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Leafing through time: Ink Analysis of the longest Qur'ān on Papyrus

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Abstract – **The fragments preserved at the Staats- und Universitätsbibliothek Hamburg, under the shelfmark P. Hamb. Arab. 68 are, to date, the longest and oldest excerpt of extant Qurʾān on papyrus. The fragments contain the Sura 2 in its entirety, written over seven bifolia originally sewed in a single quire. The writing incorporates the use of diacritical dots as well as markers indicating the ends of verses and text. Three of the seven folios were analysed to determine the inks used in writing the texts, the dots and the markers. The results indicate that the text was written with a carbon-based ink characterised by the presence of trace amounts of copper, possibly due to impurities in the water or the use of a copper or bronze inkwell. The diacritical dots completing the text were penned using the same ink while a different carbon ink, without copper, was used for the decorative elements of the text.**

Key words – Papyrus Qurʾān, ink analysis, carbon ink, XRF

I. INTRODUCTION

The early centuries of Islam were characterised by the presence of multiple writing supports. Papyrus, used since antiquity in ancient Egypt, was adopted and used for administrative purposes by the new rulers of Egypt until paper eventually replaced it as the writing support of choice [1], [2]. Parchments were similarly used for writing content that required durability, including marriage contracts, purchase deeds and in particular, religious texts [3]. The perceived durability and prestige associated with parchment made it the preferred choice for recording the word of God. Consequently, the number of extant Qurʾāns on papyrus is very limited. Correspondingly, different compositions of inks are well attested in the Arabic sources from tenth century C.E onwards [4]. Typologically, three primary classes of inks emerge: carbon ink, plant ink and iron gall ink [5], [6]. Carbon ink is traditionally made of soot or charcoal mixed with a water-soluble binder (usually gum Arabic), followed by its dispersion in water before use. Plant inks are composed of tannins, obtained from various parts of the plants, i.e. bark, leaves, fruits, and flowers. Iron-gall ink results from the reaction of Fe^{2+} and gallic acid, in the presence of a binder (usually gum Arabic) in a water-based solvent. The reaction of Fe^{2+} and gallic acid (extracted from gall nuts or tannins rich plants) results in the formation of a dark Fe (III) gallate complex. The source of iron is often reported to be vitriol (a mixture of metallic sulphates, including $FeSO_4$); however, some recipes also indicate the use of iron fillings, slags, and pieces of iron for the production of iron-gall inks. The differentiation between the three pure classes of inks is relatively easy thanks to their different optical properties. Plant ink appears transparent under 940 nm light while iron-gall ink exhibits a decrease in opacity under infrared light, eventually turning transparent under higher wavelength; carbon ink, however, appears unchanged throughout [7]. Under ultraviolet light, plant inks appear darker due to an increase in contrast compared to the writing support, a result of quenching of fluorescence by the tannins present in the ink. The combination of carbon inks with either plant inks or iron-gall inks results in an additional class of inks: mixed inks [5], [8]. Recipes for mixed inks appear in Arabic sources from tenth century onwards, making it a popular typology of inks. The identification of mixed inks is not so simple since their optical properties depend on the predominant components and therefore it is difficult to differentiate them from the pure classes. Additionally, it is not possible to univocally identify the presence of tannins exclusively with non-destructive techniques. Even when metals are detected with X-ray fluorescence spectroscopy in carbon inks, they cannot be identified beyond any doubt as mixed ink. In fact, the presence of metals (iron, copper or lead) in carbon inks has been reported increasingly in recent years [8]–[12]. In particular, the presence of copper in carbon ink was attributed either to a contamination of the source of carbon, or to the results of experimentations leading to the manufacture of new inks.

The adoption of a multi-disciplinary approach for the study of written artefacts, complementing palaeographic and philological studies with the investigation of the materials using non-destructive and non-invasive techniques from the natural sciences, provides a wealth of information and answers that cannot be obtained from one perspective alone [13], [14]. For the study of the Qurʾānic fragments on papyrus, preserved at the Staats- und Universitätsbibliothek, Hamburg, we have adopted this approach, with an attempt to answer questions on the nature of ink used for writing these manuscripts.

