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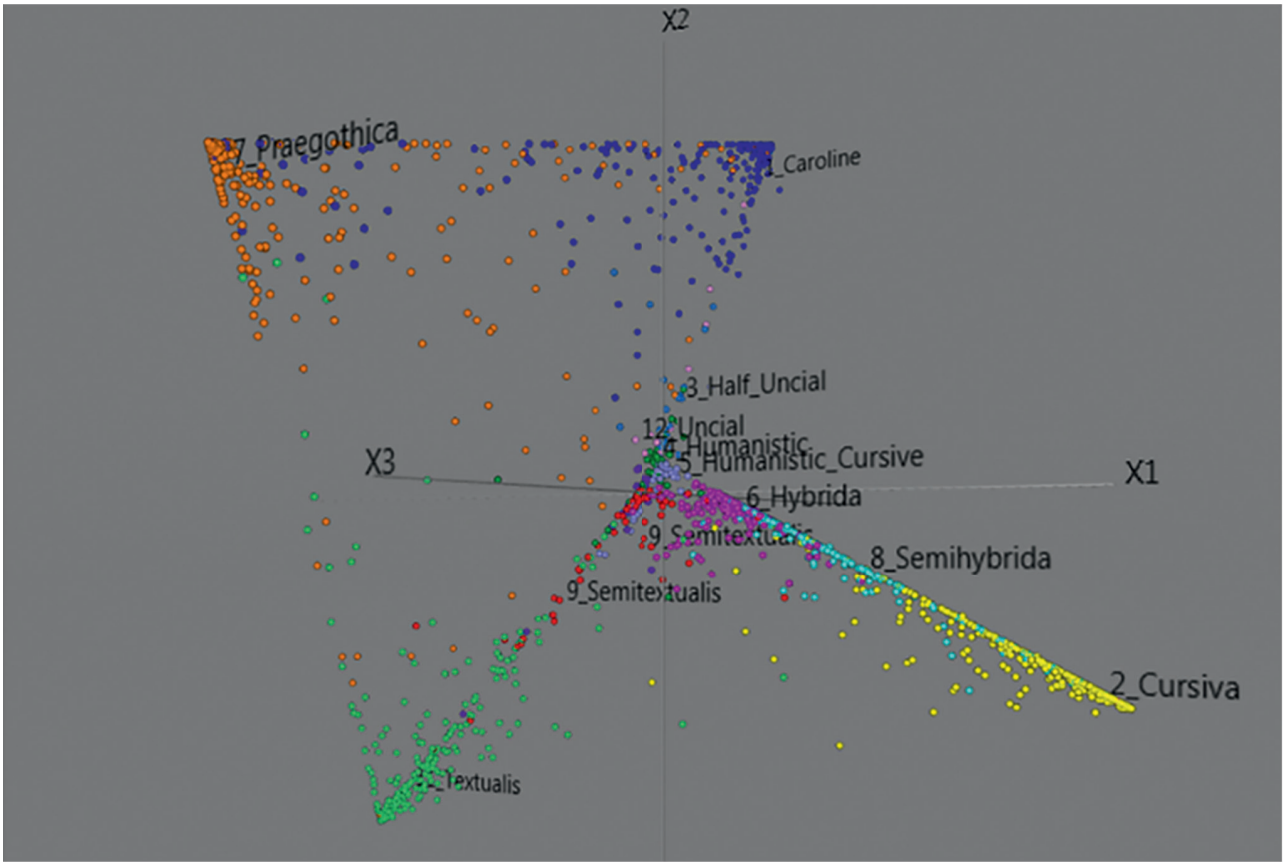

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Edited by Oliver Hahn, Volker Märgner, Ira Rabin, and H. Siegfried Stiehl

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Article

Papyrus as a Writing Support

Myriam Krutzsch | Berlin

Abstract

Papyrus was used as a writing support for about 4,000 years (*c*.3000 BCE – *c*.1000 CE) and displays varying qualities that can be localised temporally and geographically. It is astonishing that the quality of the oldest papyri from the Fifth Dynasty (the Old Kingdom of Egypt) is characterised by their regular fibre structure, fineness and very thin sheets. The Middle Kingdom also used papyri of high quality; only a practised eye can distinguish the difference in quality between the recto and the verso. Papyri from the time of the pharaohs are translucent, sometimes so much so that the writing on the reverse side can be recognised on the upper side.

This high degree of transparency disappeared in Greco-Roman times as the material became firmer, thicker and more compact. The first reason for this is that a different writing implement was used: the *kalamos*, which was much harder and stiffer than the soft, brush-like *bulrush* of pharaonic times. Second, the constantly growing demand for papyrus material led to a decline in its quality. Along with the poor and usually coarse papyrus of Arabian times, though, a conspicuously fine, high-quality material was used. It is unclear how this 'renaissance' of papyrus came about, however.

