Initial inspection of reagent damage to the Vercelli Book

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Summary

The use of chemical reagents for text enhancement was quite common in the nineteenth century. Their application resulted in permanent damage, irreversibly obscuring the writing. This paper describes an effort to find a suitable technique to read the passages in the Vercelli Book that were obliterated by the use of the gallnut tincture.

Reuse of parchment, well attested since late Antiquity, involved erasure of the primary inscription and production of pristine-looking material ready for the new ones. Wattenbach reports that this practice, very common in the Middle Ages, destroyed a huge number of extremely important texts.[1] Fortunately, abrasive or chemical action did not remove completely the original inks that deeply penetrate the writing supports. In many cases ageing and oxidation processes reveal the old text in varying degrees of clarity under the overlying inscriptions.

Throughout the nineteenth century, great difficulties experienced by the scholars in their attempts to read and describe erased or faded texts led to application of chemical reagents to enhance the readability of the primary inscriptions. Their effect, however, was short-lived, and the inscriptions became completely obliterated soon after. As a general rule, one used the reagents capable of producing visible precipitates with iron from the ink. The recipe for gallnut alcohol extracts that bind free Fe^{2+}-ions and mimic the production of iron gall ink appeared first in Caneparius' *De atramentis cuiuscunque generis* in 1619[2] and remained in use until the twentieth century, albeit at a certain

1 Wattenbach 1896, 299–317.
2 Caneparius 1619, 179.

time the gallnut extract was replaced by gallic acid.[3] The effectiveness of this tincture depends strongly on the sufficient presence of free Fe^{2+}-ions in the faded areas. In erased and rewritten manuscripts (palimpsests), free Fe^{2+}-ions from the overlying text would also respond to the infusion and produce permanent black staining. Therefore, in the worst case the application of the gallnut tincture covered the page with black iron(III) gallate whereas the minimal damage resulted in brown staining of the parchment from tannins. Objections to the application of this pernicious and often counterproductive tool voiced as early as 1825[4] were followed by suggestions of alternative chemical means, namely, various sulphur-based compounds to produce black iron sulfide or acidic solution of potassium ferrocyanide to produce a blue complex of iron known as Prussian blue. This latter reaction, suggested by Bagden in 1797 as a test for presence of iron in the inks entered the history of chemical treatments of palimpsests under the name of Gioberti tincture and proved to be as hazardous as gallnut infusion.[5] Ironically, the damage inflicted on the manuscripts can only be compared with the production of the palimpsests themselves. Luckily, by the end of the nineteenth century, photographic methods for the separation of under- and overtexts became available to scholars.[6]

Ever accelerating translation of scientific knowledge into technologies greatly supported a complete re-thinking of the attitude towards the ancient manuscripts that are considered now to be valuable artefacts *per se* rather than mere text carriers. The use of UV and IR light has replaced chemical reagents in new attempts at deciphering faded iron gall and carbon inks, respectively. In the first case, UV light enhances contrast between non-tanned parchment and the residual tannins of the ink, as tannins are effective scavengers of fluorescence. In the second, the enhanced contrast is due to the difference in reflectance at long wavelengths between parchment and amorphous carbon of the inks.

Further technological development has yielded multi-spectral imaging (MSI) applications to recover obscured writing and other information from damaged, deteriorated manuscripts or palimpsests. The Eureka Vision system (MegaVision) collects high-resolution images at 13 wavelengths (365 nm to 1040 nm) and supports the differentiation of UV reflectance and UV fluorescence data and the differentiation of UV fluorescence data into blue, green, orange, and red components. Experience has shown that the collection of both UV fluorescence images at various colours and UV reflectance images makes

3 Mitchell 1925; Cunha 1971, I, 171.
4 Ebert 1825, 83, 230.
5 Handbuch 1905.
6 Pringsheim and Gradenwitz 1894.

possible the recovery of obscured writing and reveals distinctive features of the ink and its support. In addition, the collection of images from UV to the near IR contributes to the identification of classes of inks (e.g. iron gall or carbon-based inks).

