indicated by bottom left arrow in figure 2d); tears of the secondary support adhered to the papyrus; a smudge across a section of writing which may be due to slightly wet ink being touched when still slightly wet (See bottom right arrow in figure 2d); Numerous lacunae of different shapes and sizes (large one in central lower section, three medium in the upper section see figure 2d, 2e) and various small distributed in the mid-section (see figure 2b); Twisted fibres (see circled area in figure 2a).

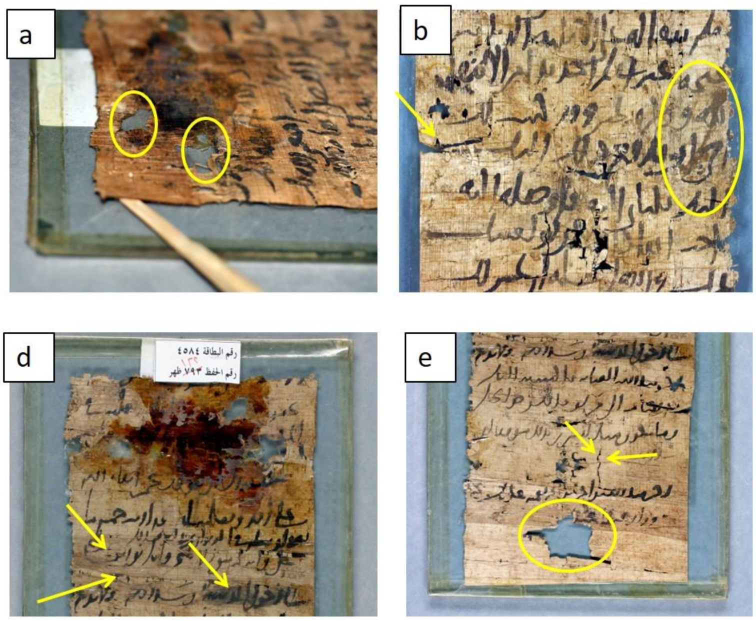

Fig.2. Photographic images illustrate the deterioration aspects of both sides of selected papyrus

3.1.2. pH measurements: Measurement of the pH values of several spots on the papyrus surface was carried out using a portable pH meter (Hi99171)**.** Obtained values of 6 to 6.5 indicating that the papyrus does not suffer from severe acidity and thus does not require de-acidification treatment.

3.1.3. Papyrus thickness: Investigation of papyrus surface revealed the difference in thickness of papyrus sheet alone or the papyrus stuck with the gelatine support, the papyrus was 0.50 mm but the thickness of papyrus and gelatine together as one layer was 0.4mm in the upper part of the object that means the gelatine penetrate the papyrus fibre. The thickness of the papyrus sheet after removing the gelatine was 0.3mm.

3.1.4. Visible light microscopy: Visible light microscopy revealed penetration of gelatine adhesive inside the papyrus surface and both became as one layer (figure 3b) and also the ink has some cracks beside falling from some places (figure 3a) .From the shape of the strips in the verso of the papyrus, we can say stripping process is the manufacture technique of this papyrus sheet. The big size of the ink's grains and also its dark color indicate it is a carbon ink.

