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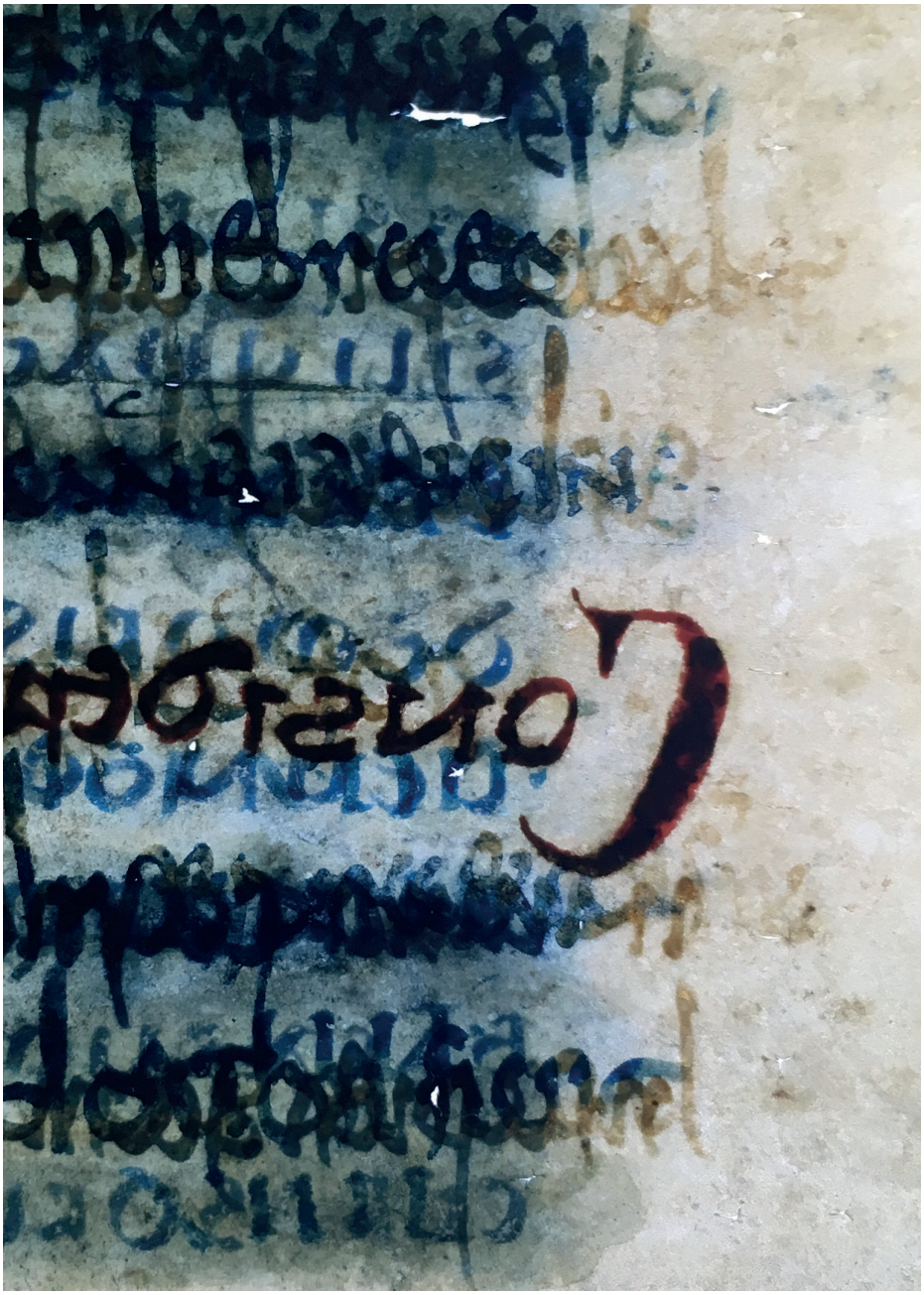

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Transmitted light image (detail) of Codex 3/1 (5th century Luxueil or 7th–8th century Italy), Benedictine Abbey St Paul in Lavant Valley, Austria. Hieronymus, *Commentarius in Ecclesiasten*; Plinius Secundus, *Historia naturalis*. Photography by Thomas Drechsler, Berlin.

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Article

The *Atri Fragment* Revisited I: Multispectral Imaging and Ink Identification*

Sebastian Bosch, Claudia Colini, Oliver Hahn, Andreas Janke, and Ivan Shevchuk | Hamburg

Abstract

This paper reports the outcome of an interdisciplinary team's application of multispectral imaging techniques and material analysis to a music fragment from the first decades of the fifteenth century: Atri, Archivio Capitolare, Museo della Basilica Cattedrale, Biblioteca del Capitolo della Cattedrale, Frammento 17. This important parchment leaf has rarely been investigated since its discovery 45 years ago. Thanks to the applied techniques and methods (such as the evaluation of the data using the fingerprint model), it is now possible to discuss new evidence supporting conclusions regarding the fragment's origin and afterlife.

The *Atri Fragment*

In 1973, Agostino Ziino reported the discovery of a music fragment from the first decades of the fifteenth century containing a copy of the well-known *Gloria Micinella* (Fig. 1) by the papal scribe and composer Antonio Zacara da Teramo (ca. 1360–1416).[1] This *Atri Fragment*[2] contains on its verso side the *ballata Be'llo sa Dio*, which recently could be attributed to the same Antonio (Fig. 2).[3] The secular text and the music of this *ballata* were (partially) transmitted and reworked in different contexts from the first decades of the fifteenth century until the end of the fifteenth century and even into the sixteenth century.[4] Unfortunately, not much more is known about this version of *Be'llo sa Dio*, since the verso side of the fragment suffered badly because bookbinders reused the parchment leaf at least two times.[5]

In this paper, a team consisting of scholars, scientists, conservators, and technicians revisits the *Atri Fragment*, applying state-of-the-art technology to recover the lost writing and to identify the inks used. This will lead to new insights on this important manuscript source from the beginning of the fifteenth century and allow further investigations.[6] This endeavour was made possible by the director of the Museum and Chapter Archive in Atri (Italy), Don Filippo Lanci, who gave permission to Francesco Zimei to carry this valuable object to the Centre for the Study of Manuscript Cultures in Hamburg for multispectral imaging and ink measurements during a two-day conference on *Liturgical Books and Music Manuscripts with Polyphonic Settings of the Mass in Medieval Europe*.[7] We thank Filippo Lanci and Francesco Zimei for the kind support that made this paper possible.

The fragment measures 24 × 30 cm and seems to already have been detached from its host volume by the time of its discovery.[8] Unfortunately, the host volume has yet to be found. There are not enough indicators that could help

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[1] Ziino 1973. The *Gloria* is not complete, since the conjoint parchment leaf and the rest of the fascicle are missing.

[2] Atri, Archivio Capitolare, Museo della Basilica Cattedrale, Biblioteca del Capitolo della Cattedrale, Frammento 17; *olim* Archivio Capitolare, Sala Innocenzo IV, Cartella A, frammento n. 5.

[3] Janke and Nádas 2015.

[4] Ziino 1973, 237–239; Fallows 1999, 504–505, 2010a, 15, and 2010b; Wilson 2009, 41–55; Janke and Nádas 2015, 209–211.

[5] One concordance is found in the *San Lorenzo Palimpsest* (Florence, Archivio del Capitolo di San Lorenzo, MS 2211), fol. CXXXV^{r}, but without the text, see No. 151 in Janke and Nádas 2016.

[6] A second article on this fragment is in preparation by Andreas Janke and Francesco Zimei: 'The *Atri Fragment* Revisited II', forthcoming in the series *Musica Mensurabilis*, 9.

[7] Organised by Oliver Huck and Andreas Janke.

[8] See Ziino 1973, 235.

determine with certainty the recto and verso side, but the margins are wider on the right of the hair side and on the left of the flesh side, thus supporting Ziino's interpretation. Therefore, the legible part, the hair side, is referred to as the recto side (Fig. 1) and the mostly illegible flesh side as the verso side (Fig. 2).