If the differences between ink and substrate across the wavelength bands are very subtle, methods that evaluate the statistical properties across the ensemble of bands may be necessary to find the combinations of bands that enhance the text contrast. For example, principal component analysis (PCA) analyses an image set consisting of N bands to find an equivalent set of N bands ordered by variance. The most subtle differences in contrast may be isolated into a small subset of processed bands that may then be combined to form pseudocolour renderings with legible text.

Recently a new method for the reading of erased or damaged texts written with inks containing metal-ions was demonstrated by Bergmann.[7] Using xy scanning X-ray fluorescence (XRF) the text can be retrieved by detecting metallic components of the inks. Here incident X-rays cause characteristic X-ray emission from the irradiated matter. Currently employed systems do not deploy vacuum or purging with helium, and therefore only elements heavier than potassium can be detected and imaged. Until now, successful results were achieved with the incident X-ray beams of high intensity at the synchrotron facilities. However, recent development of a new high-speed XRF scanning device raises hopes for a wider application to palimpsests. Here, as in the case of the chemical reagents, a sufficient amount of detectable elements in the areas of the damaged text presents the crucial condition for the success of the enterprise. It is to be hoped that in future both methods—MSI and XRF—will be used together to complement each other and to improve retrieval of the damaged texts. In this context it is important to emphasize that both methods are non-invasive and do not harm the manuscripts under investigation.

In this work we report our investigation of the portions of the texts in the Vercelli Book that were obliterated by the use of a chemical reagent in the nineteenth century.

The Vercelli Book (Vercelli, Biblioteca Capitolare, MS 117) is a compilation of poems, homilies, and a prose saint's life in Old English dating to the second half of the tenth century.[8] It is among the oldest examples of Anglo-Saxon in existence and is the only manuscript to preserve the famous poem 'The Dream of the Rood'. Why it travelled from England to Vercelli is still a matter of scholarly dispute;[9] what is not in dispute is that it arrived there before the middle of the twelfth century. Its linguistic oddity amidst the Latin

7 Bergmann 2011.

8 Förster 1913, 28, Ker 1957, 460-464.

9 Halsall 1969, 1545-1550, Sisam 1976, 45-50.

tomes of a Northern Italian cathedral school contributed to its desuetude for six centuries in which it languished under the title *Homiliarium liber ignoti idiomatis* (‘A book of homilies in an unknown language’).

In 1822, the German philologist and legal historian Friedrich Bluhme made the adventitious find and identified the Vercelli Book as having been written in Old English, duly reporting it in several publications.[10] Indirectly through Bluhme it came to the attention of Charles Purton Cooper, secretary of the Record Commission in London, a decade later. Charged with gathering important documents of the realm, Cooper sought an appropriate transcriber for the manuscript in Germany, and by the recommendation of the historian Leopold Warnkönig at Ghent University, settled in 1833 on a recent doctoral graduate of Tübingen named Christian Maier who happened also to be a protégé of Bluhme’s. In 1823, Maier had spent some time with Bluhme in Vercelli and it was from him that Maier seems to have learned the formulation and use of chemical reagents that he was to deploy later on the Vercelli Book.

Maier arrived in Vercelli in late autumn of 1833, but was able to begin work in earnest only in January of 1834, finishing his transcription in early March. Despite the fact that the manuscript had only a small number of erasures, Maier treated it with reagent on 33 leaves of which folio 1 shows the most serious damage. Maier’s transcript of the Vercelli Book, now held at Lincoln’s Inn Library in London, remains a witness of enduring value inasmuch as it records unique readings now invisible from reagent damage.

In our study of the Vercelli Book in 2014, we performed full multi-spectral imaging of the book and inorganic trace analysis using X-ray fluorescence on the selected ink and reagent spots. For imaging we used the Megavision imaging system, whose LED light sources provide narrowband illumination from the UV (365 nm) through the visible spectrum to the near IR (940 nm). LED illumination offers several advantages over traditional light sources: it does not expose vulnerable originals to heat, minimizes the light exposure necessary for multi-spectral imaging, and supports pixel-for-pixel registration of images captured with high-resolution cameras. The system features a 50 MP monochrome camera and a specially-designed 120 mm quartz lens that achieves sharp focus (i.e. is apochromatic) at all 12 wavelengths of illumination. A dual filter wheel in front of the lens enables the capture of images of UV reflectance and of different colours of UV fluorescence. Raking lights in blue and IR provide low incidence angle illumination to discern the topography and fine surface texture of parchment, papyrus or paper originals, while a transmissive light provides illumination from beneath the folio in seven wavelengths between 450 nm and 940 nm.