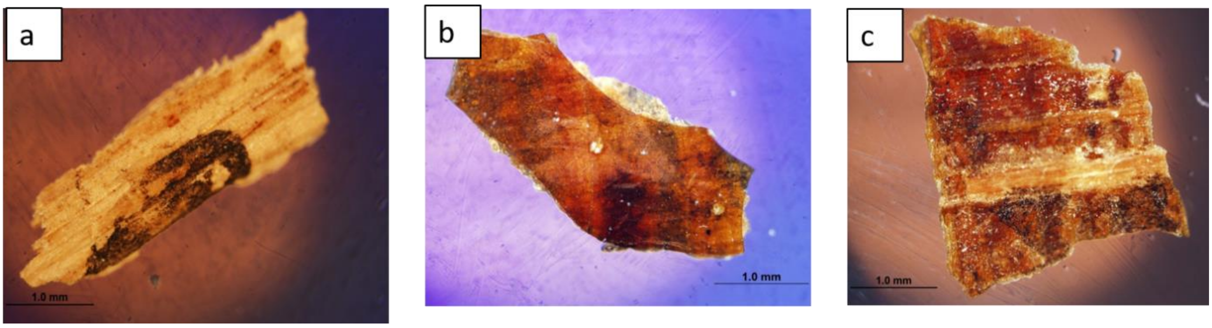

Fig.3. photos of inks and adhesive on papyrus samples using optical microscopy

3.1.5. SEM and SEM-EDS analysis: **The first sample:** In order to identify the type of ink used for writing the Arabic text in the selected papyrus, SEM-EDS was used to analyse the samples. The result illustrates that carbon is the main component of the sample (figure 4a), so the black ink is a carbon ink. Analyzing the papyrus support shows carbon is a main element accompanied with calcium, sodium, and silicon (figures 4b,c) calcium carbonate was added to the papyrus surface during manufacturing process to obtain white color or to make surface suitable to write during manufacture of papyrus sheet. According to Dimarogonas 1995 [16] Pliny mentioned that clay (Al_2O_3,2SiO2,2H2O) existed on Nile water which was used to moisten the papyrus strips to stick the layers together to get the papyrus sheet or clay was used as a filler on the papyrus surface in order to reduce the absorptivity of ink. Investigation of the surface morphology by a scanning electron microscope (SEM) revealed destroy the structure of fibre (figure 4c) and the black ink surface was darker than the papyrus surface without ink (figure 4a) and many cracks in the ink surface. **The second sample:** The examination of the second sample from the papyrus shows spread of silica grains among the papyrus fibres (figure 5b) and also small particles with different sizes as a crust, cracks), using EDS illustrates that the ink sample consists mainly from carbon element and that means the writing ink is carbon ink.

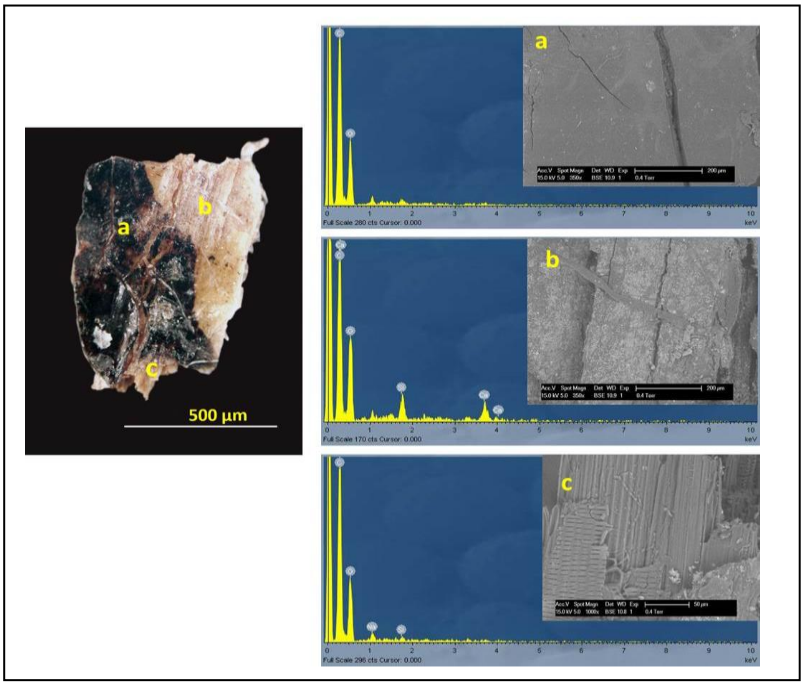

Fig.4. SEM-EDS spectra and SEM pictures of the sample (a) the ink,(b) papyrus surface (c) the cellulose fibers.

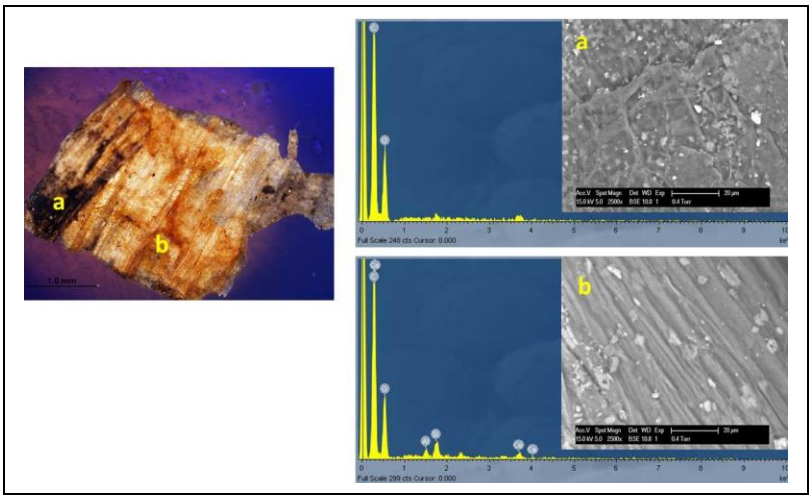

Fig.5. SEM-EDS spectra and SEM pictures; (a) spectrum of black ink, (b) spectrum of papyrus surface.