After removing it from its original codicological structure, the fragment was surely reused to protect a fascicle, as were the fragments that today are referred to as the *Lucca Codex* (Lucca, Archivio di Stato, Ms. 184; Perugia, Biblioteca Comunale 'Augusta', Ms. 3065).[9] The *Atri* parchment leaf was folded in half: the fold is still visible, although the fragment is now perfectly flat, since it was particularly damaged by water or humidity. There are traces of mechanical damage, although some of the holes are compatible with archival sewing.[10]

The flesh side is much more damaged than the hair side, indicating that the latter was probably in contact with the fascicle while the former was the external part of the protection. The thickness of the fold, the place and number of the sewing holes and the different levels of damage to the parchment suggest that the fragment was used to protect a small fascicle, possibly containing the index of an independent volume or of an archival series. The fact that the right portion of the flesh side is more damaged than the left portion reinforces the hypothesis of an independently bound fascicle, unlike some of the *Lucca Codex* fragments, which were also reused as fascicle protections but stored or even sewn inside the host volumes. The level of damage seen in *Atri* indicates that the fragment was kept in this state for a considerable amount of time.

It is likely that in a second stage the fragment was reused again, this time as a paste-down of a different volume. The fragment was unfolded, and the now more damaged side was glued to the new board, using a water-soluble paste, gelatine, or starch-based adhesive. During this procedure, the fragment was damp: this may have caused a transfer of some parts and particles of the inks to the board (on the side in contact with the new binding), but also the washout of the more mobile ions from the ink strokes and their dispersion through the parchment's surface (on both sides). This reuse hypothesis is supported by the presence of a small round green stain in the margin of the verso, at the end of the 5th system (Fig. 2), possibly caused by the corrosion of a nail used to attach a fastening component. Another round mark, although larger and characterised only by a darker shade of the parchment, can be seen in the bottom corner of the same margin – it might also have been caused by a nail, in this case attaching a studded corner. Moreover, a group of woodworm holes is visible on the same margin (at the end of the 4th system), but none of the holes is present on the left margin. This indicates that they were most likely created when the fragment was unfolded. Since the majority of woodworm species prefer cellulosic material, it is unlikely that this damage was done while the fragment was part of its original parchment manuscript, but it is probable that the infestation was in the paper leaves or the wooden board of the second host volume.

More recently, the fragment underwent a conservation treatment. The detachment was probably done by humidifying the parchment so that the moistened glue softened, making the removal of the parchment more effective and less harmful to the support. It is possible that what was not damaged during the positioning of the paste-down was damaged during the removal, causing the partial transfer of the inks to the board, the abrasions on the parchment and the displacement of some of the movable ions from the inks to the support. The wet parchment was probably flattened after detachment while drying, since no wrinkle or wave can be seen, not even in the location of the middle fold.

Multispectral Imaging

Although Multispectral Imaging (MSI) is an established method for the recovery of lost writing, it is only in recent years that MSI has been applied successfully to different kinds of damaged music manuscripts, among them the *San Lorenzo Palimpsest*[11] and the *Rostocker Liederbuch*[12] – all work carried out by scholars and scientists connected to or collaborating with the Hamburg Centre for the Study of Manuscript Cultures.

[9] See the description of the 'vacchette' in Nádas and Ziino 1990, 15–16.

[10] See in particular in Fig. 1 the four small holes visible in the middle of the fold: first, above the 1st system; second, on the 4th stave line below the minima of the 2nd system; third, below the 5th system, but above the text (letter 'l' of 'altissimus'); fourth, on the 5th stave line of the 7th system. On the term 'archival sewing', see Szirmai 1999, 301, and 303, Fig. 10.15.a.

[11] Florence, Archivio del Capitolo di San Lorenzo, Ms. 2211, see Janke and MacDonald 2014, and more recently Janke and Nadas 2016.

[12] Rostock, Universitätsbibliothek, Mss. philol. 100/2. See *Digitales Archiv zum Rostocker Liederbuch (DARL)* <http://www.rostocker-liederbuch.de>. Ivan Shevchuk and Franz-Joseph Holznagel are preparing an article about the imaging process.

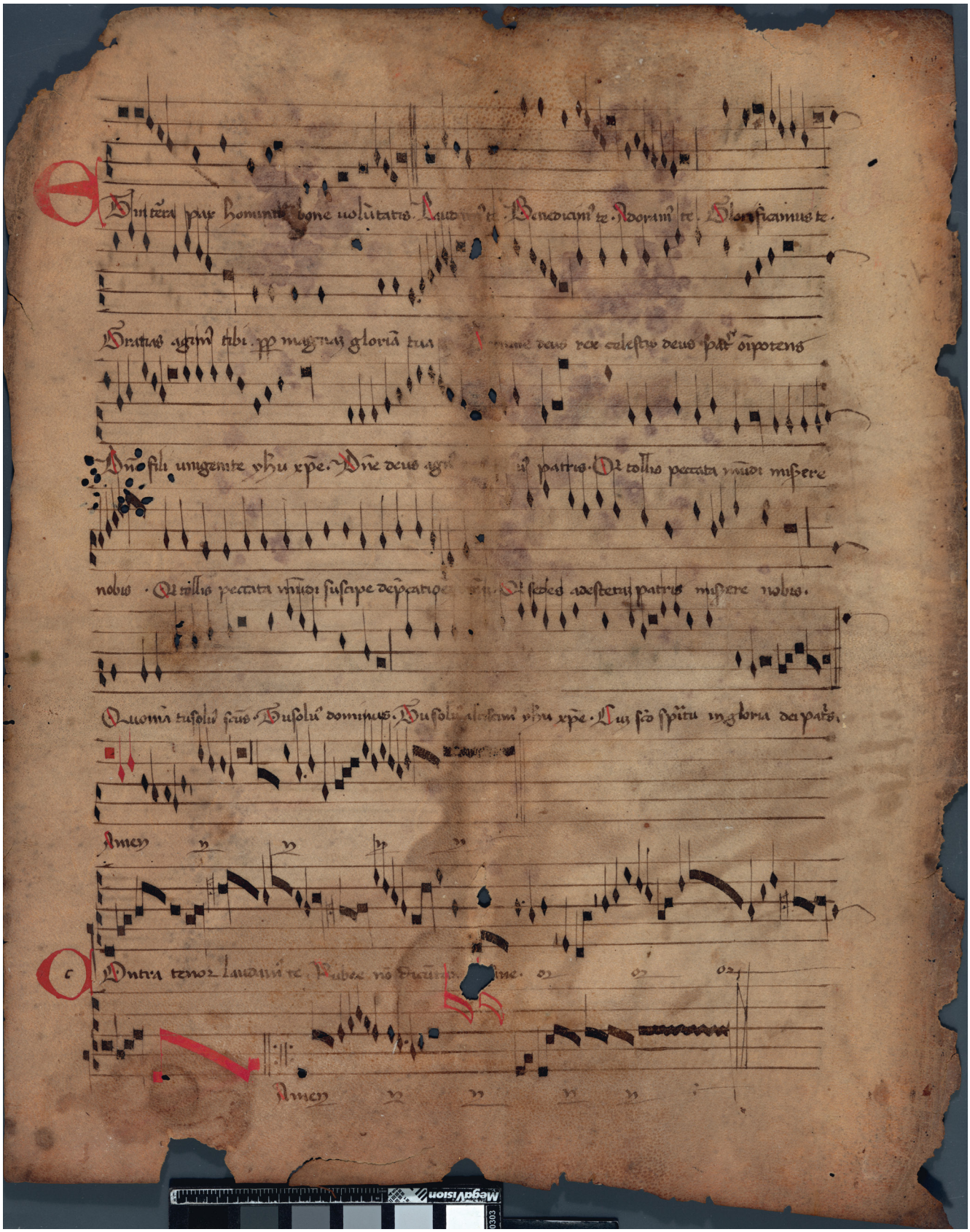

Fig. 1: *Atri Fragment*, recto.

