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## Conservation and Technical Evaluation of an Early Medieval Papyrus Codex

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### ABSTRACT

In 2005, a team of Polish archaeologists discovered three Coptic codices, two on papyrus and one on parchment, in the rubbish dump of a hermitage at Sheik Abd el-Gurna, Egypt. While the parchment codex and the remains of the bindings of the papyrus ones have been conserved, the text blocks of the papyrus codices were opened and disassembled and after being disinfected remained untouched for nearly 15 years, until the current project started. Currently, all three books are stored in the collection of the Coptic Museum in Cairo. Our team undertook the conservation of and archaeometric research on the papyrus codices. The first of the books contains the Canons of Pseudo-Basil, while the second is an Encomium of St. Pisenithios. Both codices have been palaeographically dated to the seventh-eighth centuries CE. In this paper, we describe our project and present the results of the work carried out on the Canons of Pseudo-Basil. Our work involved photography in transmitted light, measurements of the thickness of the papyrus leaves, and digital microscopy under three-light illumination. These measurements allowed us to determine the types of the inks and characterize the papyrus writing substrate. For conservation, we used a novel method developed in the Egyptian Museum in Berlin that comprises suspending papyrus folios on a translucent, extremely thin Japanese paper inside glass frames without the use of adhesives.

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Papyrus; codex;  
conservation; iron gall ink;  
Coptic

## Introduction

### Papyrus manufacture

The oldest surviving record describing the production of papyrus sheets is Pliny the Elder's first-century CE *Historia Naturalis* (Lewis 1974; Hendricks 1980). This record, however, is relatively young for a material that has been in use since about 2500 BCE. In short, it is assumed, based on both Pliny's text and experimental findings, that production started by either cutting the pith of *Papyrus Cyperus* L. in thin strips (Bausch et al. 2022) or opening it using a needle (Hendricks 1984). In the next step, the strips or the thin layer of pith were soaked in water and put in two orthogonal layers. After that, the layers were pressed and left to dry in the sun. Resulting sheets (*kollemata*) were then glued to create rolls, an arrangement in which they were available for sale. The sheet joints in the form of overlapping parts of the sheets are called *kolleses*. The rolls could be directly inscribed or cut into sheets of different sizes for documents or bifolios for the text blocks of codices. Based on the alignment of the papyrus strips, the side where the strips run horizontally is called the *recto*, and this is the side where *kolleses* can be observed. The reverse side with the strips placed vertically is called the *verso*. Usually, sheets were inscribed following

the orientation of the papyrus strips, i.e. on the *recto*. However, if the text was written at a 90-degree angle to the fibres, then the sheet is called *transversa charta*.

### Papyrus conservation

Thousands of papyrus manuscripts are stored in collections around the globe. Originally, any treatment of such objects belonged to the field of papyrology. In 1891, Hugo Ibscher started working with the papyri of the Berlin collection and revolutionized the field (Leach 2006). Because of the great success of his methods, book and paper conservators gradually replaced papyrologists when dealing with the material aspects of papyri. It is worth noting, however, that to this day the academic education programme for conservation does not include papyrus conservation. For this reason, mostly paper and book conservators with experience treating cellulose-based materials have worked on papyri, introducing new techniques and materials known from other fields of art conservation (Graf and Krutzsch 2006; Menei 2017).

### Material studies of papyri

Since 1983, most scientific studies have focused on determining the ratio of the amounts of lignin and

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cellulose in hopes of using it to determine the age of papyri (Wiedemann and Bayer 1983; Flieder et al. 2001). Unfortunately, the ratio is affected by many factors and cannot be used for this purpose, as proved by Bausch et al. (2021), who recently revisited the methodology for the determination of the lignin content in papyri, and compared the composition and lignin content of modern, commercially available papyrus sheets to native papyrus pith, as well as the accuracy of several scientific methods. The authors recommended using the acetyl bromide soluble lignin method for further studies instead of the previous thermogravimetric analysis approach, praising the former's reproducibility, accuracy, and minute sample requirements. Finally, Bausch et al. (2021) showed that papyri contain much less lignin than reported in previous studies and criticised the use of paper as a reference material.

One of the important outcomes of these studies, though, is the demonstration of the harmful influence of UV light; this finding has had a positive effect on the preservation of papyri. Recently, using spectroscopic, diffraction, and chromatographic analytical methods, Łojewska et al. (2017) further investigated the mechanisms of the degradation of papyri. The authors concluded that the degree of polymerisation of cellulose indicates the state of preservation. Bausch et al. (2022) also studied the mechanisms of papyrus degradation; while focusing on light-induced degradation, they also pointed out that the degradation is reflected in the decreasing degree of polymerization of the cellulose. In addition, to gain insight into the degradation of conserved materials, Graf et al. studied white precipitations from the papyrus' glass frames. The authors showed that the deposits comprised sodium chloride and sodium nitrate salts and suggested that their formation could be reduced by using low-sodium glass for the frames (Graf, Villmann, and Schlattner 2018).