3.1.6. FTIR-ATR spectroscopy:

FTIR analysis of the secondary support in comparison with an authentic sample of gelatin e, show characteristic amide absorption bands at 1628 and 1536 cm-1 (figure 7), which are consistent with the support being composed of a protein-based material, such as gelatine. [17-20]. According to The Amide I band, near 1628 cm−1, is associated with C=O stretching vibration of peptide groups and presents several frequencies that depend upon the chemical environment and consequently upon the conformational state of polypeptides. The Amide II band, near 1536 cm−1 is associated with C–N stretching and N–H bending vibrations of peptide groups. These two bands are usually considered to be valuable indicators of the presence of gelatine, the infrared band near 3295 cm−1 assigned to N-H stretching band and the other near 3110 cm−1 assigned to C-H stretching bands, 1450 band assigned to C-H bending (amide III) of gelatine. As well as a high similarity between gelatine standard spectrum and analyzed sample.

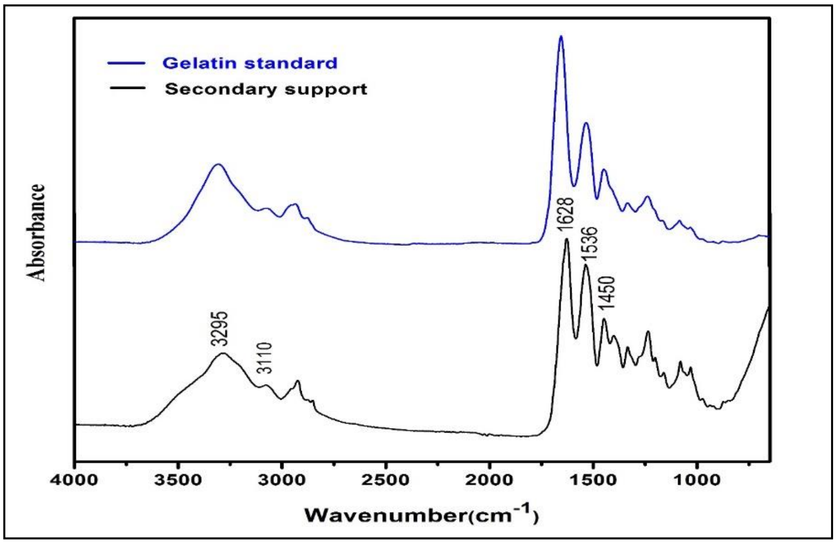

Fig.6.FTIR spectra of papyrus secondary support compared to gelatine standard sample.

4. Restoration processes:

Restoration of this papyrus was challenging due to its poor condition; it was a big challenge to remove the papyrus from the gelatine support without causing further deterioration. The aims of removal papyrus from its old mounting are to improve the condition of the papyrus and also prevent ongoing deterioration, so the restoration process was started with opening the frame of the collection by scalpel, but papyrus was strongly adhered with gelatin sheet and glass sheet from one side (Fig.8a) so the collection was put inside the humidification chamber containing warm water for one hour. After that the glass was separated from the gelatine sheet, gelatin sheet was removed manually from non-adhered parts.

4.1. Cleaning:

Before starting in the cleaning process, tests on small spots of ink were used to check the effect of water and cleaning solution on the color alteration or bleeding of the inks using small piece of blotting paper impregnated with the solution.
Grains of clay were spread in the verso side of the papyrus surface covering text beneath, so cleaning the surface was done by using soft brush in the direction of the fibers. A rubber air bulb was used to blow away loose particles followed by damp cotton swab with solution from 40% water and 60% ethyl alcohol without affecting the carbon ink in the papyrus surface.

4.2. Removing the gelatine support:

The second step was removal the sticky parts by using dampened acid free blotting paper with warm water under light weight for five minutes to soften and swell the gelatin sheet to facilitate its removal using tweezers in the direction of the papyrus fibers (figures 8b,c).Due to the fragility of the upper part ;it took long time with more accuracy and care (figure 8d), papyrus was sandwiched between two sheets of blotting paper until the drying of papyrus with changing the blotting from time to time.