First of all, the typical structure of papyrus as a writing material will be explained here, which is fundamentally different from paper. The differences lie both in the source material and in the manufacturing method, and therefore result in different consistency, structure and behaviour of the produced writing support.

1. Description of the material

Conservation projects always begin with an assessment of the state of an object's preservation. Over the centuries, the original character of papyrus can change, but still be recognisable. A material description of papyrus consists of the measurement of its dimensions and a number of other criteria that are documented in a conservation protocol along with the current state of the material, namely:

1. its colour
2. the production method used
3. fibres
4. sheets
5. sheet joins
6. roll ends.

1.1 Colour

The original colour of the papyrus sheets that were examined was presumably light ochre, yellow or brown. The colour, and particularly its susceptibility to change, depends on various factors (Table 1).

Since the colour of ancient papyrus can continue to change, depending on what the climatic or storage conditions are like, it cannot be taken into consideration as an indication of the exact location when reconstructing its background.

1.2 Production methods

To date, we only know of one written source mentioning the production of papyrus as a writing support – that of Pliny the Elder.[3] His records are very simple and concise; there are just notes, and yet two different

Table 1: Colour changes in papyrus.

Cause	Effect	Example
UV radiation	Bleaches the papyrus and damages the cellulose ↳ consistency becomes soft and rotten	Berlin P 9875
Water[1] and other liquids	Browning and cellulose decay; spots ↳ consistency becomes brittle and often frayed	Berlin P 15995 - 98
Heat and fire	Browning and destruction of the cellulose ↳ extreme brittleness to the point of disintegration	Elephantine 26774a[2]

[1] Constant, long-lasting influence from water is meant here, for example due to the annual flooding of the Nile.

[2] The current location of this papyrus document is unknown.

[3] In his *Naturalis Historia*, Pliny the Elder dedicated several chapters of book 13 to papyrus as a writing material, its production and use (chapters XXI–XXVII); on the production of it, see chapter 13, XXIII.

production methods can be found in them for separating papyrus fibres from the pulp (Table 2).

The structure of the two layers of fibres differs, depending on the production method. Unlike the classic method, sheets produced by the peeling method contain what are called expansion gaps, which come from using a needle to inscribe or score the corners of the triangular stalk. This damages the fibres in these areas.

1.3 Fibres

Three types of fibres can be distinguished: especially fine ones, coarse ones and ones in the middle. Moreover, individual fibres and bundles of fibres can be recognised. Depending on the number of fibres there are, the result can be a broad or dense structure or one in between. Differences can also be seen in the course of the fibres. Thus, there are not only linear arrangements, but different slanted or wave-like forms. Although all of these phenomena can be found in a single layer of fibre, they can also occur in both layers.

Table 2: Papyrus manufacturing techniques.

Classical method	Peeling method
Work with a **knife**	Work with a **needle**
The stalk is cut in lengthwise strips that get narrower from the outside to the inside.	The stalk is unwrapped from the outside to the inside, so to speak, resulting in wider sections.

1.4 Sheet description

According to Pliny the Elder, a new papyrus roll could contain up to 20 individual sheets joined together by overlapping and gluing. The classification of these sheet joins leads to the examination of the forms of sheets used and thus to different types of sheets (Table 3).

1.4.1 Types

There are three different types of sheets, which differ with regard to their lateral edges (Table 4).

1.4.2 Edge forms

It is also striking that there are sheets whose edges have been trimmed, while others display a very irregular course; in sheets of types I and II, there are narrow to broad overlapping recto fibres (approx. 1 cm to 3 cm long), both in the trimmed and the untrimmed sheets.

1.4.3 Proportions

First of all, individual sheets were produced, up to 20 of which were joined in a roll as a rule.[4] How large were these individual sheets, though? Pliny writes that the size of sheets indicates their quality. Moreover, it was also typical of a specific production site, at least in Greco-Roman times.[5] Different sheet formats can be found in pharaonic times as well.[6] The degree to which they are connected with the production sites is currently unknown.

1.4.4 Sheet thickness

Measurements of sheet thickness show that there is a developmental series extending from very thin material in the Old and Middle Kingdoms approx. 0.1 mm in size to up to 0.3 mm in Byzantine times (see Table 5).

1.4.5 Consistency

If we ignore the fact that the consistency of papyri has gone through a change over the centuries and millennia along with their colour, we can distinguish three main groups: soft – flexible – brittle. Originally, papyrus material was so flexible that it could be folded easily, not just rolled up or unrolled. Many papyri still have this flexibility today. Others are characterised by their especially soft consistency – these papyri come from Abusir. I count frayed papyri as belonging to this soft group, the consistency of which has changed over long periods of time due to the repeated influence of water.