As it is often the case, simple conservation of a rather well-preserved papyrus manuscript does not require elaborate chemical analysis. Moreover, the studies reported above required either sampling or access to a well-equipped chemical laboratory, making such analysis often impossible to perform. In contrast to these advanced methods, the descriptive approach for characterising papyrus substrate proposed by Krutzsch focuses on measurable physical properties such as the size and thickness of the papyrus sheets and the types and width of sheet joints and is well suited for work on-site. The data collected by such methods, which leads to a complete physical description, is usually needed for the codicological and palaeographical reconstruction of papyri. If reconstructed correctly, this minimises the future need for handling and conservators' interventions. Krutzsch (2008) proposed a classification of sheet

joints based on the number of papyrus layers in the joint: type I comprising two layers with *recto* side over *recto* side; type II with three layers with a *recto* side over *recto* and *verso* of a second sheet; type III made of four layers with *recto* and *verso* sheet pasted over *recto* and *verso*; and type IV, which comprises type III with an additional *verso* strip securing the connection. Krutzsch also proposed a classification of sheet types: type I with the *recto* side longer on both ends of a sheet than the *verso*; type II with the *recto* longer only on one side of the papyrus sheet; and type III with the *recto* and *verso* sides completely covering one another. According to Krutzsch, freshly manufactured papyrus changed in accordance with the time and place of production, so the physical description supports specifying the provenance and dating of papyri (Krutzsch 2008, 2012).

### **History of the codex**

The complete papyrus codex containing the Canons of Pseudo-Basil, MS13488, was discovered together with two other manuscripts in 2005 in hermitage MMA1151 by a team of Polish archaeologists led by Górecki (Górecki 2005; Górecki and Wipszycka 2018). All three codices are palaeographically dated to the end of the seventh or the beginning of the eighth century CE and are now stored in the collection of the Coptic Museum in Cairo. The Canons of Pseudo-Basil have been previously studied philologically (Camplani and Contardi 2017, 2018) and codicologically (Carlig 2018). These studies emphasised the importance of the find of this complete codex, which allowed scholars to recover some previously unknown passages. Shortly after excavation, the Canons underwent conservation intervention, consisting of the disinfection and disassembly of the codex into leaves (Kordowska 2008). The previous teams temporarily reinforced some broken fragments of papyrus leaves using Japanese paper as shown in Figure 1 and put stickers with quire and folio numbers on one side of each of the folios. They also stabilised and secured the remains of the leather binding. The object remained in that state until the beginning of the current project. In the case of this object, we obtained information about the previous treatments from a member of the team who conducted them, so the analysis of previous material used was not needed for the complete description, as would be the case with a codex of unknown history.

### **Methods**

#### **Examination and assessment of the papyrus**

The dimensions of the codices were measured with a ruler (0.5 mm precision), whereby the highest and the widest measurements were recorded (single



**Figure 1.** Condition of folios H4 and H5 of the Canons of Pseudo-Basil at the beginning of our project.

protruding fibres were included in the measurements). The thickness of the folios was measured with a thickness gauge (Azcei, 0.001 mm precision) in at least five points on each folio; only the extreme values were recorded and rounded to 0.01 cm. To further characterize the papyrus writing surface, each folio of the manuscript was photographed in reflected and transmitted light using a DSLR camera and a LED light table (AGPTEK LED A3USB). The sheets' features were documented based on the description initially proposed by Krutzsch, which includes sheet and sheet joint measurements, arrangement, and type recognition (Krutzsch 2008, 2012). We have collected physical data for each folio in a table, an excerpt of which is shown in Table 1.

Besides the dimensions of the folios and the type of the ink, the table contains a section dedicated to the dimensions of the sheet joints (*kolleses*). Based on the photographs taken with the DLSR camera and the light pad, their number, width, type, (Krutzsch 2017) and order were established and recorded. Because of the varying translucency of the folios,

*kolleses* could not be identified on every sheet of the Canons. The width of the sheet joints was measured in the widest and narrowest areas. The same section contains a column with the record of the type of the makeup of the bifolios from the single sheets as initially manufactured in a roll, with respect to the text layout. Sheets arranged from top to bottom are marked V, bottom to top ^, left over right >, and right over left <. The bifolios that contain mixed folios are highlighted in the column 'comment'. Surface features such as the orientation of the fibres, the homogeneity of the structure, and the translucency of the papyrus are described in the column 'quality'. To minimize subjective assessment, we used the following criteria and their abbreviations: T – translucent (with light passing through almost the whole sheet), NT – not translucent (no light passing through the papyrus), PT – partly translucent (light passing through the papyrus, but not throughout the complete bifolio), RA – right-angled fibres, W – wavy fibres, I – inclined fibres. Using these abbreviations, a partly translucent folio with right-angled fibres would

**Table 1.** Excerpt from the material analysis table.

Folio	Folio dimensions			Ink type Ink type	Kolleses				Quality & direction of writing		Comment
	Height (cm)	Width (cm)	Thickness (mm)		Number	Width (mm)	Type	Order	Quality*	Trans-versa Charta	
B3	32.5	23.6	0.35–0.55	iron gall					PT, RA		
B8	33.0	23.6	0.35–0.51	iron gall					PT, RA		
B5	32.7	23.8	0.43–0.66	Iron gall	1	25	II	^	PT, RA	TC	
B6	32.7	24	0.46–0.64	Iron gall	1	25	II	^	PT, RA	TC	

Abbreviations used in the entire table: ^ – bottom over top, V – top over bottom, < – left over right, > – right over left, T – translucent, NT – not translucent, PT – partly translucent, RA – right-angled, W – wavy, I – inclined, TC – *transversa charta*

be described as simply PT, RA. Finally, we also recorded whether the bifolio is a transversa charta.