4.3. Bridging:

The next step was to join tears and support weak areas with strips from remoistenable tissue made from Kozo-Shi Haini Tengujo 1 (5.8 g/m^2) and a 50:50 mixture of carboxy methyl cellulose and Shofu wheat starch paste in the papyrus laboratory in the Egyptian library and archives using small amount of water to reactivate the adhesive using light brush pressure to hold in place for a few seconds. (figure 8e) followed by realignment of twisted fibers in their correct position. This repair alignment technique has been used before by Lau-Lamb 2007 [21]; remoistenable tape paper was used to avoid the disadvantages of other kinds of tape like pressure sensitive tape which can cause discoloration and irreversibility [21, 22].

4.4. Mounting:

Finally, papyrus was placed on passe-partout from acid free canson (Gravure 270 g/m^2) between two glass sheets (figure 8f) which allow both sides of the papyrus to be viewed. Using passe-partout make papyrus held in place without any adhesive and also reduce the pressure from glass sheets [21] .The collection was enclosed from four sides with plastic slide binder bar(MINTRA)(figure 8f), after that the papyrus had placed inside Tyvek envelope to protect it from dust, abrasion and pollutants to keep in storage.

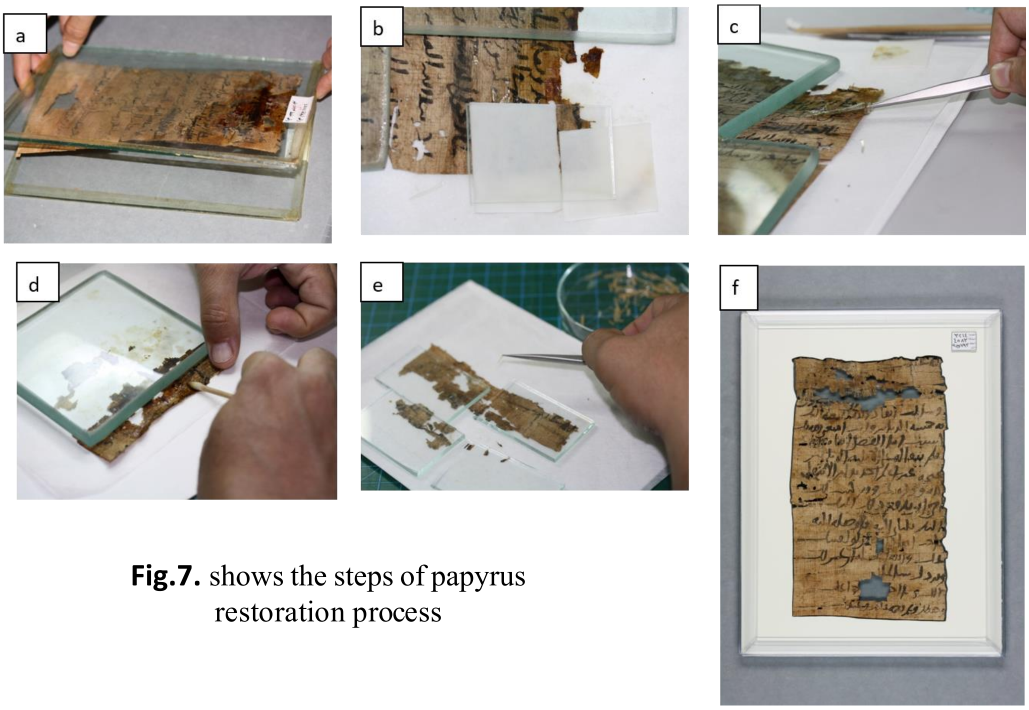

Fig.7. shows the steps of papyrus restoration process

5. Conclusion:

In conclusion, modern analysis devices have a great role in success of conservation process. In this study FTIR-ATR analysis has confirmed that the secondary support was composed of gelatine which led to select the appropriate technique to remove it successfully, in addition to that SEM-EDS have been successfully employed for the characterization of papyrus surface and identification the type of ink. From the perspective of conservation, a successful method of removing the gelatine secondary support had depended on recognizing its properties especially toward water and chemical materials, using small poultices from blotting paper damped with warm water is an effective technique to facilitate the removal of gelatine secondary support and should followed by using tweezers and this technique can be used in the similar cases.

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