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Raphael and His Workshop Practices: A Technical and Art Historical Examination of the Tradition of Facsimile

THESIS

submitted in partial satisfaction of the requirements
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by

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DEDICATION

To

my parents, for their many sacrifices
and continued support

And

To my daughter, my reason for being.

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ABSTRACT OF THE THESIS

The Madonna of Divine Love by Raphael:
A Technical and Art Historical Examination of the Tradition of Replication

by

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Through an interdisciplinary examination of a privately-owned copy after Raphael Sanzio's *Madonna of Divine Love* , this thesis synthesizes technical analysis and art historical knowledge to establish consistencies in technique between the copy and its original. The lead, tin, and trace elements discovered in every area examined hold particular significance and suggest a traditional method of canvas preparation. The artwork's support material and pigments are identified and compared with the materials Raphael was known to have used in his practice. All evidence and data gathered suggests that the copy's current attribution to Raphael adjacent artist, Gian Francesco Penni, is possible and/or the painting could have been produced sometime in the one-hundred-year period following Raphael's death in 1520.

INTRODUCTION

In her introduction to the published proceedings from a Raphael symposium that took place at Princeton University in 1983, Marcia Hall describes a fundamental problem present at the heart of most museums or collections. She explains that, regardless of the possible insights to be gleaned through scientific examinations of works of art, "...it is virtually never undertaken in the interest of pure research."[1] That is, museums often need or want confirmation of authenticity, and this makes the possibility of disinterested research less likely. However, this thesis seeks to do just that. By first delving into the old Renaissance master Raphael da Urbino's career, painting techniques, and workshop the groundwork will be established from which to synthesize an analysis of a single painting that appears to be a copy of a famous late work attributed to Raphael and his workshop. Raphael's paintings were copied incessantly both during and after his lifetime, making the attribution and dating of these works challenging. This thesis will examine a work that appears to be a copy of the *Madonna of Divine Love*, a work associated with Raphael that is currently in Naples, Italy, at the National Museum of Capodimonte (fig. 1). The copy being examined here is currently attributed to a Raphael adjacent artist, Gian Francesco Penni, who worked in Raphael's workshop (fig. 2). Using a variety of both visual and scientific analyses, the organic and inorganic materials of the artwork's support and pigments have been identified establishing a baseline through which to compare known techniques and media employed by Raphael and his workshop to those used to create this copy.

[1] John K. G. Shearman, and Marcia B. Hall, "The Princeton Raphael Symposium: Science in the Service of Art History," (Princeton, N.J: Princeton University Press, 1990,) xiv.

CHAPTER ONE

Figure 1. Said to be the original *Madonna of Divine Love* by Raphael. Located in Naples, Italy at the National Museum of Capodimonte (image taken from Wikimedia Commons, July 19, 2024).

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CHAPTER ONE

Figure 2. *Madonna of Divine Love* copy under analysis, currently attributed to Gian Francesco Penni and in the ownership of Karyss Gonzalez. Photograph taken during phase one of analysis.

CHAPTER ONE

Raphael's late period (1513-1520) is most pertinent to this paper's purposes as it is during this time that the original *Madonna of Divine Love* was produced (fig. 1).[2] Throughout his career, Raphael's dynamic abilities were remarkable. Aside from being an accomplished painter, he was also a sculptor, administrator, architect, and even archeologist.[3] However, the fullness of his genius did not come to fruition until the start of his Roman period in 1508 when he was called to the Vatican by Pope Julius II. It is during his time in Rome that Raphael's career quickly builds momentum, beginning with his very first large-scale frescoes to adorn the walls of the papal apartments.[4] Following the death of Julius II, Raphael received extensive papal patronage from his successor, Leo X. Upon Raphael's sudden death in 1520 at the age of just thirty-seven, the artist was lavished with an honorary burial, "…accompanied by one hundred torchbearers [said to be painters with whom he collaborated] ...buried in the Pantheon-an honor accorded no other artist before and only rarely since." [5] Raphael's death was certainly untimely, as the artist was experiencing his zenith.

Accelerating this explosion of productivity was his appointment as the architect for St Peter's Basilica. To take on these enormous tasks, Raphael was forced to delegate increasing

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[2] Tom Henry and Paul Joannides, "Raphael and His Workshop between 1513 and 1525," In Late *Raphael*, (New York, NY: Thames & Hudson, 2013) 17.

[3] Tom Henry and Paul Joannides, "Raphael and His Workshop between 1513 and 1525," In Late *Raphael*, (New York, NY: Thames & Hudson, 2013) 17.

[4] "A Brief Introduction to Raphael's Life and Times," n.p.

