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Imaging as a Diagnostic Tool for Manuscript Inspection

The primary task of the Photographic Department of the Vatican Apostolic Library is the production of photographic reproductions of the Library's materials, for the research and publication purposes of scholars and users, and for the enrichment and completion of its own archive. As a part of this, for the last ten years, the Photographic Department has managed, monitored, and verified all the photographic processes involved in the large-scale digital preservation project aimed at reproducing and then disseminating online the entire manuscript collection held by the Library. The history of photographic reproduction in the Vatican Library dates back to the mid-19th century, and over the course of those years photography itself has changed and developed enormously, one of the most significant changes being the move from analogue to digital technology. Additionally, since the laboratory was instituted in its official form in 1938, it has been developing experimental activities using X-rays as well as ultraviolet and infrared radiation. Now, multispectral digital technologies have been in use for about a decade. Without harming the originals, these allow for important and sometimes decisive breakthroughs in understanding of both the content of a manuscript and its conservation state. The results which follow are the fruits of the Laboratory's activities from 2015–2017.

Many previously illegible texts have been detected optically: The Barb. lat. 4076,¹ a codex whose text was partially unreadable due to fading ink, has been recovered by ultraviolet fluorescence imaging. In the manuscript Ferr. 841 in which the text on the verso of the end flyleaf had transmigrated, by impression, onto the back pastedown, the text has been reconstructed thanks to ultraviolet imaging of both pages, followed by enhancing its readability through mirroring it onto its original page.

In other cases, discovery took place unintentionally, such as in Reg. lat. 1290, a palimpsest photographed in ultraviolet fluorescence that revealed not only the undertext, but whose drawings, present on some of the folios, were emphasized by fluorescence, allowing a better decryption of both the hidden text and the decoration.

In the codex Urb. lat. 13, the application of a green filter² when photographing with a camera modified for shooting in the infrared spectrum made it possible to increase contrast and to obtain better legibility of the illumination around the coat of arms as well as a better reconstruction of the writing that began to fade in the other shots which used longer wavelengths in the infrared spectrum. In any case, we are still continuing to encounter problems when focusing in the infrared spectrum. This is due to different indices of light refraction in optical filters particularly in those wavelengths, and the fact that lenses have been manufactured and enhanced for photography in the visible spectrum.³

In another case, a blazon in an early printed paper book had been covered by gluing a new one, also designed on paper, over it. Even though long wavelengths penetrate best through material, infrared reflectography did not make it possible to image the original drawing through the superimposed layer. Two different attempts to access the older design were made: one using reflectography with a camera equipped with an InGaAs (*indium gallium arsenide*) sensor, an infrared detector which is sensitive to wavelengths from 1200 up to ca. 1700 nm; the other using thermography, which detects radiation in the long-infrared range (in our case, in the spectral region of 3000–5000 nm). We were successful with the InGaAs detector, whose radiation was sufficient to

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¹ This manuscript is the well-known autograph of the 'Documenti d'Amore' by Francesco da Barberino, and unfortunately the text (and, partially, also the decoration) have been damaged due to the detachment of the ink and pigment.

² Wratten 61, which blocks a great part of the visible light (cutting at 600 nm) in IR photography and consequently emphasizes the effects of imaging at infrared frequencies, while partially maintaining the advantages of illumination through visible light. The use of photographic filters during shooting, if done with awareness, is normally preferable—or, at least, we may say that it is complementary—to digital post-processing of the acquired images.

³ For the performance of photocameras with removed anti-aliasing filter, see Melis *et al.*, Variante Full Range su fotocamere Nikon.

reveal the original blazon under the current one.⁴

An aspect that is often neglected is the physical condition of the parchment or paper containing the text to be read or illustration to be deciphered. In photography, trans-illumination and innovative three-dimensional technologies are becoming of increasing interest⁵ because they are possible ways of investigating the materiality and the conservation state of a writing support in order to get better access to the text. In this context, the simple technique of raking light that provides low incidence angle illumination is also sometimes the best way to obtain more information on the surface structure of the manuscript. A detail of the *canzone* 'Poi ch'ad Amore piace', preserved in the Canzoniere Vaticano Vat. lat. 3793, f. 101r, is illegible because of a stain caused by moisture. An image shot with ultraviolet fluorescence and ulterior image processing in Camera RAW gave access to the physical residues of the text; but the text could nevertheless not be fully recovered with absolute certainty. Subsequent imaging with raking light revealed, in addition to the water damage, an injury to the parchment and its slight roughening, perhaps due to scraping at that point. Both images could be used by scholars for the reconstruction of the text as well as of the history of the support on which the text was written and which permitted its transmission through the centuries.⁶