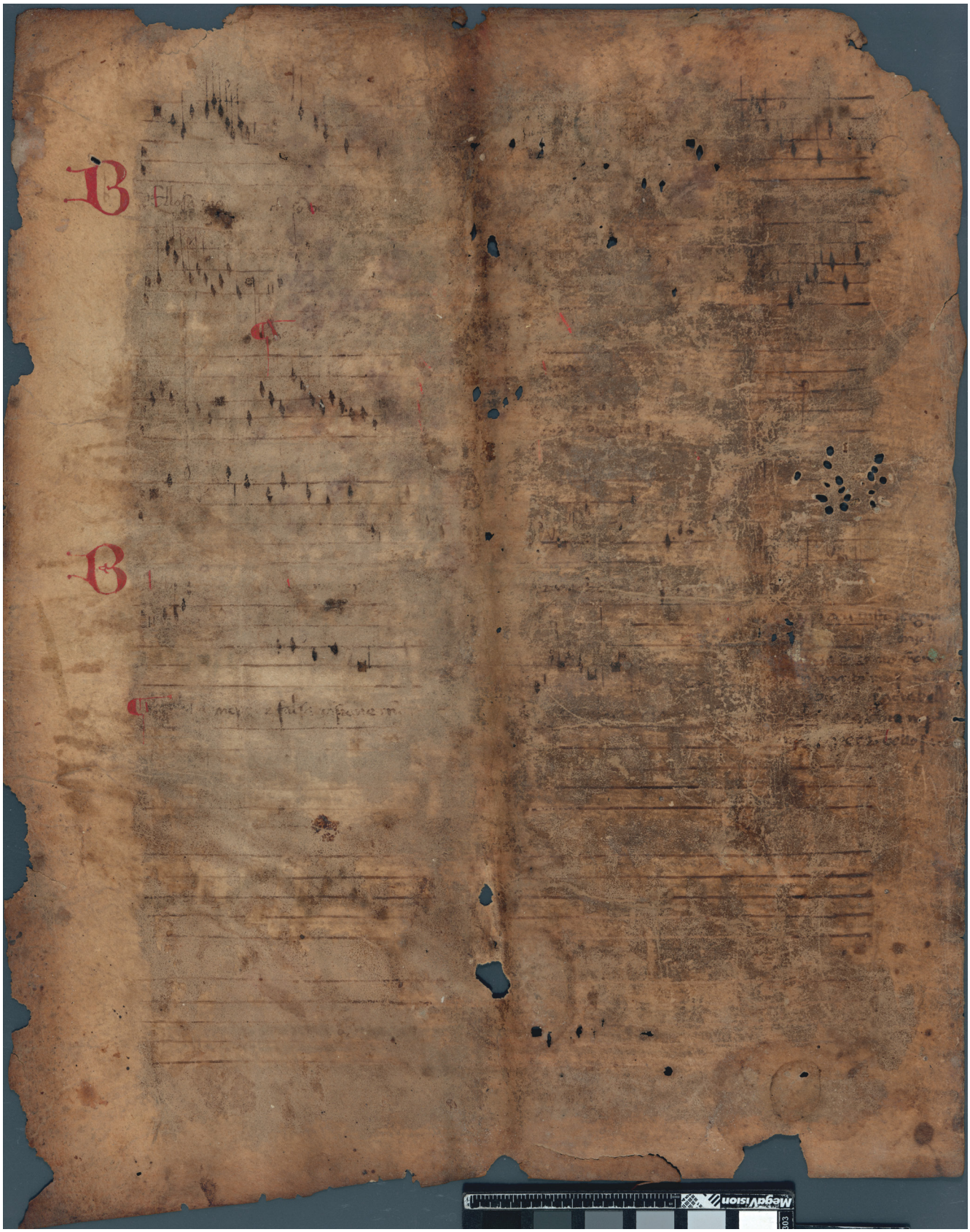

Fig. 2: *Atri Fragment*, verso.

Fig. 3: *Atri Fragment*, verso, processed image.

The general camera setup and processing methods have already been described in detail,[13] but in 2016 our MSI camera system was upgraded. Key hardware improvements include the use of more powerful LED light sources, with additional wavelengths in the ultraviolet and visible range, and a transmissive light sheet. In total, the number of images taken during a single sequence was increased from around 24 to 50 images. The illumination range of the imaging setup (365–1050 nm) has not been changed. A new Orange filter[14] was added to the filter wheel; it supresses shorter wavelengths below 550 nm and lets the longer wavelengths through. This filter has proven to be especially useful for the recovery of iron gall inks. Fluorescence images taken with the Orange and Red filter[15] using short wavelengths in the region of 365–450 nm provided most of the useful information for the recovery of *Be'llo sa Dio*.

The image processing was performed in two steps: First, feature extraction, using statistical analysis techniques, was performed in ENVI 5.3 Classic by extracting independent and principal components of the fragment. Second, the contrast between the writing, extracted during statistical processing, and the background was increased to further improve overall legibility and appearance in GIMP 2.8.22. For statistical processing, the 50 greyscale images were divided into four different types: reflectance (20), fluorescence (22), raking (4) and transmissive (4), and each was statistically processed separately. Images of each type were combined into 3D Arrays (cubes). Standard image-processing algorithms, such as Independent Component Analysis (ICA) and Principal Component Analysis (PCA), were applied to the pre-processed image cubes. After statistical processing, a pseudocolour image was created from the bands that held the best information. The result can be seen in Fig. 3.

Compared with the verso side seen with the naked eye (Fig. 2), the pseudocolour image reveals significantly more of the music and text. This is especially true for the void notational signs, which by their nature disappear quickly when the surface of a manuscript is damaged. Further, we can now recognize two text *residua*,[16] which allow us to understand the text and its transmission in a much clearer way.[17] Particularly interesting is the *custos*[18] at the end of system one. In the pseudocolour image, it is rendered more legible; moreover, we can also see *custodes* in systems two and four. All three of them resemble the *custodes* used on the recto side. This is usually an indication that both musical settings were written by the same scribe. However, a closer look reveals slight differences in the shapes of the note signs between the recto and verso side, which could contradict the hypothesis of a single scribe. We will return to this question after having discussed the ink measurements.

On the recto side, remnants of red ink can barely be seen in the top margin (Fig. 1).[19] In music manuscripts from the beginning of the fifteenth century, this is usually the space used for providing composer attributions (if intended by the compiler). In this case, the name of the composer of the *Gloria* – Antonio Zacara da Teramo – is already known due to concordances of the *Gloria* that appear in other manuscript sources.[20] One of these provides an attribution: 'Z. Micinella', which refers to Antonio Zacara da Teramo. Since the residue red ink does not block the underlying parchment from fluorescing, as there are no fluorescence blockers such as tannins, it is difficult to recover the text using the fluorescence images. However, the outline of what had been the attribution can be partially recovered using ICA on reflectance images and appears in black in Fig. 4.

Unfortunately, due to the properties of the red ink and the damage to the fragment, the composer's name could not be recovered in a way that allows one to read at least parts of it. However, it is now possible to understand that originally a quite extensive attribution (ca. 66 mm) was entered on the

[13] Janke and MacDonald 2014; Janke and Nádas 2016, vol. I, 9–15.

[14] Wratten O22 Deep Orange Longpass filter.

[15] Wratten R25.

[16] Usually the refrain and the first stanza are written below the musical notation. A text *residuum* contains additional stanzas of the poem and is written down in a single text block wherever on the page or the opening space was available.

[17] The text will be discussed in Janke and Zimei (forthcoming).

[18] The sign placed at the end of a system to denote the pitch of the first note in the following system.

[19] The verso side also shows some remnants of red, but not in the correct position for an attribution.