II. DESCRIPTION OF THE ARTEFACT

Discovered in Egypt in the first quarter of the twentieth century, P. Hamb. Arab. 68 is to date, the longest and oldest extant extract of Qur'ān written on papyrus [15]. It contains almost the entire text of the second Sura (The cow) and is dated paleographically to the late seventh-early eighth century. The text was copied in an archaic script called *Ḥiǧāzī*, and a defective spelling is adopted in many instances, as common in early Qurʾāns. Some diacritical dots are used to distinguish homographs. Concentric circles of dots and dashes were used as ten-verse dividers and verse separators. The end of the Sura is marked by a decorated 'headband' and is followed by a short text. The text was copied in single columns with an irregular number of lines on seven bifolia. They were folded in the middle to form a single quire, with the dimension of circa 20 × 25 cm, which was then stitched by stab-sewing or overcasting, as suggested by the presence of parallel sewing holes on the side of the fold. Each bifolio is now preserved separately between glass, numbered from 1 (the internal bifolio, Fig. 1) to 7 (the most external bifolio). The papyrus was obtained by cutting a scroll, as indicated by the presence of joints on P. Hamb, Arab. 68.2, 3 and 7. Both textual and codicological evidence suggests that P. Hamb. Arab. 68 was an autonomous booklet, containing only Sura 2. However, it was probably discarded not long after its production, as it sports a number of important omissions and errors in the text. In order to clarify the production process of this precious manuscript, in particular whether the diacritics and the decorative elements were penned during the same writing stage, we analysed the inks of three of the seven bifolia: P. Hamb. Arab. 68.1, 6 and 7.

III. METHODOLOGY

The analytical protocol developed by the Centre for study of manuscript culture (CSMC), Universität Hamburg and Bundesanstalt für Materialforschung und -prüfung (BAM) for the study of inks in written artefacts was followed for the investigation of the fragments [16], [17]. An initial screening was carried out using a digital microscope

Fig. 1 P. Hamb. Arab. 68.1 recto (left) and verso (right).

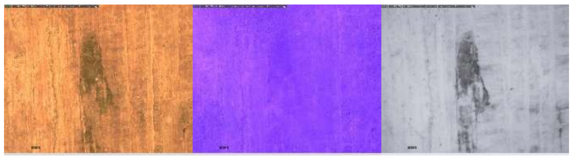

Fig. 2 Digital microscope images under white (left), UV (centre) and NIR (right) light of the main ink.

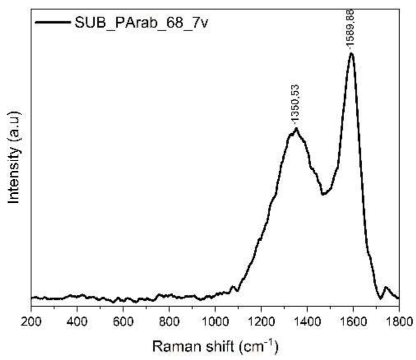

Fig. 3 Raman spectrum of the main ink of using 532 nm laser.

(DinoLite AD4113T-I2V) under ultraviolet (395 nm), near infrared (940 nm) and visible (white) light source to discriminate between the ink types.

This was followed by X-ray fluorescence (XRF) spectroscopy for the elemental characterisation of inks and papyrus. Spatial maps corresponding to the elemental distributions were obtained using Bruker M6 Jetstream equipped with Rh tube, under a voltage of 50 kV and current 600 µA. We selected an X-Ray spot size of 50 µm, a measuring time of 30 ms, and a measuring distance of 50 µm. Point measurements were carried out using Bruker / XG lab Elio, with Rh tube and a voltage of 40 kV, current 80 µA, spot size 1 mm and acquisition time of 120s. Measurements were taken on both the writing support and the ink. Raman spectroscopy measurements were carried out on selected spots to characterise carbon inks, using

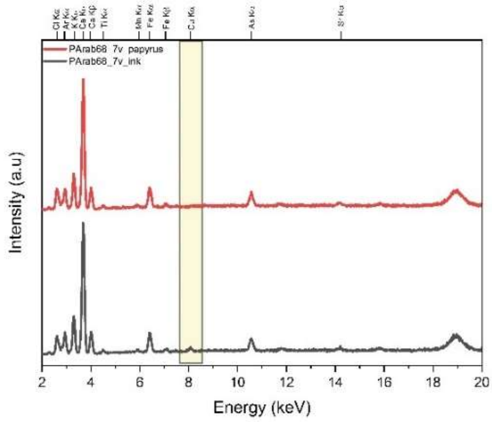

Fig. 4 XRF spectra of the ink and papyrus, highlighting the presence of copper, measured using Elio (Bruker/ XG lab).

Fig. 5 Image of P. Hamb. Arab. 68.6r (top) indicating the area analysed; B/W image of the analysed section (left), and XRF map (relative intensity) of copper (right), using M6 Jetstream (Bruker nano Gmbh).