10 E.g. Bluhme 1836, I, 99.

Fig. 1. The Vercelli Book. F. 26r (left) and f. 25r (right).

To check whether the crucial condition of the sufficient presence of the detectable elements was fulfilled we used a commercial micro-XRF spectrometer specially designed for the study of archaeometric objects *in situ* (ArtTAX, Bruker Nano GmbH). It consists of an air-cooled low-power X-ray tube, polycapillary X-ray optics (measuring spot size 70 µm in diameter), an electro-thermally cooled Xflash detector and a CCD camera for sample positioning. To obtain statistically relevant characterization of the ink, staining, and parchment we used line-scan modus with at least 10 points per scan. All measurements were made using a 30 W low-power Mo tube, operated at 50 kV and 600 µA, and with an acquisition time of 20 – 100 s (live time). For semi-quantitative determination of the composition we used the commercial software 'Spectra', by Röntec, that fitted the spectra and calculated the net peak areas.

The 33 leaves treated by Maier display damage of varying degrees of severity ranging from the tracing of single letters and words to the generous application of the tincture over large areas. The brown to black colour of the staining fits perfectly the description of the damage induced by gall-nut extract well described in many sources.[11] In the first instance, this hypothesis is supported by the fact that Maier learned the handwork from Friedrich Bluhme, an ardent defender of the merits of gallnut infusions.[12] Below we will present more evidence for our identification on the basis of the XRF analysis.

In his excellent study, Bock considers various reasons for the bizarre text mutilation performed by Maier and the interested reader is invited to consult his work.[13] In short, in some cases Maier tried to retrieve previously erased texts whereas in the others, namely the administering of the tincture to the intact text, is attributed to the trials. We agree that Maier was most probably testing the effect of the solution as it must have been known to him that the desirable effect strongly depended on the type of ink. It remains unclear, though, how Maier determined the quality or effectiveness of his tincture. Moreover, it is improbable that Maier applied all the tincture in one day. On one hand, only fresh solution could yield a desirable result. On the other, the effect is not immediately obvious as exposure to light and to air is needed to complete the reaction. This last observation may explain one of the most striking features of the damaged pages: the stains' colour varies from light beige to brownish black. The latter seems to occur when the tincture was applied more than once to the same spot, notably to the previously erased text.

Furthermore, it would be desirable to establish whether the infusion was indeed prepared from the crushed gall nuts and white wine as suggested in the original recipe or rather from the chemically pure reagents, gallic acid and alcohol.[14] Only in the latter case could a fresh solution be easily prepared. The processing of the galls, on the other hand, is less simple. In such a case, Maier would have used the same solution more than once, increasing the damage.

Optical properties of a pure tannic solution would allow its differentiation from the iron-gall inks that become transparent at longer wavelengths.[15] However, the brown to black stains on the Vercelli book display much lower reflectance in the NIR region than that of the untempered ink. The dark colour results most probably from the iron(III) gallate produced when the tincture came in contact with free Fe^{2+}-ions that could be either washed out of the ink during the application or present in the parchment.

As explained above, subtle differences in reflectance behaviour of the support (in this case stained parchment) and the inks are exploited by the MSI to obtain images of a contrast sufficient to make text legible. In fig. 2 we compare reflectance curves of the ink and the stains on page 26r shown

11 Albrecht 2012.
12 Bluhme 1864, 451.
13 Bock 2015.
14 Handbuch 1905.
15 Rabin et al. 2012.

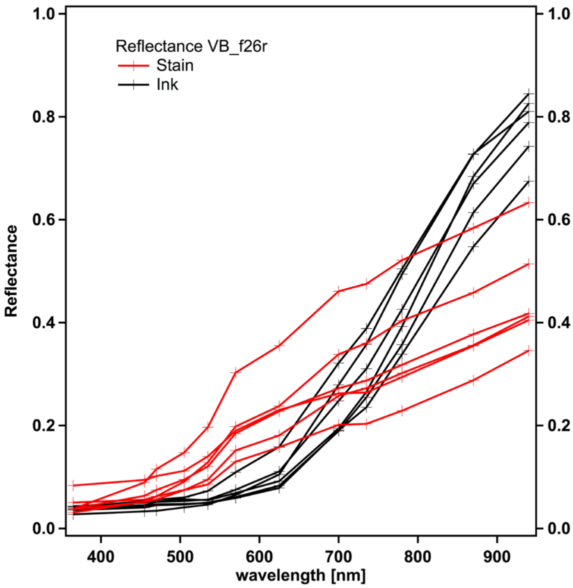

Fig. 2. Reflectance curves of the non-tampered ink (black) and stains (red) on f. 26r.