[20] The *Gloria* is found in five other sources: Bologna, Civico Museo bibliografico musicale, Ms. Q 1, recto; Bologna, Civico Museo bibliografico musicale, Ms. Q 15, fols 16^{v}–17^{r}; Bologna, Biblioteca Universitaria, Ms. 2216, fol. 4^{v}; Grottaferrata, Biblioteca dell'Abbazia di S. Nilo, Ms. segn. provv. Kript. Lat. 224, fol. 4^{v}; London, British Library, Add, Ms. 82959, verso.

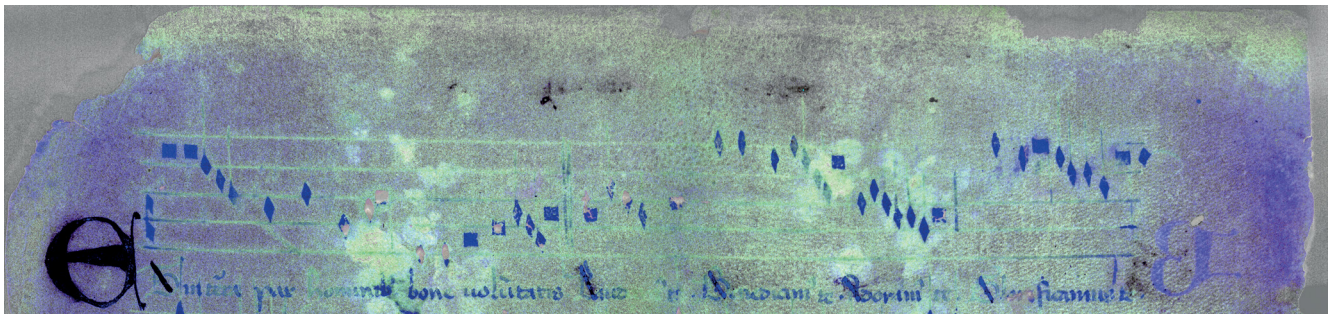

Fig. 4: *Atri Fragment*, recto, processed detail.

recto folio. It is quite possible that the attribution included not only a name, but also toponymic information such as 'Teramo' or other descriptors like 'Micinella'.[21]

Ink measurements

In the field of manuscript studies, the application of analytical techniques can provide valuable information about the material composition of artifacts and is thus capable of answering still unresolved questions about the history of manuscripts. However, dealing with such precious objects requires careful handling and non-invasive methods. In combining fast, precise and non-destructive data acquisition, X-ray Fluorescence Spectroscopy (XRF) has been established as a powerful tool in identifying inorganic compounds in inks and colourants used for writing and decorating manuscripts.[22] Here, we can demonstrate the potential of XRF analysis applied to the determination of the inks (black[23] and red) used in the *Atri Fragment*. The XRF results of the red ink are further supported by additional measurements with visible spectrophotometry – another non-destructive method for the identification of colourants based on their properties in reflecting visible light. Additionally, we will point out some limitations of the applied analytical methods and comment on the exact analytical protocol, which had to be adapted in a specific way in order to collect reliable data in a limited period of time.[24]

The XRF analysis was carried out with the energy dispersive micro-X-ray spectrometer ELIO,[25] which consists of an air-cooled, low-power rhodium tube (40 kV, 20 µA) as excitation source, a large-area silicon drift detector (SDD, 25 mm^2) and a microscope camera for easy object positioning. The excitation X-ray beam is collimated to a 1.2 mm spot diameter on the sample surface, which also offers the possibility of precisely analysing very small ink areas. Recorded XRF spectra were evaluated with the ArtTAX software[26] and finally presented here, making use of the fingerprint model.[27]

The red ink in the *Atri Fragment* was further examined with the colour spectrometer eXact[28] in order to measure the reflection of visible light (380–730 nm) from coloured materials such as dyes and pigments. The measuring spot is 1 mm in diameter and illuminates the object at an angle of 45° for less than a second using a small 2 W light bulb. The reflected light from the object's surface is recorded in a resulting reflectance spectrum, which can be compared with a reference in order to identify the specific colourant.[29]

[21] There are around forty known attributions that refer to Antonio Zacara da Teramo. These are discussed and listed in Nádas 1986, 172–174. See also the catalogue of works by this composer in Zimei 2004, 391–419: 400–401 and Janke and Nádas 2015, 201–202. One cannot rule out the possibility that the missing verso side of this opening, which once contained all voices of Antonio's *Gloria*, also contained parts of the attribution. On another erased (and this time overwritten) attribution by Antonio Zacara da Teramo, on fol. 55^r in the *Lucca Codex*, see Calvia 2017, 46–52.

[22] See for example Hahn et al. 2005.

[23] This refers also to inks that today appear to be brown.

[24] The fragment had to be imaged and measured within only two days.

[25] XGLab S. R. L., Italy.

[26] Bruker Nano GmbH, Germany.

[27] Hahn 2010.

[28] X-rite GmbH, Germany.

[29] Fuchs and Oltrogge 1994.

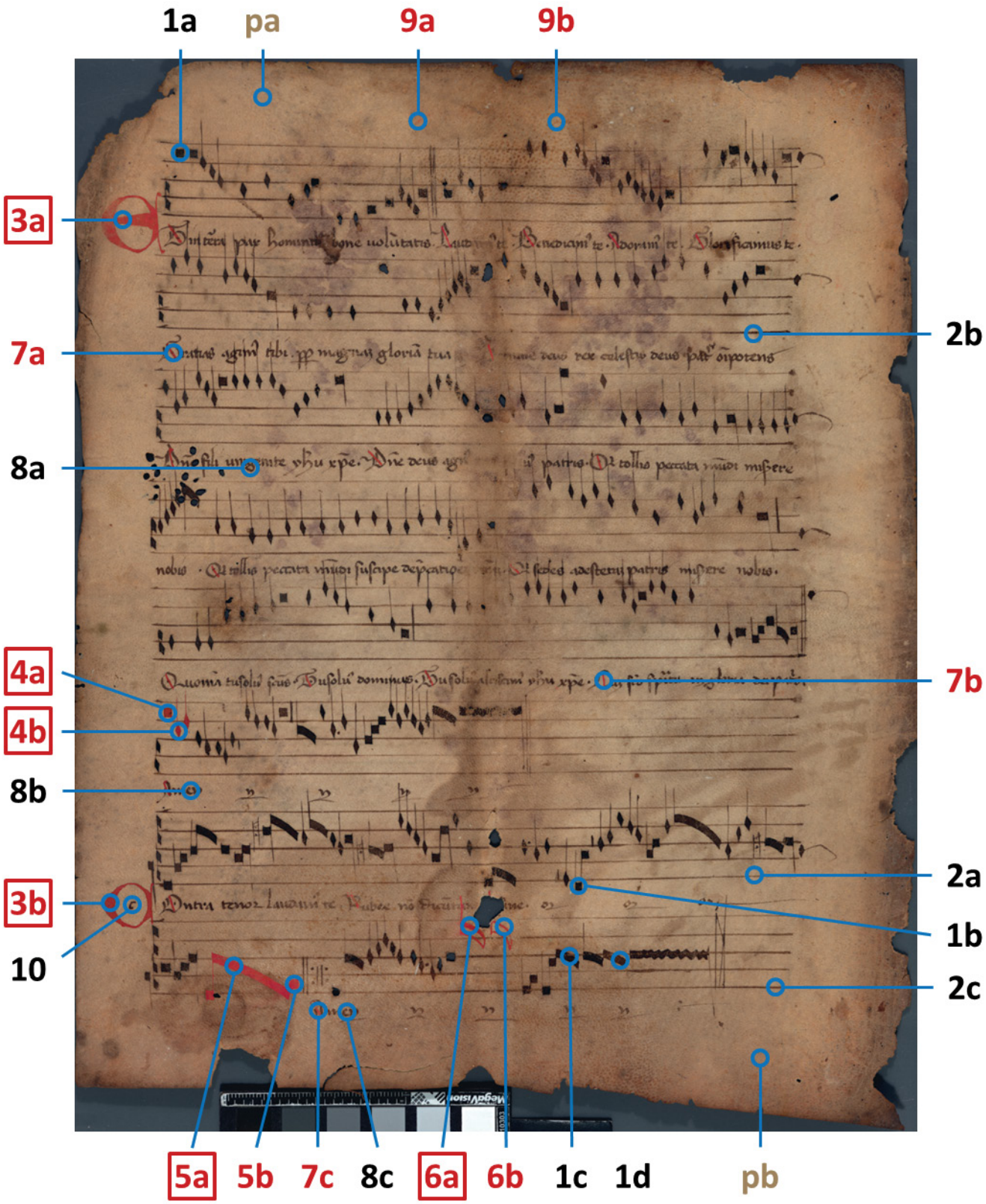

Fig. 5: Measured spots on the recto side of *Atri Fragment*. The black, brown and red numbering corresponds to XRF measurements. Numbers with a red frame indicate additional reflectance measurements by spectrophotometry.