### Determination of the ink type

The screening of the inks under three-wavelength illumination is part of the manuscript analysis protocol developed at the Bundesanstalt für Materialforschung und -prüfung (BAM) and the Centre for the Study of Manuscript Cultures (CSMC) and is described in detail elsewhere (Nehring et al. 2021). This assessment proposes distinguishing among three basic types of ink based on their optical properties (Rabin et al. 2012). Plant inks are transparent at  $\sim 750$  nm, iron gall inks gradually lose their opacity towards the longer wavelengths (700–1000 nm) and become transparent around 1400 nm, while carbon-based inks remain black at any wavelength (Mrusek, Fuchs, and Oltrogge 1995). Furthermore, tannins present in both plant and iron gall inks quench the fluorescence of the substrate and appear dark under UV illumination, as verified by the authors. For the analysis, we used a portable digital microscope (Dinolite AD4113T-I2 V USB) equipped with three sources of light: ultraviolet (UV, 395 nm), visible (VIS), and near infrared (NIR, 940 nm).

### Damage assessment

We evaluated each folio from the papyrus text block as if it was a single object and then added up the results to describe the entire book. To achieve this goal, we adapted an assessment method based on damage scores to evaluate historical books developed in the Department of Paper and Leather Conservation of the Nicolaus Copernicus University in Poland (Jabłońska 2007). The criteria of our evaluation are collected in Table 2. The degrees of damage were determined using a 4-step damage score (DS) scale. In cases of both old repairs and mould, the scale is 5-step; '0' has been added in those cases, because all the other assessed features in the studied object always occur at least to the smallest extent. The ink corrosion was assessed based on Banik's description of stages of iron gall ink corrosion, available at <https://irongallink.org/ink-corrosion-chemistry.html>.

## Results of the material investigation

### Physical description of the papyrus sheets

Today, the disassembled codex comprises the following elements:

- Remains of black, tooled leather binding: three fragments, the largest one approx.  $21 \times 17$  cm, and two smaller ones  $4.8 \times 2$  cm and  $8 \times 2.7$  cm.

- Remains of the front board measuring approximately  $31.5 \times 24$  cm and 9.3 - 10.2 mm thick, made of papyrus waste, with three double sewing cords attached.
- 'Board fragments', presumably from the back board. A group of at least 20 papyrus fragments of varying size and thickness.
- 'Cover fragments', also presumably from the back board; at least 20 papyrus pieces of varying size and thickness.
- Front pastedown preserved as one large and several small papyrus fragments. The large piece measures approx.  $28.7 \times 21.7$  cm and is 0.9–2.05 mm thick.
- Papyrus text block comprising 73 separated leaves and 1 preserved bifolio, divided by the previous team into 9 quires, and labelled from A to I (Kordowska 2008).<sup>1</sup> The dimensions of the folios range from 27 to 33.5 cm in height and from 20.8–24.2 cm in width. The unseparated bifolio, D5 and D6, is 33 cm high and 47.8 cm wide. The thickness of the folios varies from 0.24–0.74 mm, with an average thickness of 0.46 mm.

Based on the technical evaluation of papyrus substrate features conducted as we show in Table 1, the text block of the Canons of Pseudo-Basil can be divided into three main groups, indicating that three different papyrus rolls were used to produce the folios. The first group consists of the bifolios of quire A and most of the folios of quire B (except for bifolio B5 and B6). These papyri are barely translucent and right-angled. The sheets that were taken from a roll to make these bifolios are folded and inscribed parallel to the recto fibres. Thanks to two kolleses preserved on two bifolios (A3 and A4 and A2 and A5), it is possible to measure the width of the original roll sheets that equals approximately 25 cm. The order of the sheets always descends, with sheets on the left overlapping the sheets on the right side.

The second group contains bifolios of quires B, C, D, E, and F. All these leaves/sheets are partly translucent and right-angled with easily recognisable kolleses placed approximately in the middle of each bifolio. The third group contains bifolios of quires G, H, and I, none of them translucent but all right-angled. Both the second and the third group are written only in *transversa charta*, which distinguishes them from the first group. The assessment carried out using the photographs in reflected and transmitted light led to identification and rearrangement of the misplaced folios and reintegration of some broken folio fragments.