above (fig. 1, left). From the curves' profile we conclude that the original ink is more opaque in the spectrum region between 505 and 625 nm than the stained parchment. And indeed in several lines the intact text can be still read under the tincture. However, in the second of the treated lines no ink can be discerned anymore: it may have faded previously or been smeared by the infusion. To investigate the presence of the ink obscured by the stains, we have tested the ink response by XRF. Figure 3 shows a scan across the intact and damaged text.

Such a profiling of the inks delivers information on the elemental composition of the materials along the scan. In fig. 3 the first two group of peaks centred at 0.75 mm and 2.1 mm, respectively, correspond to the inks of the letter 'ð' (eth); the third group at 3.5 mm coincides with a partly obscured letter whereas the last group around 4.9 mm displays the existence of a letter not discernible optically. The first two groups display identical patterns with enhanced intensities of the elements calcium (Ca), iron (Fe), potassium (K), lead (Pb), manganese (Mn) and zinc (Zn) belonging to the ink while the intensity of chlorine (Cl) is depleted because it originates from the parchment only. Note that the intensity of Ca though somewhat enhanced in the ink is mostly derived from the parchment. In contrast, abundance of Fe grows by only one order of magnitude, raising the question of whether we are dealing here with an iron-gall ink. Both the presence of the elemental satellites Mn and Zn, commonly encountered in vitriols, and reflectography would support

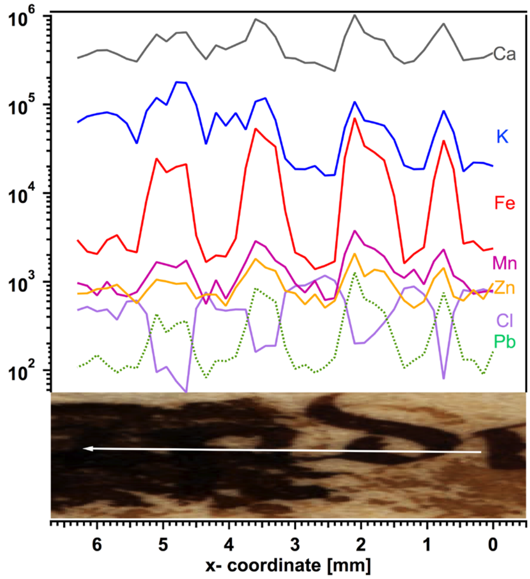

Fig. 3. Net peak intensities of the elements extracted from the scan across a line with partially obscured inks. The white arrow in the image in the lower part of the diagram indicates the position of the line scanned, with the step of 0.15 mm.

this identification: the ink is faintly visible in the NIR region. Yet the amount of iron in this ink is very low. In contrast with the ink in the Vercelli Book, the intensity of iron in a classical iron gall ink on the parchment exceeds by far that of Ca from the parchment as well as that of K. The latter may originate from three different sources: alum ($KAl(SO_4)_2 \cdot 12H_2O$), occasionally present in the recipe of the iron gall ink; gum arabic, a common binder; and tannins from the gall nuts. The fact that the intensity of K exceeds that of Fe in the ink of the Vercelli book implies that the type defining component of the ink in the Vercelli book is rather of plant or tannic nature. The trace amounts of lead (Pb) do not derive from the intentionally added components but most probably arise from the water used in the ink preparation.

The third and the fourth groups of peaks in our scan have the same structure indicating that the ink is hardly disturbed by the presence of the overlaying tincture. The only detectable change associated with the presence of the tincture concerns the element K that is associated with the tannins. Abundance of K does not return to the level characteristic of the parchment but steadily grows throughout the staining. However, at the location of the obscured ink the intensity of K is higher than in the stain around it leading us to a tentative conclusion that the desirable reaction between the added gallnut infusion and iron from the ink indeed took place in this case. Furthermore, the results of this scan would indicate that XRF imaging would be capable of unveiling the preserved text.