At the other end of the scale, we have the large group of brittle or even embrittled papyri. While the embrittled consistency tends to result from the solidity of strong fibres and is mostly found in thicker or coarser papyri, brittleness or fracture susceptibility is the result of the cellulose deteriorating over time, which is also a consequence of aging.

1.4.6 Opacity

Furthermore, three different levels of opacity can be found in papyrus: transparent – translucent – opaque. In pharaonic times, papyrus sheets were usually transparent and sometimes

[4] Pliny the Elder, *Naturalis Historia* 13, XXIII.

[5] Pliny the Elder, *Naturalis Historia* 13, XXIV.

[6] Möller 1917, 6–7.

Table 3: Comparison of historic hand-made paper and papyrus.

Writing support		
Material	**Paper**	**Papyrus**
Period of use	since *c.* the 9th century CE in the Arab world	from *c.*2700 BCE (Old Kingdom), again from *c.* the 10th/11th century CE
Raw materials	- chopped-up fibres from plants or textiles - glue - colourants - fillers	- fibres from the stalk of the plant of the same name
	- water	- water from the Nile
Production method	- mixing all the ingredients together	- orientation of the core fibres in a vertical and overlaying horizontal position
	- scooping - couching (draining)	- rapping and pressing
	- drying	- drying
	- surface treatment (of the front side)	---
Result	- one-layer sheet with the fibres and expansion in one direction	- two-layered sheet with the fibres and expansion in two directions
	- material shows the structure of the scooping sieve	- material shows the individual structure and direction of the fibres in both layers
	- sheets have the structure of the scooping sieve	- every sheet has a unique fibre structure
Designation of the sheet side	- front side, higher quality	- recto = horizontal fibre layer, higher quality
	- reverse side, poorer quality	- verso = vertical fibre layer, poorer quality
Depiction of examples	bars and ribs in handmade paper  modern, handmade paper	Berlin P 13583: detail of recto  cross-section:   Berlin P 13583: detail of verso

Table 4: Different sheet edges.

Type I	Recto fibres extend beyond the verso fibres to the right and left
Type II	Recto fibres only extend beyond the verso fibres on one side
Type III	Recto and verso fibres are flush on the right- and left-hand side

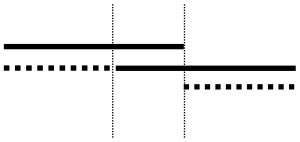
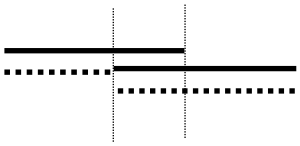
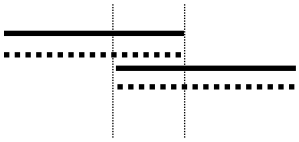
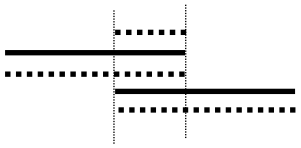
Table 5: Evolution of sheet thickness.

Date	**Thickness of the sheets**	**Examples from the Berlin Papyrus Collection**
Old Kingdom	0.075 – 0.1 mm	0.1 mm: P 15722
Middle Kingdom	0.1 – 0.2 mm	0.1 mm: P 10012
New Kingdom		0.2 mm: P 10487
Late Period		0.25 mm: P 13540
Greek Period	0.25 – 0.3 mm	0.25 mm: P 16985
Byzantine Period	0.3 – 0.4 mm	0.3 mm: P 13275
Arabic Period	0.2 – 0.3 mm	0.2 mm: P 13352

Table 6: The three kinds of join forms.

Manufacturing joins	**Writer's joins**	**File joins**
Carried out in manufacturing as the final step in producing the writing surface	Carried out by the writer before or during writing	Carried out in the office to put individual documents together
The arrangement and quality are even	The order of the sheets and diligence in execution varies	Made with little diligence and often even glued over the writing
 Berlin P 3003 H-K, detail	 Berlin P 3005, detail	 Berlin P 11652 B, detail

Table 7: Classification of the join forms.

Type I	Type II	Type III	Type IV
			
Two-layered	Three-layered	Four-layered	Five-layered

even translucent, i.e. the writing on the reverse side was visible on the front. This translucency increasingly disappeared from Greco-Roman times onwards and the sheets became markedly denser. Later, in Arab times, sheets of papyrus were made in a transparent form again and a high level of quality was achieved in their manufacture, hence we can speak of a 'renaissance' of the material as a writing support.

1.4.7 Surface texture

The surface of the two sides of a papyrus sheet is determined by its fibres, their type, density and arrangement, and not least the skill of the papyrus-maker. Consequently, the surface can vary from being rough to flat and smooth. In addition to that, a matt surface and a silky, glossy surface achieved by polishing can be distinguished.