### Results of the ink screening

The inks were inspected on every page. Images were captured for conservation at the beginning and end

**Table 2.** Assessment of the condition of the text block, 4-point damage score scale.

Damage score (DS)	Papyrus writing surface								Inks		
	Losses	Cracks and breaks	Loose areas	Delamination	Deformation/ folded areas/ deformed fibres	Surface deposits & stains (glues, stains, dirt, etc.)	Brownish area around the edges	Mould	Old repairs	Ink flaking/or cracking	Ink corrosion
1	None or very little, Covering only unscribed areas	None or insignificant and few	None or very little	None or very little	None or very little	None or very little	None or very little	Few spores	Few, easily reversible	Slight or no cracks, good adhesion to the substrate	None or very early stages
2	Small, missing small or very small inscribed areas	Small, few	Small, singular	Small, singular, and local	Small, few	Small, single clusters of dirt	Up to approx. 25% of the edges	Several spores spread in more than one area	Multiple, easily reversible	Small cracks, decent adhesion to the substrate	Slight halos
3	Significant losses	Significant and multiple	Significant and multiple	Intense, multiple	Intense, multiple	Intense, multiple clusters	Up to approx. 50% of the edges	Multiple spores, spore clusters	Large number of easily reversible or a few very difficult to reverse and/or covering large areas	Weak adhesion, extensive flaking, text missing in important areas	Intense halos, cracking ink
4	Very significant losses	Very significant/ Covering broad areas	Very significant/ Covering vast areas	Very intense, papyrus layers falling apart	Very intense	Very intense/ covering large areas	Very extensive	Many spores in multiple areas	Multiple; very difficult to reverse	Very weak adhesion to the substrate, ink flaking and text missing in multiple areas	Very intense halos and final stages of ink corrosion in the form of cracking and lacunae in the inscribed and surrounding areas

of each quire. Two different results of the ink analysis are depicted in Figure 2.

The ink in the first row of Figure 2, captured at the front pastedown, appears black under each kind of illumination. Based on this observation, we conclude that the ink contains carbon. At first glance, the ink in the micrograph from folio B1r registered in the visible range appears very similar to the ink from the upper row, although unlike the previous example, it loses opacity in the NIR region. The whole letter from folio B1r, including a small fragment that flaked off at the right side of the letter (as seen in the VIS image), appears black under UV illumination. Both plant and iron gall inks penetrate the substrate, and this observation attests to tannins or iron species that migrated into the substrate and, while invisible in the VIS range, quench the UV fluorescence of the substrate. The observed reaction of the ink from folio B1r to different types of illuminations, losing opacity under NIR illumination and becoming uniform under UV, helps us categorise this ink as mainly iron gall type. Based on the ink screening, we found that the main text of the Canons is written with an iron gall-based ink, whereas carbon-based inks are identified only on the end leaves made of papyrus waste.

### Assessment of the condition

As already mentioned, the Canons of Pseudo-Basil was disassembled. Since earlier teams treated the remains of the binding, we omit them in this description and focus on the description of the folios as shown above.

All the papyrus leaves, which are lignocellulosic materials, have been damaged to varying extents by hydrolysis and oxidation; in Table 2, this damage is registered in the column 'brownish area around edges'. The chart in Figure 3 displays the total score for each type of damage (columns) summed up for all the leaves. We see that the most significant types

of destructive factors are cracks and breaks that led to various broad losses and loose areas followed by delamination, that do not correlate with the iron gall ink deterioration.

To a large extent, the pages are also covered by surface dirt and stains, which we could not chemically analyse due to the impossibility the folios. Such deposits have accumulated on many pages, especially on the areas surrounding kolleses. In those areas, the glue used to connect papyrus sheets is dark and thick, and it was applied in excess in several areas.

The third most important factor is extensive repairs made with Japanese paper. These repairs were executed with a very thick Japanese paper that is stronger than the material to which it is applied and in various areas covering the script, making it illegible, as shown in Figure 4. In total, 33 out of 74 Canons folios are covered with conservation repairs that are not suited for papyrus. Earlier teams often placed repairs over cracking and flaking ink. Viewed under a digital microscope, the text's ink can be seen to be cracking. On many folios, it has lost adhesion to the substrate, leaving missing pieces of letters and fragments of text. The ink cracking is particularly present where it is written over the sheet joints' glue residues.

The most problematic repairs are given 4 DS, as they cover large, inscribed areas and in some cases are extremely difficult to reverse. 2 DS are also given to sheets containing shelf mark stickers.

To emphasize the state of preservation of the whole text block, we sorted the folios of the Canons into groups according to their score. The first group comprises slightly damaged folios that have up to 15 DS; the second group corresponds to moderately damaged folios with 16–25 DS. The heavily damaged folios belong to the third group, with more than 25 DS. As 62% (46) of the folios belong to the first group and only 11% (8) to the third group, we conclude that the folios of Canons are in relatively good