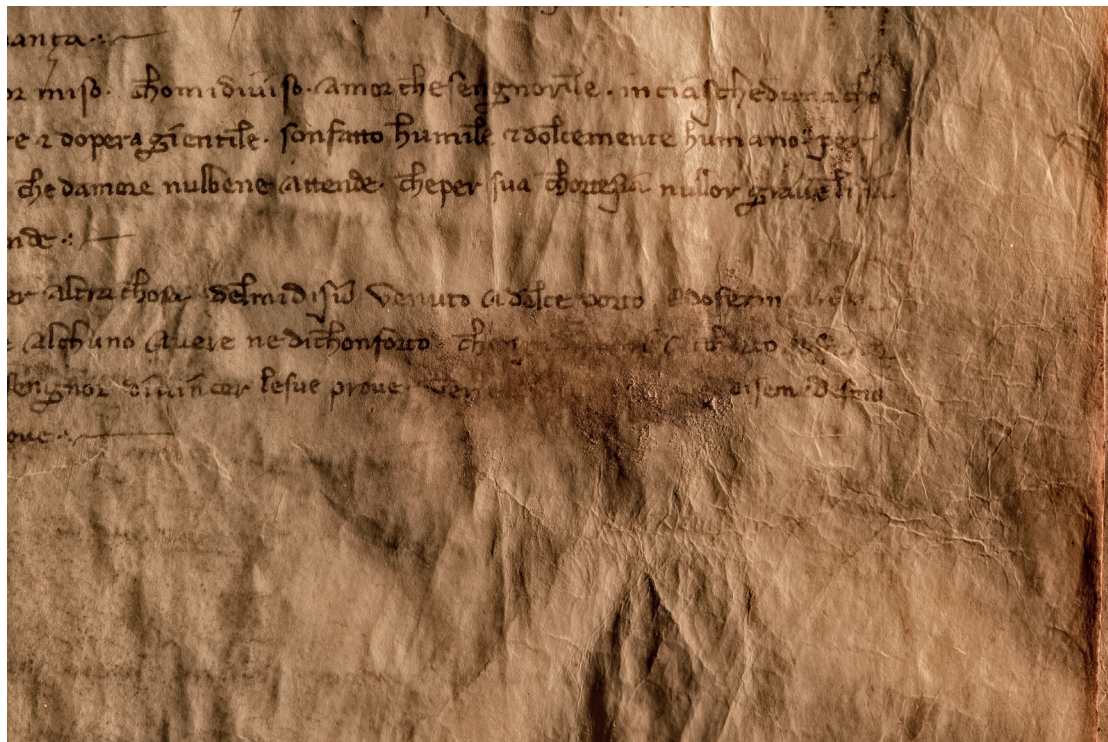


Fig. 1: Vatican Apostolic Library, Vat. lat. 3793, f. 101r (detail shot with raking light)
(© Vatican Apostolic Library)

⁴ Generally, the best results with an InGaAs detector are obtained in materials that make it possible to overcome the interference of iron gall ink (which becomes transparent at those wavelengths), or when the purpose is to highlight transparent elements under the ink (i. e. watermarks). However, in order to recover deeper layers in an object, sometimes (especially in parts without written text) the best technique may be thermal imaging, which generally makes it possible to reveal elements complementary to those detectable by InGaAs technology. Both technologies require an experimental approach and do not always guarantee acceptable quality of the visualization of the elements being investigated (the results depend on the type of material, its conservation state, and possible interference from other components present in the manuscript).

⁵ The most common three-dimensional technologies for cultural heritage objects are Reflectance Transformation Imaging (RTI) and Photogrammetry, both techniques that are cultivated and taught, for example, by the Cultural Heritage Imaging Corporation, see <http://culturalheritageimaging.org/> (accessed 01.07.2023).

⁶ The manuscript Vaticanus latinus 3793 is the earliest, as well as the only independent, testimony, to the full work of the so-called *Amico di Dante*. In the 16th-century copy of Vat. lat. 3793 made by Angelo Colocci (conserved in Vat. lat. 4823), the *canzone* 'Poi ch'ad Amore piace' appears on ff. 301r–302r, already showing the lacuna at verse 58. Michele Rinaldi, *pers. comm.*, 29 March 2018.

A specific question arose during the detection of watermarks, which is performed using a mixed technique that uses trans-illumination and photographic capture with infrared radiation: which is the correct side of the watermark? When the right and the left sides of the watermark design are symmetrical but differ slightly, it is necessary to ascertain what the original watermark design was. The fact is that the correct side is the one where wire and chain lines are less visible in raking light (and where the imprint-relief of the metal of the watermark is more visible and transparent). Thus, the answer lies again in the photographic technique of raking light shooting, which allows the identification of the proper orientation of the paper sheet.