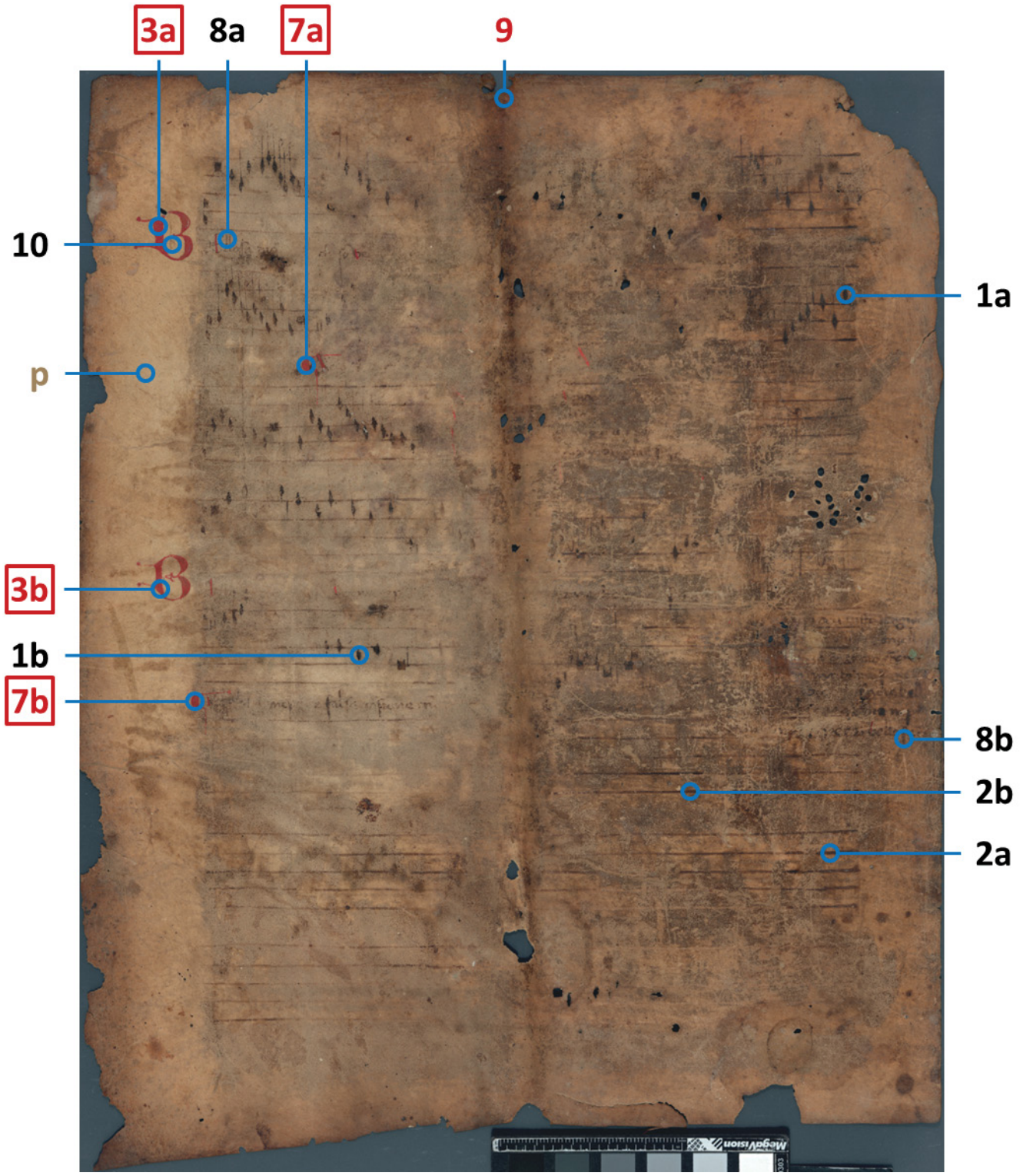

Fig. 6: Measured spots on the verso side of *Atri Fragment*. The black, brown and red numbering corresponds to XRF measurements. Numbers with a red frame indicate additional reflectance measurements by spectrophotometry.

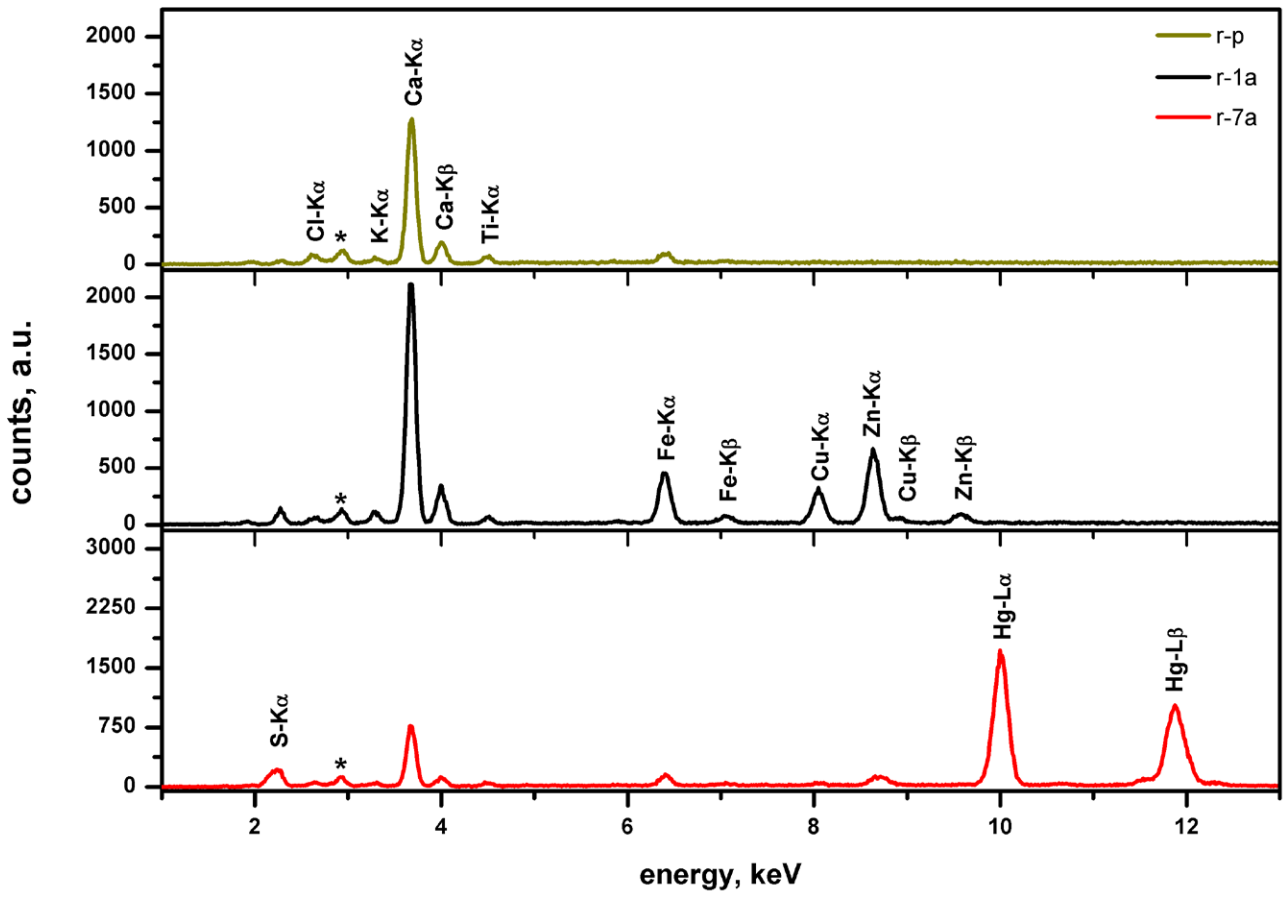

Fig. 7: Raw XRF spectra of parchment (r-p), iron gall ink (r-1a) and cinnabar (r-7a). The asterisk (*) labels the Kα peak of Argon (Ar-Kα) present in the air.