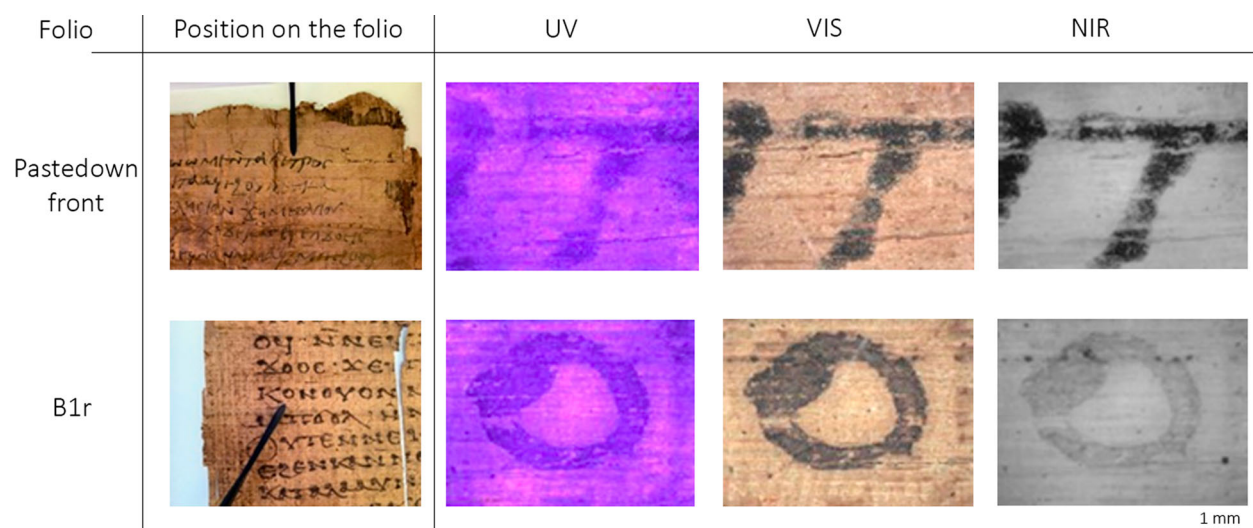
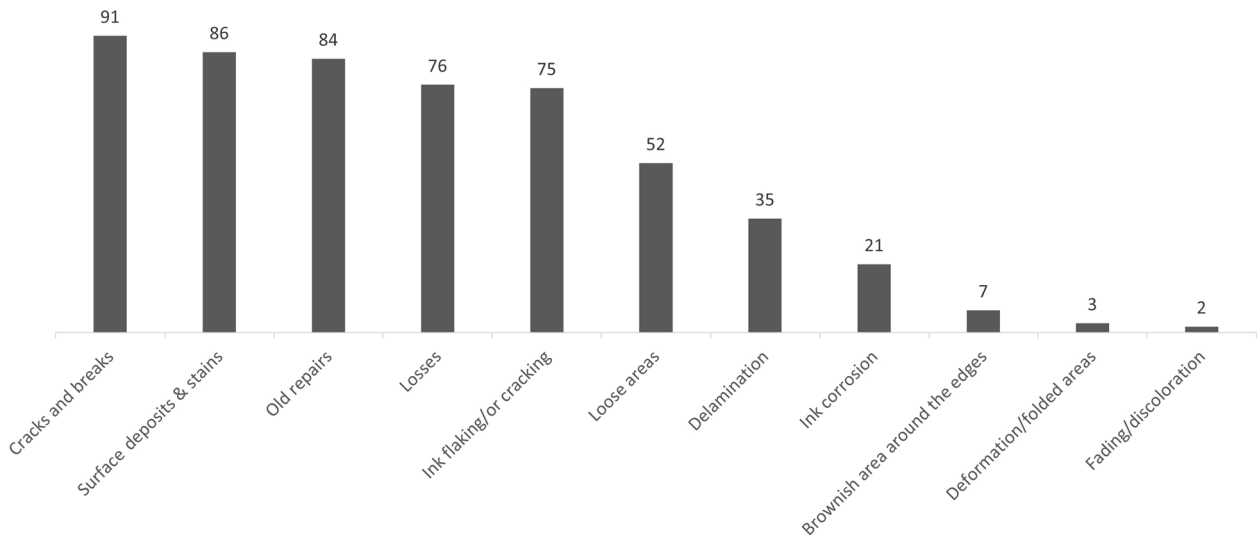


Figure 2. Canons of Pseudo-Basil: excerpt from the table in which the results of the ink reflectography have been compiled.



**Figure 3.** Canons of Pseudo-Basil: overview of all the damage scores, with the sum after the subtraction of the minimum value for each category. The total DS for all leaves is displayed over the bars. For more information about categories see [Table 2](#).

condition and that the most problematic issue is extensive repairs. These groups, however, do not overlap with the groups distinguished by the physical description of the sheets.

### Conservation treatments for the Canons of Pseudo-Basil

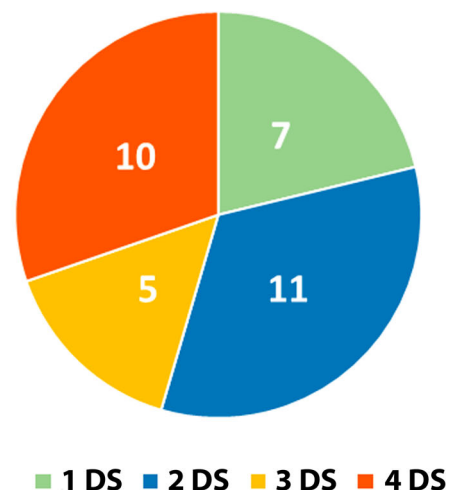
To ensure the safety of the manuscript at all stages of the current project, the handling was done using 3 mm-thick glass supports. To access the other side of bifolios, pages were covered with an extra pane of 3 mm-thick glass, secured on the edges with small clips and then firmly flipped over. This technique ensured safe manipulation of the papyri.