1.5 Sheet joins

Individual sheets of papyrus were joined together, ultimately creating a roll or scroll. The joins can be classified[7] as one of three kinds (Table 6) and four different forms (Table 7), the latter being subdivided into basic, special and mixed.

Sheet join II is the most common type, followed by type III. In contrast, types I and IV are rarely encountered. We can distinguish between basic, special and even dual mixed forms, depending on how accurately the overlapping was carried out and what the course of the recto fibres was (in particular) on the lateral margins (cf. the different sheet types). Sometimes five-layered sheet joins can be encountered, as in type IV. The latter result when a sheet from the end of a roll is attached to a sheet of type III. This form of roll end is characterised by a narrow verso fibre (approx. 1 cm wide) glued to the end of the roll as a reinforcing safeguard. This way, the papyrus has three layers at such spots. Sheet joins can also be distinguished in terms of the order of the sheets, the care taken in production, and the concentration of the glue in execution (Fig. 1).

The width and thickness of the sheet joins show a development similar to that of sheet thicknesses. Thus, the narrowest joins (of under 1 cm) are found on papyri from the Old and Middle Kingdoms. In the New Kingdom, the width of the joins is about 1.5 cm, in Greco-Roman times about 2.5 cm and in Byzantine times it finally reaches a gluing width of 3 to 3.5 cm, and in some cases even up to 4 cm.[8] Hence the width of the sheet joins can be an important criterion for dating papyrus as a writing support.

1.6 Roll ends

Along with the roll ends mentioned in section 1.5 in the form of a glued-on verso fibre strip, there is another completely different kind of roll end as well. In this case, a whole sheet was attached with the verso side facing up, i.e. it was attached to the recto side (cf. Berlin P 3147; Fig. 2).

1.7 Special forms of rolls

Occasionally, special forms are encountered as well. These appear very rarely, however, and include what I call a single-sheet roll. These sheets, which are usually excessively wide (80 cm or more), have narrow verso strips on both lateral edges as a conclusion and were thus conceived as a roll. Berlin P 10482 is an especially striking example. This papyrus is 82 cm wide and was rolled, which is clearly recognisable by its regularly recurring flaws.

2. Origin

When it comes to the origin of the writing support, I take this to mean the place where the material was first produced, which is presumably identical to or close to the place where the plant itself was cultivated, as opposed to the site where

[7] Krutzsch 2017, 217–218.

[8] Krutzsch 2017, 218.