Figures 5 and 6 show the measuring points on both sides of the *Atri* leaf, where we recorded reliable data via XRF (black, brown and red numbering) and spectrophotometry (red frame).[30] The areas of interest for black inks are thereby:

- musical notation: r-1a, r-1b, r-1c, r-1d, v-1a, v-1b
- stave lines: r-2a, r-2b, r-2c, v-2a, v-2b
- text underlay[31] and text *residuum*: r-8a, r-8b, r-8c, v-8a, v-8b
- guide letters: r-10, v-10

The areas of interest for red inks are:

- initials: r-3a, r-3b, v-3a, v-3b
- red notation: r-4a, r-4b, r-5a, r-5b, r-6a, r-6b
- highlights: r-7a, r-7b, r-7c, v-7a, v-7b
- residues on top of page: r-9a, r-9b, v-9

And, finally, we measured some reference spots from the parchment (r-pa, r-pb, v-p). It is important to point out some limitations in the XRF analysis of manuscripts, especially when using the semi-quantitative fingerprint model.[32] Due to the high penetration depth of X-rays, detected signals are always the sums of emitted X-rays from the surface materials of interest and all underlying parts, such as the writing support and the materials from the rear side of the folio. For that reason, it is necessary to exclude these interfering signals by selecting the right analytical protocol, which will be described in the following.

Rear-side effects can be minimised by predefining the most promising measuring points prior to the actual measurements. These areas are certainly limited in the case of parchment leaves, which have writing on both sides. Suitable spots must be identified by shining white light through the folio in order to discern the writing from the rear side. This was particularly challenging in the case of the *Atri Fragment*,

[30] The letters 'r' and 'v' stand for recto and verso.

[31] This term denotes the poem's text written below the musical notation.

[32] The fingerprint model is described in detail below.

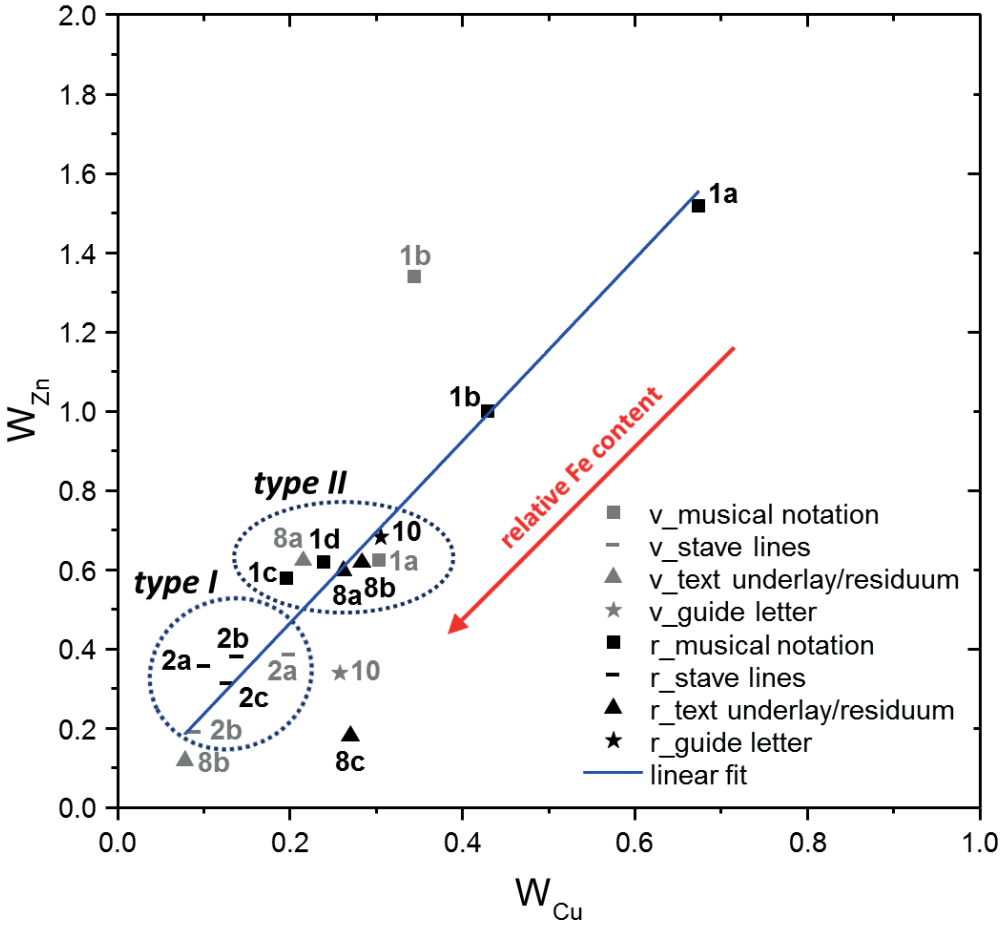

Fig. 8: Evaluated XRF data for all measured black spots without the subtraction of parchment using the fingerprint model. The composition fingerprint of zinc (W_{Zn}) as a function of the fingerprint of copper (W_{Cu}) leads to the clustering of two different ink types determined for the *Atri Fragment*.

due to its poor physical condition. Nonetheless, we managed to collect XRF data of 39 spots in total (Figs 5 and 6).

Some measurements were also taken from the parchment itself, since this data is usually used as a reference to exclude the influence of the writing support by simply subtracting integrated XRF signal intensities. However, in the present case we were faced with some difficulties in applying this procedure for the differentiation of the black iron gall inks (Fig. 7). These inks are mainly composed of iron (Fe), which could be also detected in reasonable amounts in the reference spectra of the pure parchment. Indeed, iron might be part of the parchment itself, but it is very likely that the possible water damage flushed out a class of ions from the inks, which then were randomly distributed throughout the fragment. Furthermore, at some measuring points only small amounts of ink material remained, causing rather low signal intensities and thus resulting in higher error rates when subtracting the parchment signals. Despite all these limitations, we were able to identify two types of iron gall ink (types I and II) by applying the fingerprint model to the raw data without parchment subtraction (Fig. 8).

Inorganic contaminants, such as copper (Cu) and zinc (Zn), that are present in the iron gall inks provide a basis for the characterization. Further discrimination is possible with the 'fingerprint'. For a certain minor constituent 'i' (such as Cu and Zn), a characteristic value, 'W_i' can be specified. The fingerprint method relies on the determination of specific elemental compositions in samples. These kinds of investigations are well-established methods for provenance and dating studies of glass objects,[33] as well as for the chronological classification of alloys.[34] The present XRF measurements for the iron gall inks were quantified using the composition fingerprint model, which is based on fundamental parameter procedures leading to the value W_i

[33] Hoffmann et al. 2000.

[34] Rye 1993.