### Conservation planning

While planning this on-site conservation project based on the detailed damage assessment, we had to

consider the time available for the work. It has become clear that treatments leading to complete consolidation of all the broken fragments are not possible due to the time limits. The highest scores for DS, including cracks and breaks, dirt expressed under surface deposits, and old repairs, led to prioritization of treatments and methods for handling and storing. We decided, therefore, to secure and strengthen the areas that lead to the losses and delamination expressed in the assessment under cracks and breaks. The plan was made to first clean the dirt and then to remove the harmful old repairs and stickers with folio numbers. Finally, consolidate only the active flaking areas and combine the loose areas in a reversible way, as described below.

To achieve these objectives, we also used a specific method of papyrus conservation and glazing. The glazing method named after its creator and hereinafter referred to as the Krutzsch Method, consists in hanging a historic papyrus on very thin Japanese paper



**Figure 4.** Canons: an example of the old repairs causing DS 4 (left); Distribution and number of folios according to the different DS for old repairs (right).



attached to the edges of the glass frame (Krutzsich 1999; Krutzsich 2001). The glazing consists of a set of two glass panes of equal size (with smoothed edges), with a very thin Japanese paper attached to the rear pane. The edges are sealed with a conservation-grade tape that can be remoistened. A traditional method of fixing the papyri on the glass with little strips was not suitable in this project, as it would take too much time and would be potentially irreversible when applied to the deteriorated margins of the bifolios as observed with the old repairs.

To prepare a frame, a pane of glass is placed on a flat surface (Figure 5(b)). A piece of Japanese paper is rolled over the glass and covered with another pane, as shown in Figure 5(c, d). Any excessive margin of thin Japanese paper is folded to the top pane of glass and then glued to its edge with 1% methylcellulose applied with a thin brush through the paper (Figure 5(e)). When the adhesive bonds, all excess paper is cut off with a scalpel on the top glass, leaving a small excess of about 2–3 mm close to the frame edge (Figure 6(f)). In the next step, the pane with the Japanese paper is lifted (Figure 6(g)).

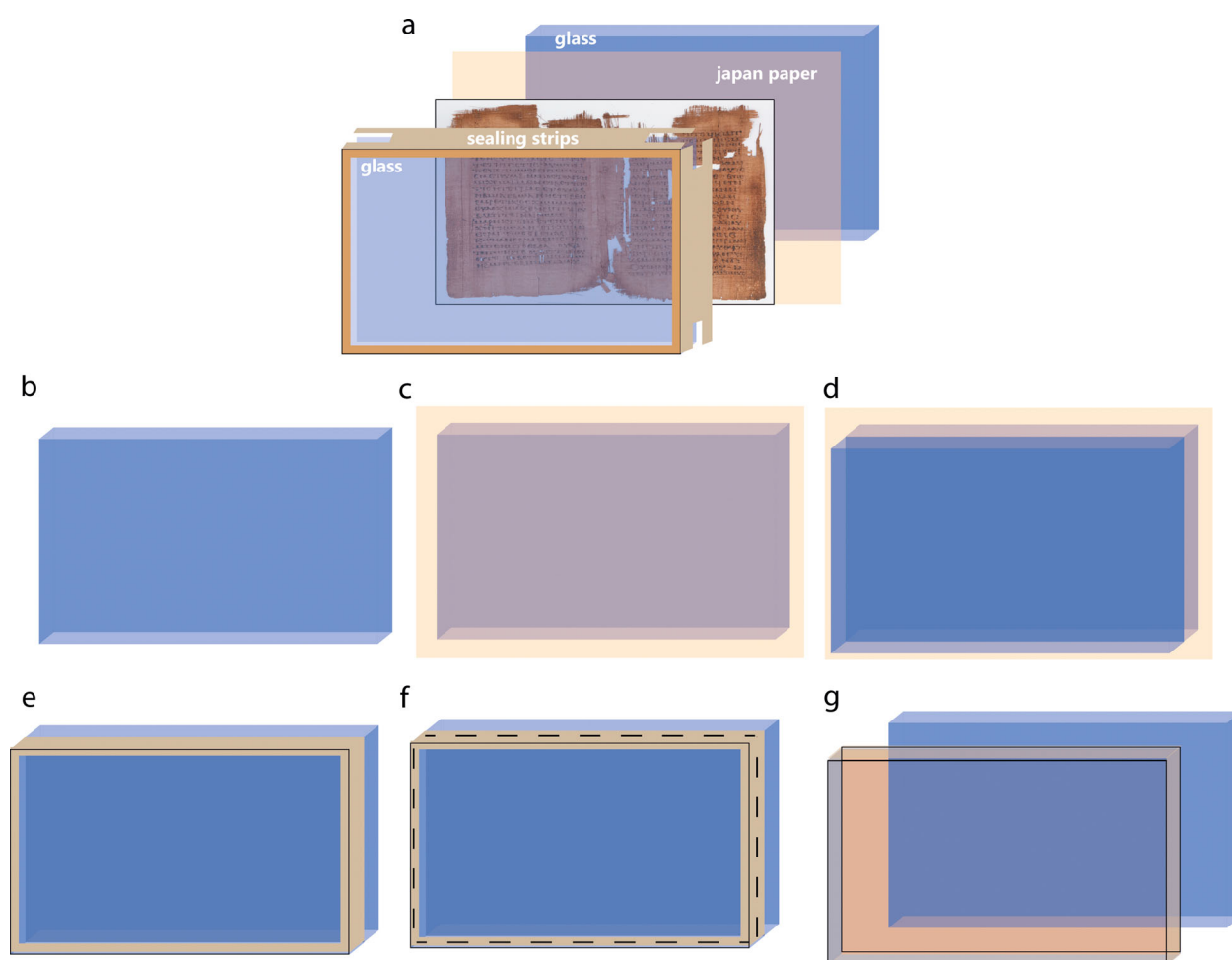
In the next step, sealing strips are prepared (the top layer of Figure 5(a)). In the first step, the tape is cut into strips as long as the lengths of the frame edges. Then,