Let me now showcase a special imaging project centred on the Papyrus of Hanna, one of the oldest surviving witnesses of the text of the New Testament, containing the Gospels of Luke and John.⁷ It is the most ancient complete manuscript in the Vatican Library (only some fragments are older),⁸ written between AD 180 and 220, and probably one of the most precious. Immediately after it was donated to the Holy See in 2006,⁹ the fifty-four pieces were photographed using 5" × 7" colour positive sheet film, unfortunately without taking the necessary precautions to prevent the formation of shadows around the edges of the papyrus fragments, which are conserved between glass plates. Errors during the developing process then produced transparencies that show an excessive blue dominance. The transfer from these ektachromes to digital format added noise to the images, and due to this and other problems related to the shadows and the lack of correct colour correspondence, the files became almost unusable for research purposes.

The new imaging project in 2015 had to produce images that could replace the originals for study and research and at the same time could be stored according to our quality standards for long-term digital preservation.¹⁰ High resolution 800 ppi RGB-images were therefore captured with a *Metis* scanner. In order to avoid the insidious problem of shadowing during the imaging process, a light box was put under the glass plates containing the papyrus fragments. As a result of these measures, it was possible to capture exceptionally high resolution and well-defined RGB files,¹¹ in addition to three-dimensional images obtained through several captures of the same original with different light settings, and three-dimensional processing of these RAW-files via the *Metis* scanner software. The *Light Inspector* software (implemented in the scanner's acquiring software) calculates information related to the incidence of light over the object directly from the captured 2D colour data.¹² It is an interactive and intuitive research tool that previews the manipulations made by the user in real time on the screen, permitting the export of these results in conventional TIF format.¹³ Valuable information regarding the surface structure and the materiality of the papyrus can be obtained by observing and studying these three-dimensional images.

⁷ See Janz, Per una edizione facsimilare del papiro Bodmer XIV–XV, where the author, amongst other things, illustrates the interesting work of reorganization and virtual alignment performed on some fragments in order to reconstruct the text. See also the *editio princeps* of the papyrus codex of 1961: Martin and Kasser, *Papyrus Bodmer XIV*; Martin and Kasser, *Papyrus Bodmer XV*.

⁸ Ambrogio M. Piazzoni, *pers. comm.*, 1. March 2018.

⁹ See an article describing the donation of the papyrus: Spiteri, His eminence, cardinal Raffaele Farina, SDB, and the papyrus Bodmer XIV–XV.

¹⁰ Regarding the Vatican Library's policy of long-term digital preservation of its electronic image data, see <https://www.vaticanlibrary.va/en/the-digital-project.html> (accessed 01.07.2023).

¹¹ These VIS images (at lower resolution and provided with an electronic watermark) are available in the Vatican Apostolic Library's digital library: [https://digi.vatlib.it/view/MSS_Pap.Hanna.1\(Mater.Verbi\)](https://digi.vatlib.it/view/MSS_Pap.Hanna.1(Mater.Verbi)) (accessed 01.07.2023).

¹² The latest version of the software makes it possible to map the real heights of the reliefs of an original, to remove specular reflections on glossy originals, and to merge images. However, it is worth considering that this kind of three-dimensional imaging remains a representation of the object—an interpretation that is not, at the present state of the art of the technology, a virtual copy.

¹³ Information about acquiring devices, software and special features distributed by the *Metis Systems* company are available at <https://www.metis-group.com/> (accessed 01.07.2023).