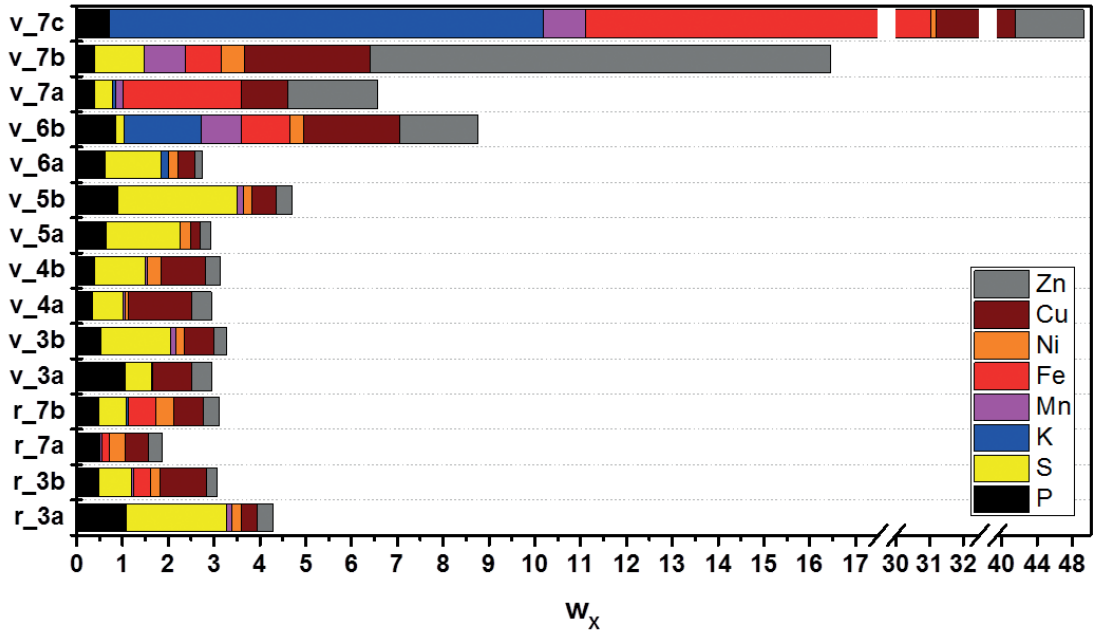

Fig. 9: Evaluated XRF data for all measured red spots depicted in a bar graph representation of trace elements (W_X in percentage) relative to mercury (Hg). Here, the amount of these trace elements is shown as a percentage of the amount of Hg, which is the main element in cinnabar (see Fig. 7).

(relative amount of weight concentration of the element i relative to Fe). The composition fingerprint value W_i involves mainly three different parameters: the experimentally determined transmittance of the entire layered system, the penetration depth of the writing material into the writing support and a normalized absorption coefficient taking into account the matrix composition. The respective calculations are based on a model ink containing a certain amount of iron sulphate as a constant parameter. Small variations of any other parameters do not crucially affect the value of W_i. Determination of such a 'fingerprint' – i.e. the amount of a minor metal component relative to the main compound iron – allows the characterization of different inks even in the absence of absolute quantification.[35]

The evaluated results of the examination of iron gall inks used in the *Atri Fragment* clearly demonstrate a clustering effect of different composition fingerprint values (W_i) for the trace elements copper (W_{Cu}) and zinc (W_{Zn}). Whereas the lines of the staves (ink type I) contain low amounts of copper and zinc, the musical notation and text underlay/*residuum* (ink type II) display a significantly higher amount of these trace elements. This compositional difference finally revealed the presence of two different ink types used for the production of this manuscript. Besides this clear result, some measured spots do not belong to these ink clusters, which can be explained by effects such as the random distribution of washed-out ions and/or the small amount of ink material remaining in these specific positions. However, considering the relatively large number of analysed spots, these outliers can be neglected in the present case.

As depicted by the fitting line in Fig. 8, another interesting result – the constant ratio of the copper and zinc fingerprint values ($2W_{Zn} = W_{Cu}$) – indicates that both ink types were produced with the same sort of vitriol. As one of the main ingredients in historical iron gall inks, the vitriol (mostly a mixture of $FeSO_4$, $CuSO_4$ and $ZnSO_4$) predefines an ink's elemental ratio between iron and trace metals such as copper and zinc. Thus, the two ink types determined in the *Atri Fragment* differ mainly in their relative amount of iron. Since the same vitriol was used for both ink types, we conclude that the manuscript's severe exposure to water lowered the iron content in ink type II. This can be explained by the different amounts of formerly used gallic acids in the ink recipes. The low amount of gallic acid in ink type II thereby led to the formation of fewer ferrous gallate complexes that afterwards were oxidised to the hardly water-soluble ferric pyrogallate

[35] Hahn et al. 2004; Malzer et al. 2004

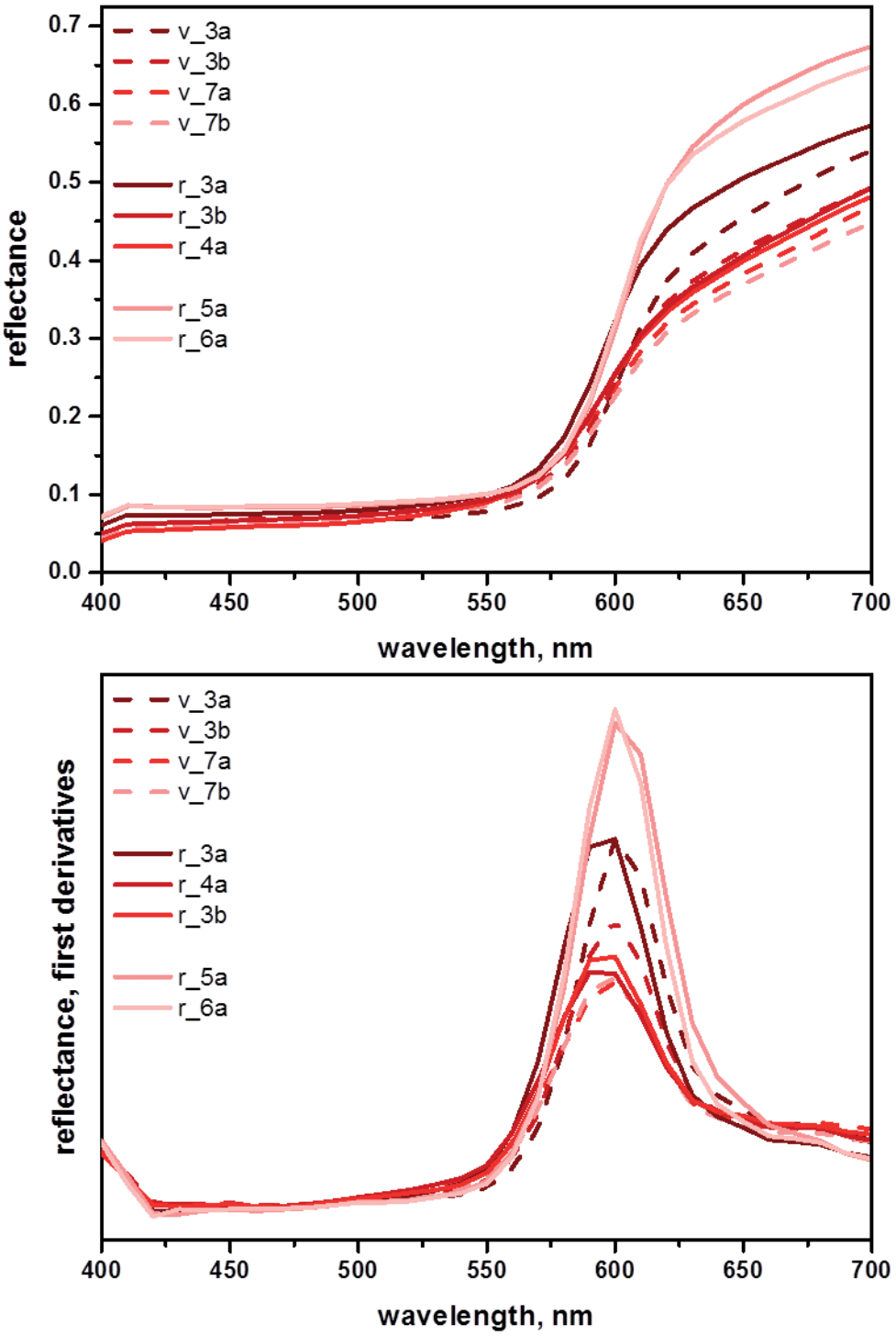

Fig. 10: Reflectance spectra of the red spots and their corresponding first derivatives, showing all inflection points at 600 nm, which is characteristic for cinnabar.