Let us turn now to another spot. In the last line of page 25r (fig. 1, right) the tincture was thickly applied to the remains of the previously erased or faded text. The colour of the line turned blackish brown with a very low reflectance throughout the visible and NIR regions. Figure 4 shows an XRF line scan that similar to the previous example starts in the visible ink and ends in the stain region. For clarity we drew the lines separating regions of the scan corresponding to the intact ink (I), intact parchment (II) and stain (III). The first and second regions display already familiar patterns of an ink and parchment, respectively. The boundary of the ink is easily recognized by a sharp fall of the intensities to their background values in the parchment. A rise in the intensity at 3.7 mm just before the end of the region II corresponds to the remains of the original text not covered by the tincture. Yet once the scan reaches the region III, that is, arrives in the stained area, we find no features that can be associated with localized ink. Instead we observe a 'smear' of the iron intensity on the background of risen intensity of K and slight decrease of that of Ca. We also observe an insignificant growth in the intensities of Mn and Zn confirming that the shapeless curves correspond to the delocalized ink. In other words, heavy application of the tincture must have mobilized the metallic ions and spread them over the whole region. In this case, the crucial condition for recovering the text does not seem to be met anymore.

Let us return now to the questions raised before: what reagent Maier used and whether he succeeded in enhancing the ink colour. Detection of the element K in the stains indicates infusion obtained from the natural gall-nuts rather than chemical reagent gallic acid. Though K would have been found in the rests of the Gioberti tincture we can safely exclude it since we observe neither a considerable increase in iron intensity nor blue discolouration of the parchment. Therefore, we may conclude that Maier made the tincture according to the original recipe requiring extraction of tannins from the crushed nuts. Furthermore, if he was working in a clandestine manner he must have found it difficult to strictly follow the instructions requiring each administration to be performed with a fresh solution, perfectly clean brush and quick removal of the excess of the solution. Given his relatively short stay in Vercelli and the number of treated pages we believe that he increased the damage considerably by multiple applications of contaminated solution and by the transfer of the mobilized iron from one spot to another.

XRF results suggest that Maier succeeded in enhancing the colour of the undamaged native inks, which encouraged him to try the reagent on the erased portions of the text. Multiple application of the tincture at the same spot suggests that some enhancement may indeed have occurred but was found by Maier insufficient for secure reading. Given the low amount of iron

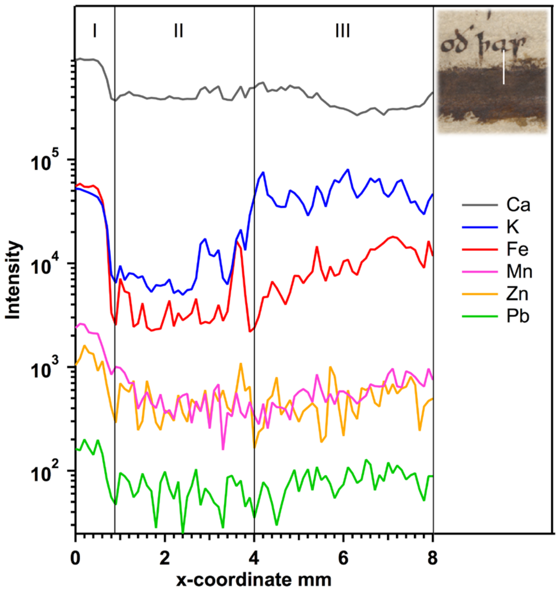

Fig. 4. Net peak intensities of the elements extracted from the scan indicated in the insert. The white line in the image indicates the position of the line scanned, with the step of 0.1 mm. Region I – intact ink; region II – intact parchment; region III – stain.

in the original ink it is highly unlikely that he could improve readability of the erased portions.

Conclusion

Our observations suggest the impossibility of establishing *apriori* whether localized text can be found under the tincture throughout the Vercelli Book. XRF imaging in this case may offer a worthwhile alternative for recovery.

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