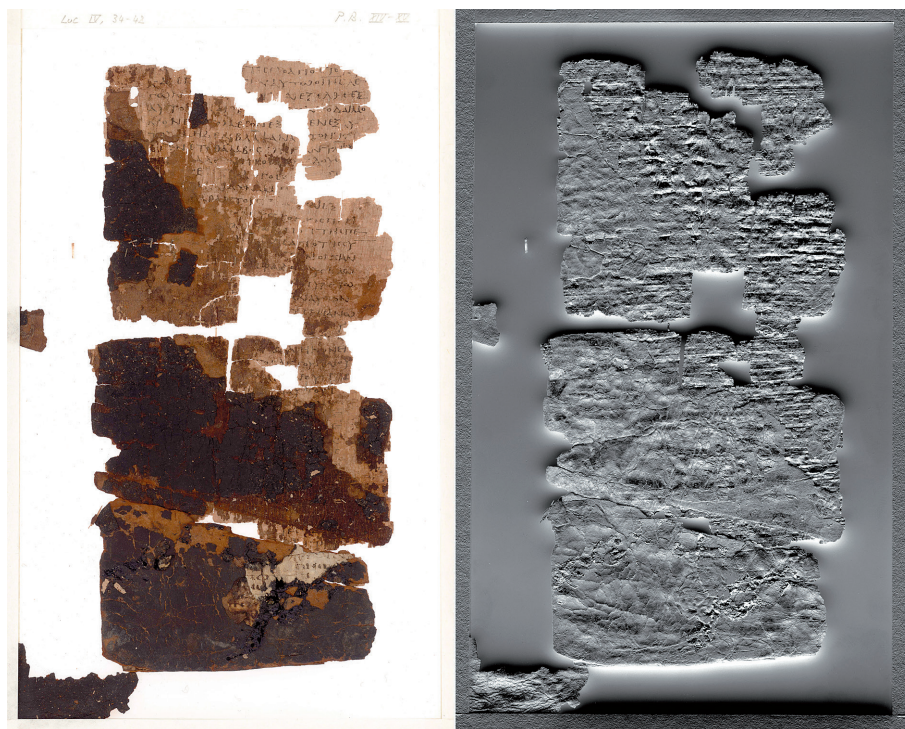


Fig. 2: Vatican Apostolic Library, Pap. Hanna 1 (*Mater Verbi*), f. 1A3r photographed in visible light and with three-dimensional imaging (© Vatican Apostolic Library)

After having captured all the pieces of the Hanna Papyrus in high quality conventional colour images, we realized that the text was faded or missing in some places. For this reason the whole manuscript was then photographed with ultraviolet fluorescence and at two different wavelengths in the infrared spectrum.¹⁴ The results were surprising: UV fluorescence images made it possible to recover text as well as to discover specific conservation states of some fragments (a number of them, under fluorescence, show yellow reflectance in some places, which suggests that a substance was apparently applied to the papyrus sheet in these sections; furthermore, many small strips that fix the papyrus fragments to each other, which had been applied during former consolidation interventions, became visible). Infrared reflectography, on the other hand, allowed excellent recovery of the writing in those places where it is covered by residues of the leather of the ancient binding that adhered to the papyrus fragments.

Unfortunately, there were two fragments, numbered 1A2 and 1A3, whose texts could not be detected completely by imaging: fragment 1A2 consists of two papyrus pieces that are glued together and whose texts hidden on the inner parts remain inaccessible; fragment 1A3 was partially covered by a particularly large, dense portion of the leather binding. So in 2016 it was decided, in collaboration with the Diagnostic Laboratory for Conservation and Restoration of the Vatican Museums, to undertake a further investigation of the materials, with a double purpose: first, to try to read the part of text not yet accessible; and second, to contextualize the materials of which the fragments are made, performing a non-invasive survey without taking micro samples. It was decided to undertake two chemical spectroscopic analyses only on these two fragments: XRF (X-ray fluorescence elemental analysis) on thirty points, and molecular analysis in Raman microscopy (μ -Raman). These materials analyses were then followed up with an investigation using X-radiography.

Data mining of elementary analysis in X-ray fluorescence (XRF spectroscopy) suggested the vegetal nature of the ink, and consequently, an excellent preservation state of the ink.¹⁵

¹⁴ The Nikon D800 full-frame camera and two Kodak Wratten filters (85b for colour conversion and 2b to block reflectance of ultraviolet) were used for imaging in UV fluorescence. NIR shots were performed with a modified Nikon D800 camera whose IR Cut filter had been removed and which was equipped with optical filters suitable to block radiation of the visible and NIR spectrum at specific wavelengths in the infrared.

¹⁵ Cf. Santamaria *et al.*, *Studi diagnostici del Papiro Hanna*, [4]: ‘Le analisi in XRF non mostrano nessuna variazione significativa

X-radiography, by contrast, did not supply new information because of the vegetable nature of the ink, as carbon black ink is not detectable by X-rays.¹⁶



Fig. 3: Examining the radiography of Pap. Hanna 1 (*Mater Verbi*)
(© Vatican Apostolic Library)

Unfortunately we did not manage to read the writing on the back of the sheets of fragment 1A2 where these overlap. The graphic elaborations of overlapping of the radiographic images made in the Diagnostic Laboratory with the RGB images done by our Photographic Laboratory make it possible, however, to locate where multiple papyrus sheets are superimposed.