[5] Henry and Joannides, "Raphael and His Workshop," 17; "A Brief Introduction to Raphael's Life and Times." A brief introduction to Raphael's life and times | The Credit Suisse Exhibition Raphael | National Gallery, London, 2022) n.p; Tom F. K. Henry, Paul Joannides, Ana González Mozo, and Bruno Martín, *Late Raphael* (Museo Nacional del Prado and Musee du Louvre, 2012) 24 & 68.

amounts of his commissions to those within his workshop, an evolution from necessity that was not without sharp criticism.[6] The overwhelming demand for artwork by the hand of Raphael created an environment that forced an adaptation of standards on behalf of both the patron and artist. Rather than Raphael's physical execution of an artwork holding the most value, it was his inspiration (or *concetto*) that began taking precedence for patrons. This certainly lends to the idea that *disegno,* or the act of creating design sketches prior to executing a painting, took on an increased importance within the atelier.[7]

Such preparation techniques placed upon the artist a burden that required a great amount of resources in the form of time and labor in order to produce the massive quantity of study sketches for each commission, as was the custom. For example, John Shearman describes the preparation by Michelangelo, whom Raphael looked to as a precedent for his own work, "The intensity and quantity of the preparatory material for the Sistine ceiling, from vestigial pen sketches to highly resolved life studies to the separate analysis of parts, down to hands, pieces of clothing, and heads, set a formidable precedent...this is the scale upon which Raphael worked in his first big Roman commission…"[8] From this we can infer an obvious relationship between the two artists; whether this can be understood as a rivalry or simply *iron sharpening iron*, it is clear that Raphael allowed his work to be shaped by those around him who were working at a high level. Furthermore, it is understood that Raphael did an extensive amount of preparation for his work like his contemporaries, and that he saw value in this practice, or he would not spend such extensive

[6] Henry and Joannides, "Raphael and His Workshop," 19.

[7] Bette Talvacchia, "Raphael's Workshop and the Development of a Managerial Style," essay, in *The Cambridge Companion to Raphael* (New York, NY: Cambridge University Press, 2005), 168.

[8] John Shearman, "The Organization of Raphael's Workshop," (Chicago, IL: Museum studies, 1983) 44.

amounts of time doing so. However, it is in this phase of his production where the artist was eventually able to conserve his time, allowing him to undertake the sheer magnitude of production seen from his workshop during his Roman period.

By allowing those within his circle to participate in the process of *disegno* (something unheard of with either Michelangelo or Leonardo), he broke away from the usual workshop practices and was able to substantially increase the efficiency of his workshop. Yet he did so without compromising his own ingenuity, a resolve he was firmly committed to.[9] Shearman describes Raphael's approach: "...he followed one natural principle: that the inventions at all costs should be his…By no means did he ever delegate the inventive stages of any work in which he was ultimately involved as painter."[10] Rather, Raphael would create loose, fast, and near manic compositional sketches which would then be further refined by those within the atelier.

This practice both trained his team in this phase of creation and trimmed the preparatory time for a given artwork.[11] According to Shearman, "The use of assistants to copy rough sketches, keep records of drawings, and make life studies was a novel departure in workshop practice."[12] The original composition was the invention of Raphael, while the artists whom he employed (or rather, deployed) acted as a means of refinement while still maintaining Raphael's initial conception. This is one way Raphael differentiated himself from his contemporaries and was able to handle the workload he amassed. As Talvacchia notes, "Pressed he certainly was; but in typical fashion,

[9] Shearman, "The Organization of Raphael's Workshop," 44.

[10] Shearman, "The Organization of Raphael's Workshop," 47-49.

[11] Shearman, "The Organization of Raphael's Workshop," 49.

[12] Shearman, "The Organization of Raphael's Workshop," 49.

Raphael transformed pressure into innovation."[13] From an economic standpoint, this innovation shifted the supply curve allowing him to meet the staggering demand for his work.

If Raphael was the mind (the innovator), his collaborators acted as the body, all working in accordance to produce within the work, "a unity of conception and a conformity of execution which rather lessens the importance of the contribution of individual hands..."[14] This aspect of his workshop was not the only deviation from those of his contemporaries. In fact, Raphael ran his workshop in an altogether novel manner, a practice that would endure postmortem and even inspire the academies to come.[15]

The administrative style employed within his atelier was another way in which Raphael's creativity manifested. His innovative use of the talents and abilities embodied in his assistants and collaborators created a template for the management of his workshop. He fostered a working environment that was adaptable and dynamic, which allowed creativity to thrive. Rather than functioning as something of an assembly line, as was the norm in *quattrocento* bottegas, Raphael's workshop functioned in a much less rigid manner; it was a flexible superorganism that "expanded and contracted" to accommodate the demands placed upon it. With this came a collection of laissez faire collaborators within the workshop as, "visitors from northern Italy, even from northern Europe, floated in and out."[16] Nevertheless, a core cadre of artists remained constant, including

[13] Talvacchia, "Raphael's Workshop and the Development of a Managerial Style," 173.