complexes.[36] The remaining iron ions not complexed by the gallic acid display a general higher solubility and thus would be washed out more easily in contact with water. This finally leads to the lower amount of iron in ink type II. Ironically, this distinction between ink types by XRF measurements could not have been detected without the severe water damage to the analysed manuscript, since only the washing out of metal ions led to the different final ink compositions.[37] Interestingly, this effect caused the same elemental changes

[36] Krekel 1998.

[37] We assume that free iron ions, being not complexed by the gallic acid, were washed out of the ink material, and thus conclude that different ink batches with varying amounts of gallic acid were used in this case.

on both sides of the folio, which leads to the assumption that the stave lines (ink type I) and the black notation and text underlay/*residuum* (ink type II) are the same on both the recto and verso sides.

Regarding the measurements of red ink, no significant changes in the different measured spots could be detected, since they all showed a typical XRF spectrum of mercury sulphide (HgS), the main compound in the pigment vermillion made from the mineral cinnabar (Fig. 7). Therefore, it can be assumed that only one type of red ink was used for the *Atri Fragment*. Only minor changes in trace elements could be identified for most of the spots (Fig. 9). As in the case of the black inks, some outliers (r-6b, r-7a, r-7b, r-7c) can be explained by the low amount of ink in these positions and the resulting higher influence of surrounding materials and parchment constituents. The spots at the top of each side (r-9a, r-9b and v-9) present the same problem and are therefore not shown in Fig. 9. However, the presence of a residual trace of mercury was detected. Such data is consistent with the MSI results depicted in Fig. 4 (r-9a and r-9b).

The XRF results of the red ink are further confirmed by the recorded reflectance spectra shown in Fig. 10. The analysed spots show similar spectral behaviour and the same inflection points at 600 nm, which is characteristic for cinnabar.[38]

Results and conclusion

The *Atri Fragment* is the remnant of a collection of polyphonic music, be it a larger volume or a smaller unit[39]. Due to its afterlife use, the surface of the verso side in particular was rendered mostly illegible, but thanks to the MSI techniques applied we were able to make most of the original writing visible, allowing further investigation, which would not be possible with simpler methods such as the sole use of ultraviolet light.[40] One important outcome is that the text of the *ballata* can now be clearly recognised as being concordant with the version of the much later *Chansonnier Cordiforme*. While in this codex the text is incomplete, we find the full text in the *Atri Fragment*.[41]

Not surprisingly, the *Atri Fragment* was produced with iron gall inks and a red cinnabar ink, as was common practice. From the limited surviving contents, it is difficult to say what the main repertorial interest of the compiler was. The only evidence at this point is the extensive attribution on the recto side, which leads to the assumption that the *Gloria* belonged to the main repertory of the original manuscript. It is very likely that the verso side never contained a composer attribution; at least there is no clear trace of it to be found by applying MSI or ink measurements. Further, the *ballata Be'llo sa Dio* differs in visual appearance from the *Gloria*, especially regarding the notational signs. These observations allow us to assume that *Be'llo sa Dio* was added to the manuscript at a different time than the *Gloria*. One could speculate that the surviving fragment might have been the final leaf of a fascicle, which was originally blank on its verso side (except for the stave lines). *Be'llo sa Dio* would be a typical piece, small enough to be added later to a manuscript wherever space was left free.[42] The fact, however, that only one type of *custos* is used on both sides and that the same ink was used for the music and text (ink type II), leads to the conclusion that both musical pieces were written by the same scribe. Therefore, any difference in the shape of the note signs between the recto and verso side probably derives from using differently sized pen nibs. The possibility of differentiating two ink types was – in this case – detectable only due to the severe water exposure of this fragment.

Ink type I was used beforehand in a preparatory step to draw all stave lines. It cannot be determined whether the same person was involved using a different ink or if someone else prepared the folios before the music scribe started his work. Due to the same relative elemental composition of trace elements, however, we can conclude that both inks were prepared in the same region with the same sort of vitriol.

[38] Aceto et al. 2004.

[39] E. g. a fascicle manuscript. This term was coined by Charles Hamm, see Hamm 1962.

[40] Agostino Ziino reported this to be unsuccessful in the case of the *Atri Fragment*, see Ziino 1973, 237.

[41] Paris, Bibliothèque nationale de France, Rothschild 2973 (I.5.13), fols 1^{v}–2^{r}. The two text versions and the variants will be discussed in Janke and Zimei (forthcoming).

[42] See the discussion on 'space filler' pieces in the *San Lorenzo Palimpsest*, and specifically No. 151 in the Inventory in Janke and Nádas 2016.

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Studies in Manuscript Cultures (SMC)

Ed. by Michael Friedrich, Harunaga Isaacson, and Jörg B. Quenzer

Writing is one of the most important cultural techniques, and writing has been handwriting throughout the greater part of human history, in some places even until very recently. Manuscripts are usually studied primarily for their contents, that is, for the texts, images and notation they carry, but they are also unique artefacts, the study of which can reveal how they were produced and used. The social and cultural history of manuscripts allows for 'grounding' the history of human knowledge and knowledge practices in material evidence in ways largely unexplored by traditional scholarship.

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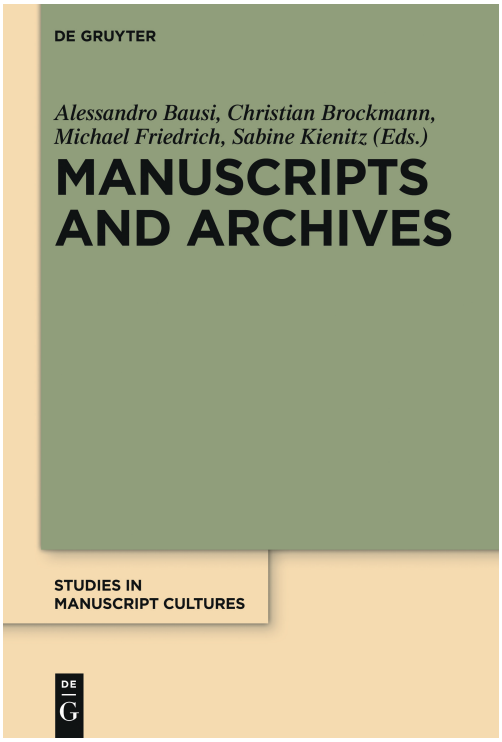

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Archives are considered to be collections of administrative, legal, commercial and other records or the actual place where they are located. They have become ubiquitous in the modern world, but emerged not much later than the invention of writing. Following Foucault, who first used the word archive in a metaphorical sense as 'the general system of the formation and transformation of statements' in his 'Archaeology of Knowledge' (1969), postmodern theorists have tried to exploit the potential of this concept and initiated the 'archival turn'. In recent years, however, archives have attracted the attention of anthropologists and historians of different denominations regarding them as historical objects and 'grounding' them again in real institutions. The papers in this volume explore the complex topic of the archive in a historical, systematic and comparative context and view it in the broader context of manuscript cultures by addressing questions like how, by whom and for which purpose were archival records produced, and if they differ from literary manuscripts regarding materials, formats, and producers (scribes).

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