Regarding the conservation status of the papyrus, the μ -Raman analysis was not supportive, since the fluorescence produced by the material itself has affected the possible information concerning the conservation state of the cellulose; however, Raman microscopy also corroborated the hypothesis of the vegetal nature of the ink.¹⁷

tra i valori (in conteggi per secondo) di ferro riscontrati sul supporto in papiro e in corrispondenza del testo. Si riscontra tuttavia la presenza di elementi metallici quali zinco, piombo e manganese che possono essere associati ad impurezze minerali. Anche la presenza in tracce di questi elementi è indicativa, poiché solo negli inchiostri a base di residui dalla combustione di ossa, avorio, carboni naturali, resine, gas naturale o olio (*carbon black*), possono contenere questi elementi come impurezze, in aggiunta a idrocarburi incombusti che impartiscono la colorazione scura (non sempre solo nera), e che rendono queste polveri in soluzione, molto stabili alla luce, agli acidi e alle basi e ne conferiscono un ottimo potere coprente. Se si trattasse, invece di inchiostri metallici, la concentrazione di metalli associata ai sali metallici della miscela sarebbe molto più significativa.’

¹⁶ *Ibid.*, ‘L’ipotesi che si tratti di inchiostro a base carboniosa è sostenuta anche dalle analisi effettuate. La radiografia non mostra nessuna variazione di radiopacità in corrispondenza del testo, ad indicare la mancanza di elementi a più alto peso atomico rispetto agli elementi che compongono la carta. Il metallo (Fe) presente negli inchiostri ferro-gallici dovrebbe mostrare una differente radiopacità, situazione che non si presenta per gli inchiostri a base carboniosa, la cui composizione è compatibile con gli elementi costituenti il supporto.’

¹⁷ *Ibid.*, [4, 5]: ‘[...] considerando comunque la condizione inficiante del supporto, l’analisi μ -Raman non ha riscontrato la presenza né di ferro gallico (1474 cm^{-1} *sharp*), né di sali metallici (580 cm^{-1} *broad*), né di complessi organici di sottoprodotto del ferro. Tuttavia, non è stata riscontrata neanche la presenza di carbonio associabile a inchiostri carboniosi ($1334, 1588\text{ cm}^{-1}$). La differenza preponderante, però, sta nell’intensità degli *stokes* dell’effetto Raman; nel caso del carbonio la loro intensità è tale da poter subire facilmente l’effetto fluorescenza e quindi perdere il segnale. Nel caso del ferro gallico, l’intensità del picco a 1474 cm^{-1} , difficilmente subisce l’effetto fluorescenza del supporto. Questo spiega facilmente che se l’inchiostro fosse stato a base di sali metallici, o

When we opened the glass plate of fragment 1A3 for the XRF-measuring, we discovered that a large segment of the leather binding was actually only laid on the papyrus; by moving it, the script underneath became visible. Fragment 1A3 was then photographed again using the same techniques as had previously been used on the rest of the manuscript at our Laboratory (high resolution scanning, 3D-scanning, UV fluorescence photography, and IR reflectography), using, in addition, a new filter that cuts at 950 nm in the infrared spectrum. A new glass plate containing the piece of leather, now designated fragment 3A7, was created.

As the goal of reading the letters hidden between the two superimposed papyrus sheets of 1A2 has not been achieved, the optimal diagnostic method to reach this objective is yet to be identified. Currently we are trying to evaluate the non-invasive analytical technique of terahertz spectroscopy (THz).¹⁸ This method is based on terahertz radiation that lies between the infrared and microwave regions (the frequency range is about 0.1–10 THz).¹⁹ As it is low energy radiation weakly absorbed in most materials, it has the property of being able to penetrate into them, allowing measurements in transmission or in reflection to be carried out. It transmits especially well through dry and thin materials, making it particularly suitable for papyri. When using reflection mode, this method seems to be able to reveal features that are present at deeper layers of the sample; it has been thus tested on numerous artefacts, from manuscripts to mummies and antique lacquered furniture.²⁰ It is harmless: ‘Unlike x-rays or ultraviolet radiation, terahertz waves don’t “energize” the electrons of the molecules that absorb them. That means that those electrons don’t change their state, altering the underlying atomic structure in the way that living tissue can be affected by x-ray radiation, or a work of art that will change color if left exposed to the sun.’²¹

At present, a modern double papyrus sample with carbon ink writing on both inner sides is being tested in T-ray imaging, in order to understand whether or not the equipment could be able to reveal the hidden text on fragment 1A2 of the Hanna Papyrus. Obviously, these tests are only suggestive, as a profound difference exists between ancient and present-day materials.

