DETECTING EARLY MEDIAEVAL COPTIC LITERATURE IN DAYR AL-ANBĀ MAQĀR, BETWEEN TEXTUAL CONSERVATION AND LITERARY REARRANGEMENT: THE CASE OF *VAT. COPT.* 57

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ABBREVIATIONS

The following abbreviations are used in this volume:

BAM Bundesanstalt für Materialforschung und -prüfung (Berlin)

CC *Clavis Coptica*
Unique identifier attributed to each work (or better textual unit) by the CMCL project (see below)

CLM Coptic Literary Manuscript
Unique identifier attributed to each literary codicological unit by the PAThs project (see below)

CMCL Corpus dei Manoscritti Copti Letterati
Project on Coptic Literature created and directed by Tito Orlandi [www.cmcl.it]

CPG *Clavis Patrum Graecorum*
Mauritius Geerard, *Clavis Patrum Graecorum*, Volumes 1-6 (Turnhout: Brepols, 1974-1998).

MACA *Siglum* attributed by the CMCL project to the virtually reconstructed codices from Dayr al-Anbā Maqār, Wādī al-Naṭrūn
Each MACA *siglum* is followed by two letters (ex.: MACA.AC corresponds to the whole *Vat. copt.* 57 that is dealt with in this volume)

MONB *Siglum* attributed by the CMCL project to the virtually reconstructed codices from the White Monastery, Atripe

PAThs Tracking Papyrus and Parchment Paths: An Archaeological Atlas of Coptic Literature. Literary Texts in their Geographical Context. Production, Copying, Usage, Dissemination and Storage
Project funded by the European Research Council, Programme Horizon 2020, ERC Advanced Grant 2015 (no. 687567), based at Sapienza University of Rome, and directed by Paola Buzi [paths.uniroma1.it]

TEA GHIGO, IRA RABIN

ARCHAEOMETRIC STUDY OF INKS FROM COPTIC MANUSCRIPTS IN THE COLLECTION OF THE APOSTOLIC VATICAN LIBRARY*

The frame of the project on Coptic inks

While studying the socio-geographic history of inks, the division 4.5 of the BAM (Bundesanstalt für Materialforschung und Prüfung),[1] dedicated to the study of cultural material, together with the Centre for the Study of Manuscript Cultures in Hamburg[2] concluded that the continuous production of Coptic manuscripts from late Antiquity to the Middle Ages offers a unique opportunity for the historical study of the ink in a large geographic area. Thanks to the collaboration with the ERC project "PAThs" (www.paths.uniroma1.it), based at the Sapienza University of Rome, and within the activities of a joint PhD project between the University of Hamburg and the Sapienza University of Rome, we therefore created a new branch of our project focused entirely on the analysis of Coptic inks, pigments, and dyes.[3] This pioneering systematic study of writing materials coming from a specific area and time frame (4th-12th century) aims not only at a better understanding of the complex Christian Egyptian multicultural and plurilingual society, but also and mainly at clarifying the links among the Coptic and other manuscript cultures between the ancient and medieval eras. Finally, it will cast light on the history of the technological development of inks in the eastern world, from Antiquity to the Middle ages.

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* The research presented in this article was carried out at the SFB 950 "Manuskriptkulturen in Asien, Afrika un Europa", funded by the German Research Foundation (Deutsche Forschungsgemeinschaft, DFG) and within the scope of the Centre for the Study of Manuscript Cultures (CSMC), in collaboration with the ERC Advanced Grant Project "PAThs" – "Tracking Papyrus and Parchment Paths: An Archaeological Atlas of Coptic Literature. Literary Texts in their Geographical Context: Production, Copying, Usage, Dissemination and Storage" (project no. 687567) of "Sapienza" University of Rome. Our special thanks go to the staff of the Apostolic Vatican Library who permitted our access and supported our work.

[1] [www.bam.de].

[2] [https://www.manuscript-cultures.uni-hamburg.de/index_e.html].