[14] Joyce Plesters, "Raphael's Cartoons for the Vatican Tapestries: A Brief Report on the Materials, Technique, and Condition," essay, in *The Princeton Raphael Symposium: Science in the Service of Art History* (Princeton, NJ: Princeton University Press, 1990), 124.

[15] Talvacchia, "Raphael's Workshop and the Development of a Managerial Style," 176.

[16] Shearman, "The Organization of Raphael's Workshop," 41.

Perino del Vaga, Giovanni Francesco Penni, Giulio Romero, Giovanni da Udine and Polidoro da Caravaggio.[17]

It is important to note that the dynamics within Raphael's bottega were still not without hierarchy, the lowest within the framework being mere *garzoni* who were expected to take on menial tasks such as sweeping and grinding pigments. Those actively learning were apprentices occupying the tier above who were likely involved in basic preparations. This stage was followed by a more advanced role that would have gained the title of "pupil" and those occupying this tier were in the process of acquiring practical skills to assist with commissioned projects, within which we could place Raphael's eventual successors Giulio Romero and Gian Francesco Penni. [18]

The lifeblood of this synergistic dynamic depended on well-discerned delegation, trust, and unique collaborative involvement that was ubiquitously applied to all stages of the artist's creative process. Alexis Culotta describes the shift in workshop practice that resulted in a creative environment that was, "not as a space of slavish apprentices following strict expectations of their masters, but rather as an environment for innovation and exchange."[19] In other words, Raphael did not utilize his apprentices as a drone workforce, but rather he seems to have analyzed and valued their individual talents, delegating responsibilities accordingly.

Moreover, the way he conceived of those at his disposal extended to the artwork itself. Talvacchia explains that Raphael "conceptualize[d] the works in a manner that took into account the talents of his numerous assistants and was fed by the particular ingredients that each collaborator

[17] Alexis Culotta, "Raphael and His Roman Workshop," in *The Renaissance World Routledge*, (London: Taylor and Francis, 2022), 7.

[18] Henry and Joannides, "Raphael and His Workshop," 19.

[19] Culotta, "Raphael and His Roman Workshop," 2.

could add to the overall effect."[20] These unique managerial choices by Raphael do not stand apart from the work itself. Rather, one must understand them as a vital orchestration of the entire creative process. Just as an artist must choose the perfect shade of color for the completion of a painting, so too must he select the hands to assist him, each having their own unique strengths and weaknesses, akin to a color's vibrancy and value. Raphael utilized those within his workshop accordingly, assigning tasks to those who would best fill a given niche.

For example, while Romano was utilized in a much more tactile way, we can understand Penni's role as an administrative one. In fact, among scholars today Penni is not considered a truly gifted artist by most, and upon the premature death of Raphael, he did not continue on to open his own workshop as Giulio Romano did.[21] This could explain the role he assumed under Raphael, working essentially as a secretary behind the scenes. What we do know about Penni is that he played a very key role in the administrative side of the workshop. Countless sources refer to him as "*il Fattore*" which implies a role akin to a liaison. This would have entailed communicating with patrons by showing them cartoons of the compositional direction a commissioned painting was headed. He could have also been responsible for recording finished artworks as a mimetic invoice done by creating a facsimile of them. John Shearman dissects the confusion surrounding the practice, "A copy has no role in the preparatory process. It is more likely to have a role ex post facto, preserving for posterity the steps in the master's creative path…this record-keeping function

[20] Talvacchia, "Raphael's Workshop and the Development of a Managerial Style," 168.

[21] Henry and Joannides, "Raphael and His Workshop," 68.

became a secretarial task." He continues, "The secretary was Giovanni Francesco Penni, who increasingly performed exactly that sort of function in the workshop."[22]

It is this function that often causes a great deal of confusion for art historians, who find attributing paintings to Penni difficult for these reasons. To make matters worse Shearman goes on to explain, "facsimiles sometimes record pentimenti…However, since they are not genuine pentimenti, they are a clue to the purpose of these copies."[23] Thus, the copies that could have been produced by Penni as he fulfilled "his function…of a visual secretary" could either be a record of the intended design for a commission, or a means of documenting completed artworks.[24] Further still, we know that artists under the tutelage of their master would often copy their paintings as a means of training. In fact, Raphael himself was required to follow this same tradition under his mentor Pietro Perugino, creating flawless copies.[25] Understandably, these facsimiles are often interpreted as preparatory cartoons leading, by proxy, to an attribution of the corresponding painting, often resulting in inaccuracies.[26]

This is precisely what befalls Raphael's *Madonna of Divine Love*, located in Naples (fig 1). The Naples panel is believed to be the original version of this painting, which was extensively copied following Raphael's death. However, attribution has been elusive over the years. Throughout the 19th century, the painting was attributed to Raphael. This later changed in 1885 when it was

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[22] Shearman, "The Organization of Raphael's Workshop," 49.