The second case study to be presented here regards a palimpsest whose origins go back to the Abbey of St. Columbanus in Bobbio, with the present call number Vaticanus latinus 5766. The upper script contains works of John Cassian copied in the 8th century, while the three different under scripts are parts of *Ius Ciuile Antejustinianum* (5th century), the *Codex Theodosianus* (7th century), and the *Lex Romana Burgundiorum* (7th–8th century).²² All four texts are written in uncial script. The undertexts run perpendicular to the direction of the overlying writing, as well as, in several cases, in the same direction (sometimes regularly, other times upside down).²³

To the naked eye, the timeworn palimpsest sheets of the unbound manuscript show an intense browning due to a treatment with iron gall solution, whose irreversible oxidation process has seriously degraded the parchment structure, compromising its mechanical resistance and significantly altering the readability of the upper and under scripts. In the Vatican Library, even at the beginning of the 20th century, the awareness of the need of consolidation of the text and writing support of endangered palimpsests determined an intervention protocol established by the new Restoration Laboratory. The sheets were flattened by humidification and under pressure, then consolidated by applying one or more coating layers of gelatin, and afterwards desiccated under pressure between absorbent paper.²⁴

più specificamente metallo-gallato, il riconoscimento dello stesso mediante microscopia Raman sarebbe stato facilitato, viceversa il carbonio, non solo subisce con maggiore facilità l’effetto della fluorescenza, ma le bande di fingerprint del carbonio, coincidono con la zona in cui si concentrano le vibrazioni degli anelli aromatici delle resine e delle deformazioni dei CH₂ e CH₃ (per cui anche quelli della cellulosa del papiro).’

¹⁸ The validity of Terahertz technology as an investigation approach in the case of the Hanna Papyrus is yet to be determined. As an alternative to this technology, undertaking a survey by submitting the manuscript to a phase contrast tomography has been considered, but not yet undertaken.

¹⁹ Cf. Doria *et al.*, *Tecnologie THz per i beni culturali presso l’Enea*.

²⁰ See the detailed introduction by Cosentino, Terahertz and Cultural Heritage Science, as well as the interesting investigation approaches in the report of Toth *et al.*, *Integrating Optical Imaging of Mummy Mask Cartonnage*.

²¹ See the interesting analysis collected by Hauser, *What Lies Beneath?*

²² Cf. Lowe, *Codices Latini antiquiores* I, 14–15; 40–41; Beeson, *The Palimpsests of Bobbio*, 176.

²³ The VIS, UVF and NIR reproduction is disseminated at https://digi.vatlib.it/view/MSS_Vat.lat.5766 (accessed 01.07.2023).

²⁴ Regarding the history of palimpsest conservation and reproduction in the Vatican Library, especially under the prefecture of Father Franz Ehrle SJ, who introduced these processes, see Németh, *Recovery of conflicting textual identities*, 412–418. Father Ehrle him-

The effects of these interventions applied to Vat. lat. 5766, together with the consequences of humidity and temperature changes over time to which the manuscript was certainly exposed,²⁵ damaged it even more, adding to the well-known problem of poor readability in areas with higher concentration of gallic acid further issues, such as the undulation and stiffening of the support treated with gelatin, and the widespread presence of cellulose microfibrils transferred from the absorbent papers used during the drying treatments.²⁶

The first approach to the imaging of the palimpsest was carried out using the technology reserved in the Vatican Library's internal Cicero Project for the imaging of palimpsests. Automatic high-resolution scanners, produced by the Japanese printing company Toppan, scan natural light and UV fluorescence images of each rewritten folio. It is then possible to superimpose these images using special software, in order to uncover the erased texts on the recycled parchment. However, the undeniable advantages of obtaining two images that can be used also separately for different purposes (natural light images for normal research, online dissemination, and printing; UV images for the study of the erased contents), together with the extremely high resolution (up to native 2.400 ppi on A3 format) of this technology, are unfortunately frustrated when we are dealing with material that has undergone an extensive application of tannic gall solution: both scanned images are dark, impenetrable, and difficult to process, also because of the static TIF format of the output file of the scanners.

We tried to overcome these limitations through a new experimental photo shoot using other equipment supplied to the Photographic Laboratory, for new imaging using both the ultraviolet and infrared spectrum.²⁷

With regard to the shots using ultraviolet fluorescence, the approach was to try to cause less reaction, to counteract the excessive fluorescence due to the presence of different substances on the parchment, primarily gelatin. This objective was partially achieved, mainly due to the use of proper filters²⁸ and the experimental post-processing in Camera Raw. However, it must be said that this technique, although very effective on many sheets, did not achieve the hoped-for effect on all the folios. In some cases the almost total abrasion of the lower writing, in others the presence of paper fibers and/or gelatin, and especially the preponderant fluorescence of gelatin compared to the ink's fluorescence, have thwarted the intervention of the imaging scientist.