[3] T. Ghigo – O. Bonnerot – P. Buzi – M. Krutzsch – O. Hahn – I. Rabin, *An attempt at a systematic study of inks from Coptic manuscripts*, in *Manuscripts Cultures* 11 (2018), pp. 157-164.

The analytical protocol

Our protocol for ink analysis consists of a primary screening to determine the type of the ink and a subsequent in-depth analysis using several spectroscopic techniques.

The primary screening is carried out by means of near-infrared reflectography. This technique allows distinguishing between carbon ink, which stays black even at longer wavelengths (above 1200 nm), iron-gall ink that becomes transparent above 1200 nm and plant ink which becomes transparent at ca. 750 nm. To perform this analysis, we use Dino-Lite, a small USB microscope equipped with three different lights: NIR (940 nm), UV (390 nm) and an external white light source. Working at 940 nm we can determine the ink typology observing the changes in its opacity. At this wavelength carbon-based inks show no change in their opacity, while the opacity of iron-gall inks changes considerably, and plant inks become totally transparent. The in-depth analysis is carried out mainly using micro X-ray fluorescence. This technique detects any chemical element heavier than sodium contained in the inks. In the case of carbon and plant inks it allows the identification of any contaminant or any other element added to the pure ink. In the case of iron-gall inks micro X-ray fluorescence (XRF) is used to establish their fingerprints, meaning the relative composition of the metal salts used to produce the ink.[4] Finally, in specific cases that may require more insight and further investigation, Raman and Fourier Transformed Infrared spectroscopies (FTIR) are performed to collect information on the chemical composition of the inks and binders, while Fibre Optic Reflectance Spectroscopy (FORS) is applied to identify colorants and coloured pigments.

Results

Thanks to the support and permission from the Apostolic Vatican Library, we examined 31 parchment leaves now bounded in 5 different modern volumes. We also examined 4 papyrus leaves from *Pap. vat. copt.* 9. Given to time and logistical reasons not all the analytical techniques mentioned in the previous paragraph were applied to all the examined leaves. The table below describes the analysis performed on each leaf.

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[4] O. HAHN – W. MALZER – B. KANNGIESSER – B. BECKOFF, *Characterization of iron-gall inks in historical manuscripts and music compositions using x-ray fluorescence spectrometry*, in *X-ray Spectrometry* 33 (2004), pp. 234-239.

Shelfmark	Leaves	Micro-NIR reflectography	XRF	FORS
Vat. copt. 1	1r	X	X	
Vat. copt. 1	31v	X	X	
Vat. copt. 1	65v	X	X	
Vat. copt. 1	66r		X	X
Vat. copt. 1	97v		X	X
Vat. copt. 1	157r	X	X	
Vat. copt. 1	166r	X	X	
Vat. copt. 1	225r	X	X	
Vat. copt. 1	225v	X	X	
Vat. copt. 57	1r	X	X	X
Vat. copt. 57	16r	X	X	
Vat. copt. 57	74r	X	X	
Vat. copt. 57	179r	X	X	X
Vat. copt. 57	184r	X	X	
Vat. copt. 57	230v	X	X	
Vat. copt. 57	256v	X	X	
Vat. copt. 58	10r		X	X
Vat. copt. 58	123r	X	X	X
Vat. copt. 58	132r	X	X	
Vat. copt. 58	138v	X	X	
Vat. copt. 58	150v	X	X	
Vat. copt. 68	5r	X	X	
Vat. copt. 68	15v	X	X	
Vat. copt. 68	16r		X	X
Vat. copt. 68	30r		X	X
Vat. copt. 68	33r		X	X
Borg. copt. 109, fasc. 141	9r	X	X	
Pap. vat. copt. 9	Glass 39	X		
Pap.vat.copt. 9	Glass 45	X		

Of the 31 examined leaves, 26 were produced in the Monastery of St. Macarius in the region of Wādī al-Naṭrūn. All the leaves coming from this monastery showed a quite homogeneous original nucleus, written using an iron-gall ink. This ink appears to be very similar in all the leaves examined since it contained mainly iron and only some traces of other metals such as copper and zinc. Considering that the amount of copper and zinc in an iron-gall ink can sometimes be very consistent depending on the composition of the salts employed in the ink making process (we found cases of iron gall ink containing 25% copper or 10% zinc), we can say that the original nucleus of the examined leaves was written with an ink manufactured using vitriol salt that contained only small amounts of metals other than iron (around 1-2%).