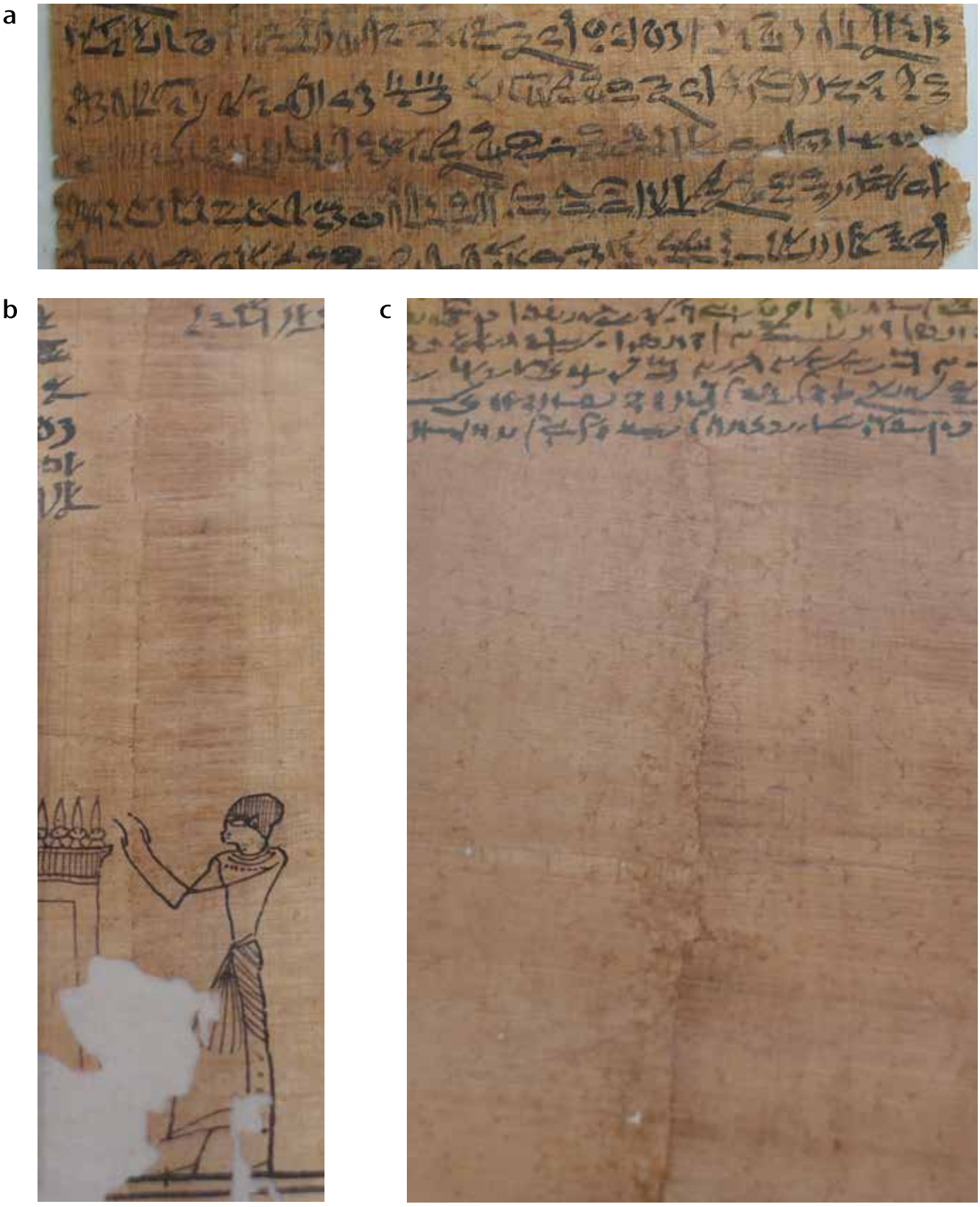


Fig. 1: Examples of the execution of different sheet joins: a) Papyrus Berlin P 10463, detail showing a practically invisible horizontal sheet join in the middle; b) Papyrus Berlin P 10478, detail showing the glue that penetrated to the front; c) Papyrus Berlin P 3100, detail showing glue that seeped to the edge.

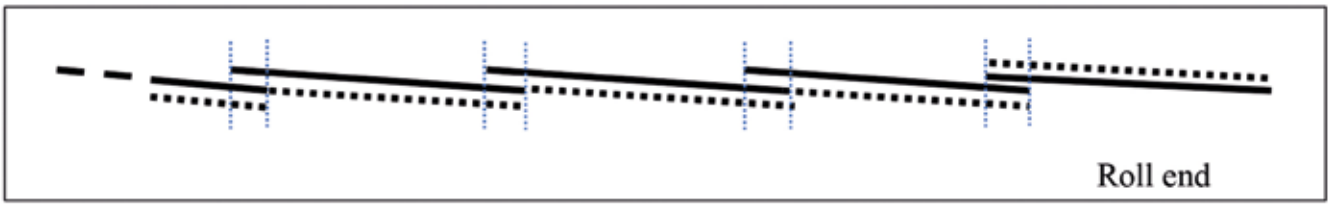


Fig. 2: Cross-sectional drawing of a roll end (right) with a complete verso sheet.