While using ultraviolet as excitation radiation, we had to take into account the fact that any substance present on the object exposed to UV radiation would have its own reaction. In our case it became clear, especially because of the brushed gelatin on the parchment sheets, that it was impossible to obtain an ink fluorescence excluding the strong fluorescence of the consolidating layer.

The new ultraviolet shots, however, compared to those produced with the Toppan scanner, improved the visibility of the text; moreover, they can be useful from a conservation point of view, since they show the different levels of concentration of gelatin on the different parts of the sheet, its distribution on the parchment, and other details evident to the expert eye of a conservator.

The extensive collaboration with the Library's Conservation Workshop permitted, at a certain point, the mechanical removal of parts with the greatest concentration of gelatin.²⁹ This operation recovers readability in

self, in *Über die Erhaltung und Ausbesserung alter Handschriften*, suggests repeating the application of formaldehyde-containing gelatin several times, where necessary, being aware that this probably will not stop the deterioration caused by the gallic acid, but hopefully slow it down. See also Ehrle, *Protokoll der internationalen Konferenz zur Erhaltung und Ausbesserung alter Handschriften*. Furthermore, in BAV, *Arch. Bibl.* 218. pt. A., and especially in ff. 208–216, we find many handwritten notes, also written by Father Ehrle, reporting on these restoration procedures and the different techniques which were evaluated or applied during these years in the Vatican Library.

²⁵ The palimpsest arrived in the Pope's Library around 1618 (Sever J. Voicu, *pers. comm.*, 12 February 2018). I am grateful to my colleagues Sever J. Voicu and András Németh for the bibliographical indications regarding the palimpsest.

²⁶ In 2008, the Diagnostic Laboratory of the Vatican Museums carried out a materials analysis by optical microscopy, Fourier-transform infrared spectroscopy FT-IR, and SEM/EDS, on the folios 43r and 45r of Vat. lat. 5766 in order to determine the nature and composition of the fibres and the coating layer present on the surface of these folios. Regarding this survey of the Diagnostic Laboratory of the Vatican Museums, see also Grimaccia, *Conservation and preservation*, [3].

²⁷ UV-induced detection in the visible range (fluorescence) with ultraviolet irradiation (UVF imaging) was performed with a Nikon D800 camera and illumination by short-wave ultraviolet radiation. For infrared reflectography, a modified Nikon D800 camera without low-pass filter, and natural warm-coloured light sources that already emit significant infrared radiation, were used.

²⁸ The same filters that have been used for the Hanna Papyrus: W2b, a long-pass UV Cut filter that absorbs ultraviolet radiation, blocking wavelengths below 395 nm, together with the amber filter W85b.

²⁹ The intervention carried out by the restorers focused on thinning, where possible, the excessive gelatin layer on single and rather limited spots.

single points and details, but cannot be considered decisive for the sheets where the concentration is such that the coating layer sometimes covers the entire folio, producing a strong white fluorescence under UV radiation.

The intervention of the colleagues of the Preservation and Conservation Department was also advantageous in the case of the folios of the Bobbio palimpsest whose legibility was compromised by the presence of paper fibres: they removed the fibres in the sections where there was major concentration, using the ultraviolet photos for better orientation. This preparatory operation made it possible to gain direct access to the writings on the parchment sheets and to fix them in clear images without disturbing interference.

Once these results had been obtained, the palimpsest was photographed in the infrared spectrum, a technique usually used in the photographic laboratory for the study of other types of documents. It was interesting to experiment with the infrared radiation's property of being able to infiltrate through the substance, both inorganic and organic, thus making it possible to reveal the lower layers invisible to the naked eye, aiming to overcome the layer made up of the gelatin-formaldehyde mixture, trying to reach the ink below.³⁰

In some cases this kind of approach did not produce the expected results, since, despite the fact that infrared radiation almost always passes through the gelatin and the stains of gallic acid, at times the infrared also passes through the ink below, both in the upper writing and in the lower script, with consequent reduction of readability. Therefore, this technique can be considered helpful, but not conclusive, for a number of the sheets.

Infrared photography, however, has proved to be decisive for those sheets containing a lower writing which is different from the upper one. In these cases the chemical component of the ink reacted decisively to this technique. Imaging made it possible to almost completely isolate the erased text from the more recent one, as well as from the extraneous materials present on the parchment, enabling almost total legibility of the inferior text.³¹ It is particularly encouraging that it was possible to obtain surprisingly good imaging of the *scriptio inferior*, especially in the case of those originals in poor condition whose corresponding images in visible light and in ultraviolet fluorescence were of very poor quality.