Iron-gall ink is, however, not the only type of ink that we found on these leaves. Evidence of later marginal notes and retracing made with carbon ink and mixed ink was found on *Vat. copt. 57*, f. 256v, *Vat. copt.* 58, f. 123r, *Vat. copt.* 1, ff. 65v and 157r. Mixed ink is a peculiar type of ink known to us through the ink recipes from the islamicate world that has often attracted little scholarly attention. A recent article casted new light on this type of ink stressing the need for an analytical procedure for unequivocal identification of it.[5] Unfortunately, the protocol we generally employ for the ink characterization isn't always sufficient in the case of inks containing both carbon and plant ink with or without the addition of metallic elements such as iron. Considering that for the time being the only written evidence we have on mixed inks comes from the islamicate world, the presence of mixed inks on Coptic manuscripts is a topic that deserves further attention. Mixed inks may offer a good opportunity to study the cultural interactions between the Egyptian and Arabic written traditions.

Another remarkable finding during the study of the collection from the Apostolic Vatican Library regards the 4 papyrus leaves that were examined (shelfmark: *Pap. copt.* 9). The analysis revealed that the ink used for writing was once an iron-gall ink. Considering the early dating of these leaves (5th century CE) this finding confirms the existence of iron-gall ink way before the appearance of the first recipe for its production we have so far (Theophilus Presbiter, 12th century CE). Although relevant, this is not a surprising result, since the first analytical evidence we have on iron-gall ink is on a Book of Proverbs preserved at the Staatsbibliothek of Berlin and dating to the 4-5th century CE (*Ms. or. oct.* 987).

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[5] C. Colini – O. Hahn – O. Bonnerot – S. Steger – Z. Cohen – T. Ghigo – T. Christiansen – M. Bicchieri – P. Biocca – M. Krutzsch – I. Rabin, *The quest for the mixed inks*, in *Manuscripts Cultures* 11 (2018), pp. 41-46.

Among the leaves from the Monastery of St. Macarius, the case of those preserved under the shelfmark *Vat. copt.* 1 was remarkable, they were all part of the same codicological unit which presents various levels of stratification: an original nucleus palaeographically dated around the 10th century, some later leaves added whose script suggest a 13th-14th century dating, a marginal Arabic translation added on all the leaves of the codex whose palaeographical dating is not possible and some illuminations covering the whole early text on some of the leaves. The analysis of inks detected a difference in the composition of the metallic salts used to produce the ink of the main text of the original leaves, which contains mainly iron, and the ink on the main text of the added leaves, which contains iron and copper. This is a proof of the fact that the leaves come from a different writing phase. In an attempt to understand in which writing phase the Arabic translation was added, we compared its ink with the ink of the main text of original leaves and added leaves. Our results show that the ink used to write the Arabic translation contains both iron and copper and the ratio of latter to the former is in average higher than in the ink used to write the main text on the added leaves. This suggests that the Arabic translation belongs to a third writing place, which unfortunately cannot be placed in time. However, given the complexity of the structure of this codex, to confirm this outcome a thorough archaeometrical codicological study (i.e., based on the results from a greater number of analytical measurements) should be performed.

FORS and XRF were applied to identify pigments and colorants from the leaves of: *Vat. copt.* 1, *Vat. copt.* 57, *Vat. copt.* 58 and *Vat. copt.* 68. The identification was difficult since the pigments were often mixed together or overlapping. We identified different types of red pigments: red ochre, minium and cinnabar. Yellows were always identified as orpiment, and greens as malachite. Unfortunately, it was not possible to identify the organic blue pigment used to paint the mantle of the Virgin on *Vat. copt.* 1, f. 66r. All the pigments identified are coherent with the dating of the examined leaves, and they represent the typical medieval palette.