at both ends of the tape, to increase the air circulation and minimise water condensation within the frames, we cut ventilation holes as wide as the two panes of glass used for the frame. In our experience, the total length of both holes should equal approximately one-fifth of the length of the edge of the glass to which the strip is attached.

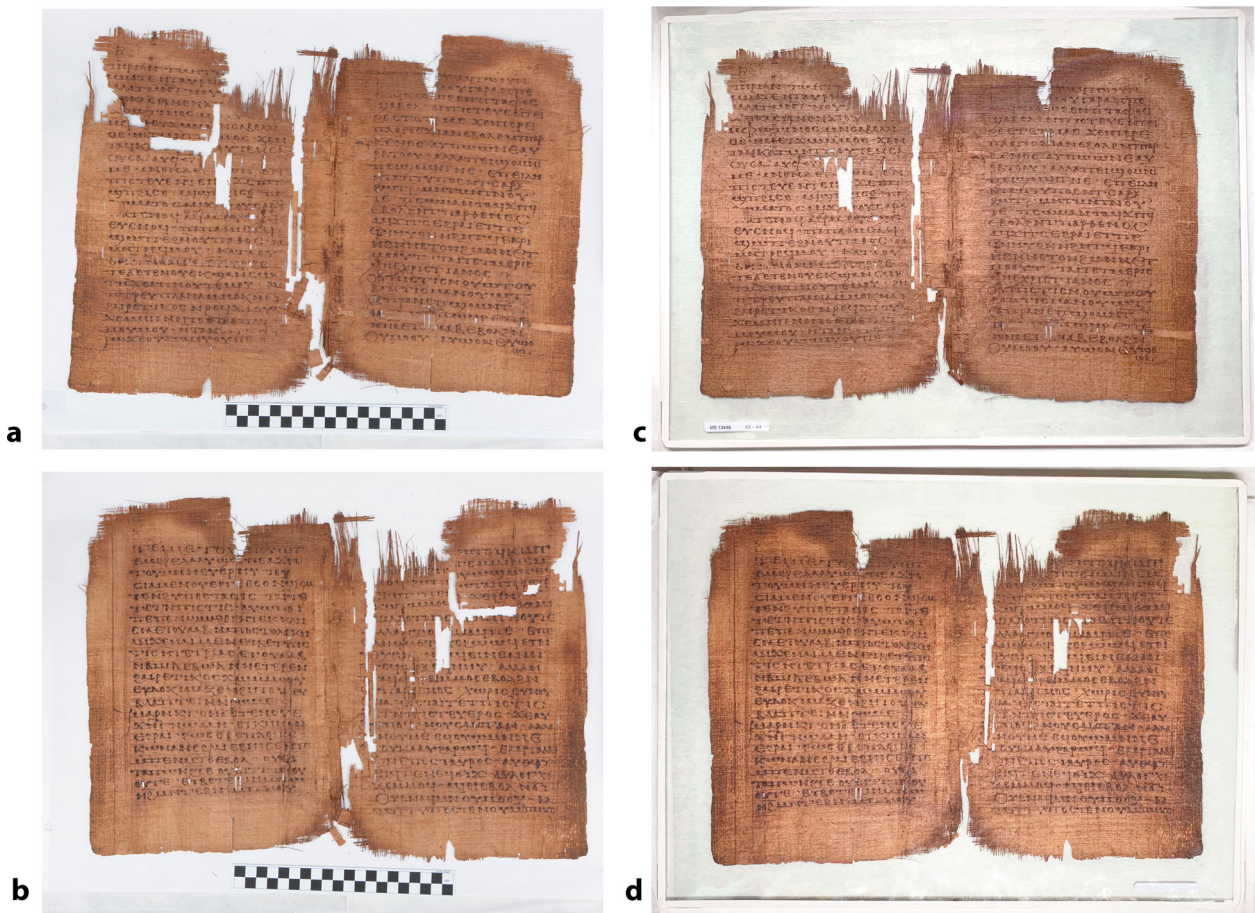
### Conservation treatments and framing

All the conservation treatments were performed with the object kept on the glass. The smooth glass surface allowed the safe manipulation of the pieces. To avoid unnecessary input of moisture into the papyrus, in this project we used solely 3% Klucel® G in ethanol as an adhesive applied to the objects. For framing, we used 3.0 mm-thick soda lime glass with smoothed edges, 2.0 g/m<sup>2</sup> Kozo Paper, and 2-cm broad Arcare Gummed Paper Tape. To achieve the best conservation outcome using the proposed method of frame preparation, we conducted the treatments as follows:

First, we gently removed the surface dust from the papyrus using soft brushes. After that, using fine spatulas, tweezers, and needles, we mechanically removed the harmful repairs, simultaneously consolidating the



**Figure 5.** Scheme for the Krutzsich Method: (a) schematic for the frame; (b – g) steps needed for the frame preparation.



**Figure 6.** Canons of Pseudo-Basil: bifolio A3 A5. (a) and (b), sides *recto* and *verso*, respectively, before conservation; (c) and (d), sides *recto* and *verso*, respectively, after conservation. Note that the repositioning and reintegration of the broken papyrus fragments led to the disappearance of some of the *lacunae* seen in (a) and (b).

layers of fibres and flaking inks with 3% Klucel® G in ethanol. If access to the other side is needed, the piece is safely turned over by securing it between two panes of glass.

In the next step, we reconnected the broken fragments of the papyrus, directly attaching them in their original position. Whenever an adhesive was used, the glued area was left to dry under a small weight. For drying non-woven material fabric, Bondina® was placed below the object and under the weight, with the smooth side of the fabric facing the papyrus.

When aligning was not possible, for example because a larger piece was missing, the fragment was placed in the chosen position, while not being permanently attached either to the glass or the papyrus, to be supported only by the long fibres of the Japanese paper. Once the treatments were finished, the object was placed on the glass pane without Japanese paper, using the 'turning with the use of support' technique. The side facing the front of the frame was intended for exhibition. To ensure that all the folios are aligned in the same manner, a paper with mm markings which act as a ruler, marked with the outline of the frame, the position of the spine fold, and the shelf mark was placed below the glass. A

label with the shelf mark and bifolio number was glued to the front glass with a drop of 3% Klucel® G in ethanol in the same area of each frame. When the desired arrangement of the bifolios was achieved, the pages were covered with the rear frame piece (the one with Japanese paper attached) and secured with clips on the glass edges.