Fig. 4: Vatican Apostolic Library, Vat. lat. 5766, f. 21r photographed in RGB, in UV fluorescence, and with infrared reflectography (© Vatican Apostolic Library)

³⁰ Materials react differently to infrared radiation, reflecting, absorbing, or transmitting it. The visible result in photography of this illumination on materials depends on the chemical interactions of the material's compounds and on the frequency of the light with which these materials are illuminated. The results in photography, therefore, are often unpredictable, and an experimental attitude has to be held, sometimes allowing interesting discoveries even because of 'errors' committed by the imaging technicians.

³¹ The two filters W89b (that cuts at 690 nm) and W87c (at 790 nm) were suitable; in almost every case, the second has been found to be the more appropriate.

The photographic recovery of Vat. lat. 5766 cannot be considered complete, as there are challenges that have not yet been overcome: the reduction of fluorescence of the gelatin coating layer in ultraviolet photography, and the overlapping of upper and under script that cannot be tackled with conventional photography. To find solutions to these problems and make advances in our research on the whole manuscript, we will have to persevere and eventually have recourse to different and more powerful technologies.³²

It is worth mentioning that the Laboratory's historic archive preserves b/w negative transparencies and glass plates of a number of folios of Vat. lat. 5766 produced during previous decades. These analogue reproductions allow a similarly good readability of both writings, as do the new digital IR-shots. The images of Vat. lat. 5766 published in Lowe's guide,³³ edited in 1934, are also of the same good quality. This confirms the importance of a historical photographic archive alongside new cutting-edge photographic technologies applied to manuscripts. The reason for this is that old reproductions often document a better preservation state of the codex, and that analogue photography often provided good—sometimes unexpectedly good—quality.

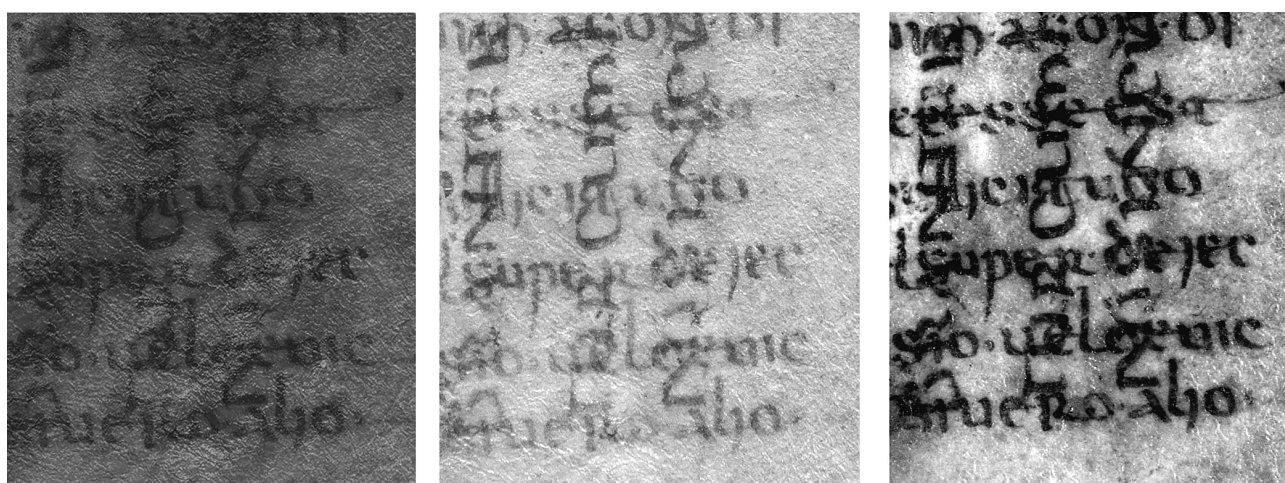


Fig. 5: Vatican Apostolic Library, Vat. lat. 5766, f. 46r (detail) captured in visible light with a palimpsest scanner, photographed digitally in NIR, and reproduced on a b/w negative transparency of the 1960s
(© Vatican Apostolic Library)

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³² A multidisciplinary approach, combining materials investigation and image analysis, could be beneficial. Given that different inks, because of their different chemical composition, should respond in distinct way to X-rays, X-ray fluorescence scanning performed in a synchrotron radiation-based source could help make it possible to separate the different text layers.

³³ Cf. Lowe, *Codices latini antiquiores* I, 14–15.

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