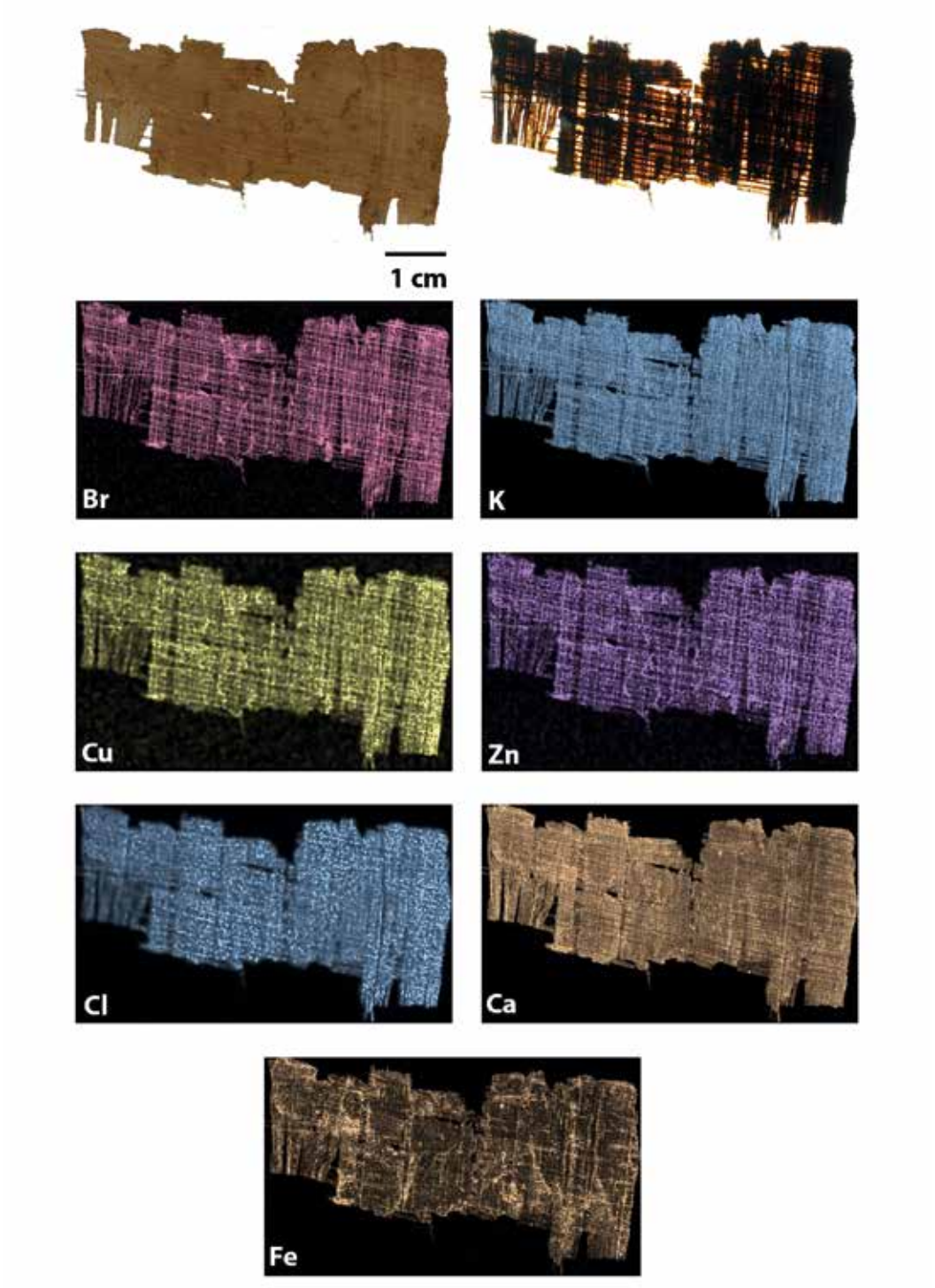


Fig. 3: Elemental distributions from an XRF scan of a fragment from Dime (Arabic times).

Table 8: Three classes of ink under different illuminations.

Illumination	Carbon ink	Mixed ink	Iron-gall ink
Normal daylight			
NIR			
UV			
Example	Berlin P 15771, detail	Berlin P 8500, detail	Berlin P 8283, detail

the written objects were found or acquired. In addition to that, there is the place where the text was written, which may be mentioned in the text. This site may not have anything in common with the site where the papyrus material originated,[9] though, so we may be dealing with four different places that need to be distinguished.

It is therefore evident that the text and the material on which it is written (the 'support') are of equal importance in codicology, so both need to be investigated. A material analysis can be an aid not only to dating objects, but to localising them as well. The first scientific investigations using the XRF Jet Stream device at the Federal Institute for Materials Research and Testing (BAM Bundesanstalt für Materialprüfung und Untersuchung, Berlin)[10] entailed an elemental analysis of papyrus fragments from different archaeological sites, which revealed some local differences. In future, we aim to compare these results with the composition of the soil samples from the corresponding archaeological sites in order to filter out the traces from the excavations.

In a fragment from Dime from Arabic times (see Fig. 3), four elements (bromine, potassium, copper and zinc) can be found in the papyrus sheet we examined that display its structure, which indicates that these elements are in the material. In contrast, the distributions of chlorine, calcium and iron are less ordered and the elements seem to be attached to particular fibres, i.e. they are likely to be contaminants on the surface of the material.

3. Inks and pigments

The three-colour Dino Lite microscope used in my analysis makes it easy to see what kind of inks are present in a sample. Soot inks never change their opacity and colour, iron-gall inks are less visible under NIR light, but are well-pronounced under UV illumination, while the mixed ink, in contrast, can be seen under both UV and IR light.

[9] Rabin and Krutzsch, 2019.

[10] My cordial thanks go to Prof Ira Rabin (BAM, Berlin and CSMC, Hamburg University) and Mr Greg Nehring for their collaboration in analysing and investigating the materials.

Table 9: Coloured drawings under different illuminations.

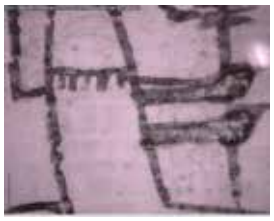
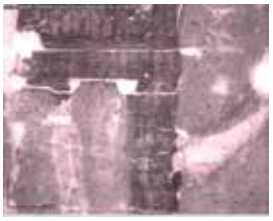
Pigments	Normal daylight	UV	NIR
(1) Red and green pigments; carbon ink (Papyrus Berlin P 3166 A)			
(2) white, green and cinnabar pigments; carbon ink (Papyrus Berlin P 3166 A)			
(3) Egyptian blue, cinnabar and yellow pigments; carbon ink (Papyrus Berlin P 3166 A)			
(4) yellow pigment with orpiment, green pigment; carbon ink (Papyrus Berlin P 3158 II)			

Table 9 shows that in the coloured drawings, soot-based pigment can clearly be seen under the NIR light producing the clear outlines, whereas no difference between the individual pigments can be discerned under UV light.