To simplify the framing process, the outer thickness of the tape was marked with a fineliner pen in a few spots at the frame edge. The frame edges were sealed progressively, the clips were removed from one side, the respective strip was moisturised and applied, and then the next edge was processed. When the whole frame was finished, it was left to dry overnight. The next day, overlapping pieces of tape at the corners were trimmed. Afterwards, the papyri were stored horizontally.

The outcome of the presented method is shown in Figure 6. The *recto* and *verso* sides of the papyrus before the treatments are shown in Figure 6(a, b), respectively. The same sides of the framed bifolio are displayed in Figure 6(c, d). Note that the thin Japanese paper used for the papyrus support is hardly visible in Figure 6(d) (the side with the Japanese paper attached to it).

## Conclusions

Any technical study is intended to be final in order to minimize the need for handling of the object in the future. The adopted protocol allowed us to conduct basic essential measurements and to document a large number of papyrus folios in a relatively short time, without the need for analytical equipment. The qualitative assessment of the condition of the papyrus codex provided a good foundation for the conservation project and helped in the conservation decision-making process. For instance, the ink screening showed no need for the treatments of the ink corrosion. The multi-wavelength examination of ink allowed characterization of the main ink as iron gall ink, and carbon-based inks in the papyrus waste. The technical evaluation of sheet physical features enabled precise planning and prioritising the necessary treatments within our limited timeframe, including selecting the novel framing method.

As demonstrated in the second part of this article, we successfully adapted the Krutzsch method of papyrus framing in this project. The proposed method is minimally invasive, as the framed object is suspended only from the long paper fibres. The method is also easily reversed, as the papyrus mounting is done without the use of any adhesives, in contrast to traditional papyrus mountings which have the potential to become irreversible. When thin enough paper is used, it is also barely visible, so can be used to stabilise areas over text (see [Figure 6](#)). Should there be a need in the future to rehouse the object or reposition some of its fragments, our approach allows the simple and safe opening of the frames and realigning of the papyrus fragments. The assessment methods were simple and did not need complex scientific equipment. They effectively aided conservation-decision making, which lead to good conservation treatment outcome.

## Note

1. Based on the codicological reconstruction done by N. Carlig, the codex was originally made of 75 folios divided into 10 quires, see Carlig (2018).

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