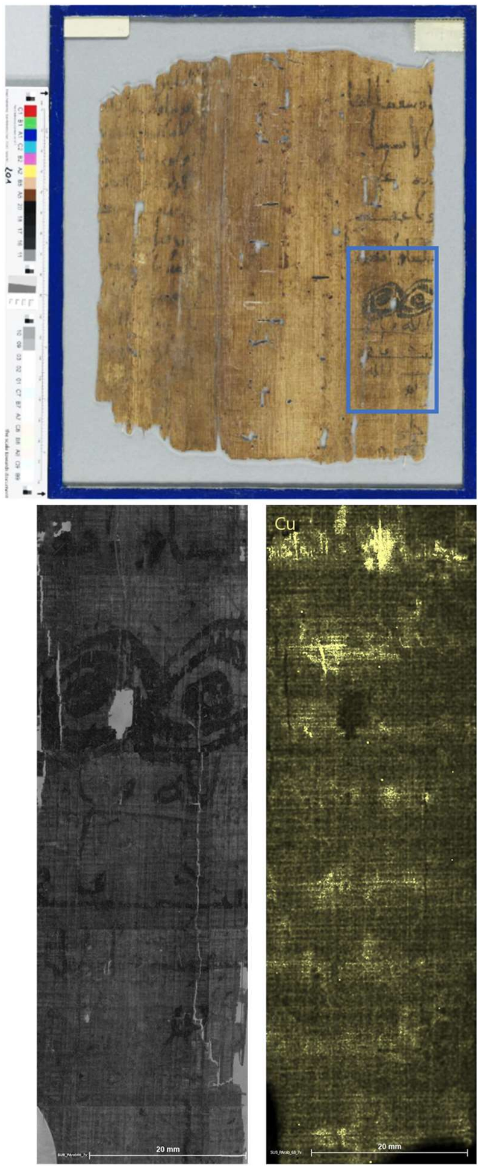

Fig. 6 Image of P. Hamb. Arab. 68.7v (top) indicating the area analysed; B/W image of the analysed section (left), and XRF map (relative intensity) of copper (right), using M6 Jetstream (Bruker nano Gmbh).

Renishaw inVia spectrometer, with 532 nm laser, with a 100× objective and 2% laser power (~1mW).

IV. RESULTS

The digital microscopy images exhibit no change in opacity under infrared light, suggesting the use of carbon-based ink in the main text (Fig. 2). Raman spectra of the ink confirms the use of carbon-based black ink (Fig. 3). The XRF spectra in Fig. 4 shows a weak signal of copper in the area of the main text and its absence in the writing support, suggesting that a trace amount of this metal is present in the ink.

To further confirm the presence of copper in the main text and to identify whether the metal is also present in the ink of the diacritical dots and the markers, we carried out area scans focussing on several region of interests. In Fig. 5, the XRF spatial scans reveal the presence of copper impurities in the ink of the main text as well as in that of the diacritical dots, suggesting that the same ink was used.

Fig. 7 Image of P. Hamb. Arab. 68.7r (top) indicating the area analysed; B/W image of the analysed section (left), and XRF map (relative intensity) of copper (right), using M6 Jetstream (Bruker nano Gmbh).

No copper presence was observed in the inked area corresponding to the decoration marking the end of the Sura, indicating the use of a different ink (Fig. 6). The traces of copper that are visible in the XRF map clearly follow a different layout and in fact correspond to the writing lines from the recto side of the fragment. The evaluation of the ink used for the verse dividers was complicated by a combination of factors – the small size of the strokes, the interference of the writing from the opposite side, and the low signal of copper and, although the map of copper does not seem to follow the pattern of the verse dividers, the analysis is still inconclusive (Fig. 7).

V. CONCLUSIONS

At least two different carbon-based ink were used in the production of this manuscript. Traces of copper were detected in the main texts and diacritical dots, while a pure carbon ink was used for the decoration marking the end of the Sura and perhaps also the verses dividers. This indicates that the quire was likely penned in two stages, with the writing of the text followed by the apposition of the decorative elements. The weak signals corresponding to the presence of copper in the ink suggest an accidental contamination rather than an intentional addition of copper-based precursors to the ink. Its source can be attributed to either the use of a copper or bronze inkwell or to the presence of copper ions in the water used to prepare the ink. The use of papyrus and carbon-based inks is rather unusual for a Qur'ānic excerpt; early Qur'ānic fragments are normally written in iron-gall ink on parchment [18]–[20]. Furthermore, the evidence obtained from the recent investigations on Greek and Coptic manuscripts from fourth to eighth century CE Egypt suggests the predominant use of carbon-based inks for the production of documentary texts [12], [21], [22]. Therefore, it is possible that this choice was motivated by a difference in the production context, in the continuation of the former tradition. The results from this study are part of a broader project on the use of inks and writing supports on manuscripts from the early Islamic centuries carried out at the Centre for the Study of Manuscript Cultures.

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