While white, red and yellow are not visible under IR light, green and blue-green look 'gravy-like'. Under UV light, white is clearly visible and blue and yellow pigments reflect. The latter yellow pigment is occasionally found with an admixture of orpiment, which is not visible under UV light, but appears white under NIR light.

This means that the investigation and identification of inks and colour pigments can be just as helpful for dating and clarifying the origins of objects as precise material analysis.

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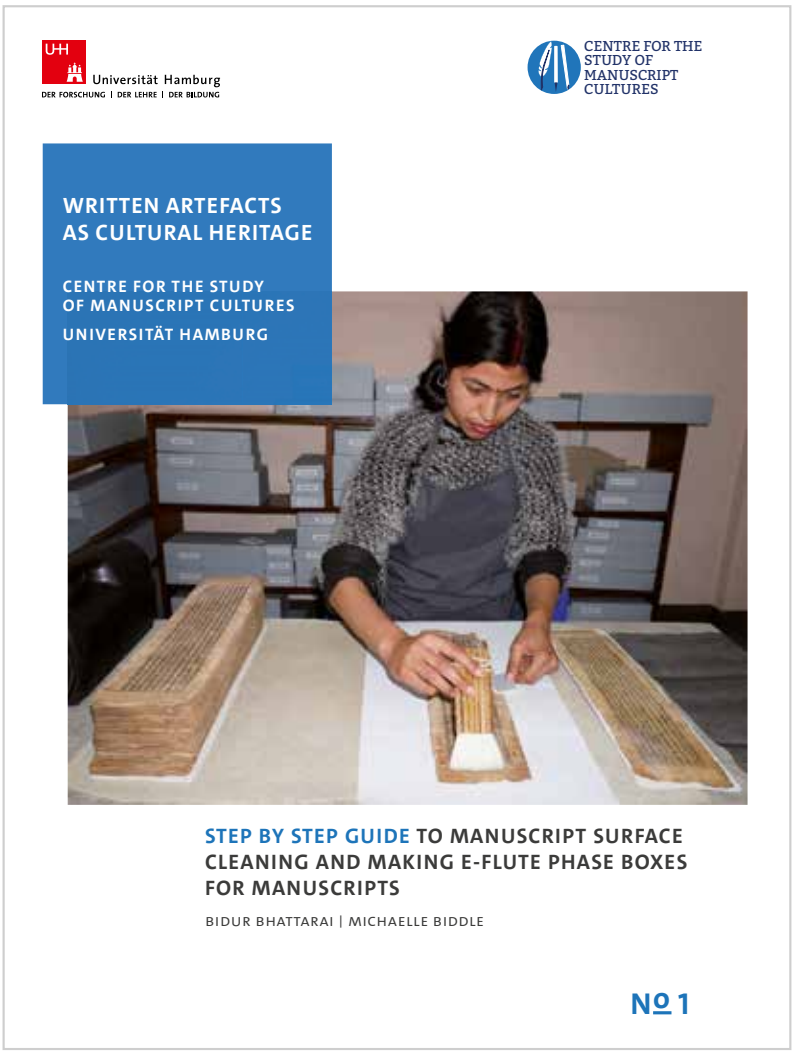

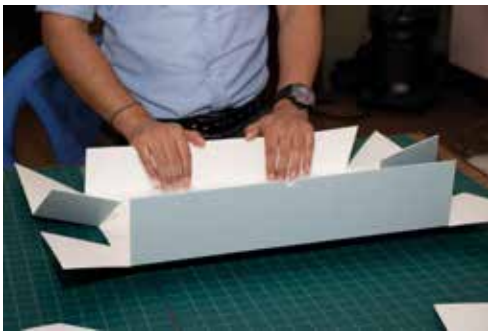

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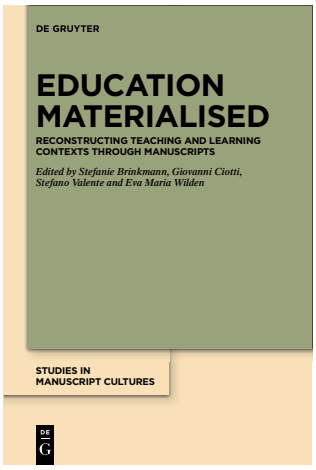