Archaeometric analysis on the Vat. copt. *57*

Our team has already many years of experience in handling unique and fragile samples for the purposes of instrumental analysis. In the specific case of *Vat. copt.* 57, during micro-NIR reflectography a piece of a Japanese paper was placed between the manuscripts and the USB microscope, to ensure no direct contact between the instrument and the page under investigation. This procedure limits the exposure of the fragile layers of

pigments and ink to physical stress. For XRF analysis the fragment must be mounted in such a way that the surface under investigation is as flat as possible. Given the large dimension of this codex, we first used foam pillows to secure it and keep it in place. Then we used small cardboard frames padded with disposable Japanese paper to delimit the spots of analysis. The frames were kept in place by light ceramic weights designed for this purpose. The exposed section was generally two-three centimeters wide.

We analyzed a total of 7 different leaves from *Vat. copt.* 57. We chose 6 spots per folio, 3 recto and 3 verso, making sure to have a good representation not only of the ink used to write the main text, but also of the inks used for the titles, the decorations, the colophon and the two different types of corrections that were possible to distinguish with the bare eye: corrections made with what now appears to be a brownish ink (visible on f. 16r) and corrections made with what appears now to be a much darker ink (f. 1r, Fig. 1).

Results showed that the original nucleus of the manuscript (the main text, the titles, the decorations, the colophons and the brownish corrections found on f. 16r) was written with iron-gall inks that display the same fingerprint, suggesting that this all belongs to a single writing phase. Given the difference in colour between these inks and the one used to write the corrections on f. 1r, one may think that a different kind of ink was used to make these corrections. However, archaeometric analysis didn't show any difference between the composition of the metallic salt of this much darker ink and of other inks used. This suggests that the ink used for the corrections on f. 1r belongs to a different writing phase, but it was written probably in the same place of production of the rest of the Codex. A difference can be seen in the content of potassium, being in the darker ink about three times higher than in the other inks. Potassium was contained in high percentage in the binder that were used to prepare the inks, as well as in the gallnuts. In this case it is likely that this ink was prepared using a different proportion of binders and gallnut water mixed with the same kind of vitriol. The present study, however, does not aim at a thorough understanding of the different writing phases of the examined leaves. To do so, a statistically sound study, i.e. investigation of a larger number of leaves is needed,[6] as it was performed in the case of the Codex Germanicus 6.[7] The study of the pigments revealed that the red used for the titles and part of

[6] I. Rabin – O. Hahn – M. Geissbühler, *Combining Codicology and X-Ray Spectrometry to unveil the history of production of Codex Germanicus 6 (Staats- und Universitätsbibliothek Hamburg)*, in *Manuscripts Cultures* 7 (2014), pp. 126-131.

[7] M. Geissbühler – I. Rabin – O. Hahn, *Advanced codicological studies of Cod. germ. 6: part 2*, in *Manuscripts Cultures* 11 (2018), pp. 133-139.

the text was in some parts retraced using a different pigment (it is clear on f. 1r). The original red used is an ochre, while the retrace is made with cinnabar, a mercury based red pigment. The yellow pigment was identified as orpiment, and the green as malachite. A final remark needs to be done on two marginal notes found on ff. 179r (in Arabic, Fig. 13), 74r (Fig. 5) and 256v (in Coptic, Fig. 17). The Coptic note on f. 256v was written using a carbon ink and it is different from the others. The notes on ff. 179r, 230v and 74r were instead written using iron-gall ink. However, while the ink of the Coptic note on f. 74r contains mostly iron and it is similar to the ink used to write the main text, the inks of the Arabic notes contain both iron and copper, suggesting that they were written in a different phase. Unfortunately, on the reason why different notes were written on the same codex with different inks we can only speculate. The results achieved so far with our project on Coptic inks do not allow to place in space and time an inscription based on the kind of ink it was written with. However, this may be possible in the future, once enough analytical data will be collected to trace a map of the technological evolution of writing inks.