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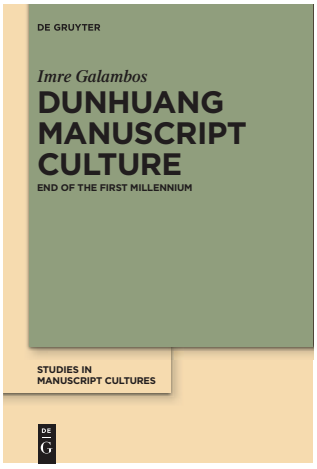

22 – *Dunhuang Manuscript Culture: End of the First Millennium*, by Imre Galambos

Dunhuang Manuscript Culture explores the world of Chinese manuscripts from ninth–tenth century Dunhuang, an oasis city along the network of pre-modern routes known today collectively as the Silk Roads. The manuscripts have been discovered in 1900 in a sealed-off side-chamber of a Buddhist cave temple, where they had lain undisturbed for for almost nine hundred years. The discovery comprised tens of thousands of texts, written in over twenty different languages and scripts, including Chinese, Tibetan, Old Uighur, Khotanese, Sogdian and Sanskrit. This study centres around four groups of manuscripts from the mid-ninth to the late tenth centuries, a period when the region was an independent kingdom ruled by local families. The central argument is that the manuscripts attest to the unique cultural diversity of the region during this period, exhibiting – alongside obvious Chinese elements – the heavy influence of Central Asian cultures. As a result, it was much less 'Chinese' than commonly portrayed in modern scholarship. The book makes a contribution to the study of cultural and linguistic interaction along the Silk Roads.

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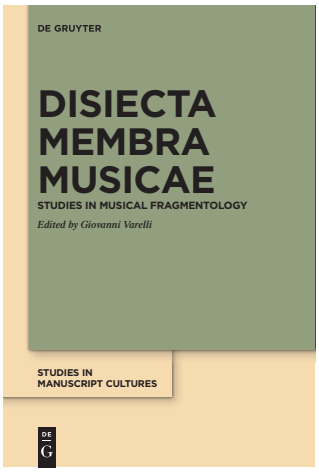
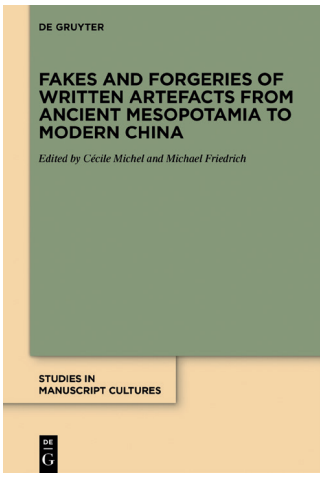


21 – *Disiecta Membra Musicae: Studies in Musical Fragmentology*, edited by Giovanni Varelli

Although fragments from music manuscripts have occupied a place of considerable importance since the very early days of modern musicology, a collective, up-to-date, and comprehensive discussion of the various techniques and approaches for their study was lacking. On-line resources have also become increasingly crucial for the identification, study, and textual/musical reconstruction of fragmentary sources. *Disiecta Membra Musicae. Studies in Musical Fragmentology* aims at reviewing the state of the art in the study of medieval music fragments in Europe, the variety of methodologies for studying the repertory and its transmission, musical palaeography, codicology, liturgy, historical and cultural contexts, etc. This collection of essays provides an opportunity to reflect also on broader issues, such as the role of fragments in last century's musicology, how fragmentary material shaped our conception of the written transmission of early European music, and how new fragments are being discovered in the digital age. Known fragments and new technology, new discoveries and traditional methodology alternate in this collection of essays, whose topics range from plainchant to *ars nova* and fifteenth- to sixteenth-century polyphony.

New release



20 – *Fakes and Forgeries of Written Artefacts from Ancient Mesopotamia to Modern China,* edited by Cécile Michel and Michael Friedrich

Fakes and forgeries are objects of fascination. This volume contains a serie of thirteen articles devoted to fakes and forgeries of written artefacts from th beginnings of writing in Mesopotamia to modern China. The studies empha sise the subtle distinctions conveyed by an established vocabulary relating t the reproduction of ancient artefacts and production of artefacts claiming t be ancient: from copies, replicas and imitations to fakes and forgeries. Fake are often a response to a demand from the public or scholarly milieu, or ever both. The motives behind their production may be economic, political, reli gious or personal – aspiring to fame or simply playing a joke. Fakes may be revealed by combining the study of their contents, codicological, epigraphi and palaeographic analyses, and scientific investigations. However, certain fa mous unsolved cases still continue to defy technology today, no matter hov advanced it is. Nowadays, one can find fakes in museums and private collec tions alike; they abound on the antique market, mixed with real artefacts tha have often been looted. The scientific community's attitude to such objects calls for ethical reflection.

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