[23] Shearman, "The Organization of Raphael's Workshop," 48; Pentimenti essentially translates to "repentances" and describes underdrawings that reveal the artist having changed their mind while executing the subsequent layers of a painting see: "Pentimento," Encyclopædia Britannica, December 9, 2014, https://www.britannica.com/art/pentimento-oil-painting, n.p.

[24] Henry and Joannides, "Raphael and His Workshop," 68.

[25] Culotta, "Raphael and His Roman Workshop," 4.

[26] Shearman, "The Organization of Raphael's Workshop," 48.

attributed to his pupil, Giulio Romano.[27] Thereafter the attribution shifted to that of Gianfrancesco Penni due to the discovery of a large-scale drawing of the exact same image also attributed to Penni (fig. A.1). The sketch was originally in the possession of Fulvio Orsini, and it was believed to be a preparatory cartoon for the painting.[28] However, this assumption has since been refuted through scientific analysis. With infrared reflectography, conservators reattributed the Naples *Madonna of Divine Love* to Raphael.[29]

Conservators concluded that the cartoon by Gianfrancesco Penni, once believed to be a preparatory drawing for the *Madonna of Divine Love*, is in fact the opposite. It is a drawing done of the finished painting, for the purpose of record keeping (which certainly fell into the jurisdiction of Penni).[30] This is now evident due to a distinctly different under drawing that was made visible upon examining the Naples painting using infrared reflectography (fig A.2). The pentimenti observed by conservators presented evidence of variations and organic adjustments to the finished artwork while the painting was being executed, a liberty only truly allotted to Raphael himself.[31]

Rather than the ponderous, aloof Saint Joseph, who is relegated to the back wall of a decrepit archway, the original sketch reveals an infinite depth of field. Some of this was already painted before the change in composition occurred. The figure grouping in the foreground was intended to occupy a raised palatial veranda, while stairs in the background would have guided the

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[27] Charles, Frank Tryon, and Karl Károly. Raphael's Madonnas & Other Great Pictures Reproduced from the Original Paintings: With a Life of Raphael and an Account of His Chief Works. (London: G. Bell & Sons, 1894), 112; Angela Cerasuolo, Patrizia Piscitello, and Marina Santucci, *Raffaello: La Madonna Del Divino Amore* (Mantova: Corraini edizioni, 2015), 20.

[28] Cerasuolo, Piscitello, and Santucci, *Raffaello: La Madonna Del Divino Amore*, 37.

[29] Cerasuolo, Piscitello, and Santucci, *Raffaello: La Madonna Del Divino Amore,* 20.

[30] Shearman, "The Organization of Raphael's Workshop," 49.

[31] Cerasuolo, Piscitello, and Santucci, *Raffaello: La Madonna Del Divino Amore,* 20.

viewer to a spacious pastoral landscape, complete with a waterway and picket fence. The entry point into the limitless horizon was to be flanked by an architectural column and balustrade with ornate posts carved into "putto-telamon" atop a sphinx (fig. A.3).[32] Historians suspect this substantial stylistic change in composition could imply that the painting was worked on over a prolonged period. By the time it was finally completed, Raphael's style had changed so much that he felt the composition ought to change as well.[33]

Most convincing is the clear visual connection between the discernible pentimenti beneath the *Madonna of Divine Love* and an engraving by Marcantonio Raimondi titled *Madonna of the Palm* created after Raphael's death (fig. A.4). The most minute elements of the under drawing are clearly represented within the print; even the small cup tied to St. John the Baptist's right side is depicted (figs A.5 and A.6). This almost perfect alignment suggests to art historians that a now lost drawing of the figure group must have been circulating at some point, eventually inspiring Raimondi's engraving sometime after the *Madonna of Divine Love* was altered.[34]

Moreover, prior to concealing the panel's agrarian landscape and antique architecture, Raphael created a study of Joseph in red chalk on paper (fig. A.7). It shows the artist's calculated readjustment to the painting, and for this reason its attribution has shifted in accordance with the facsimile sketch and painting.[35] By concealing the architecture and conjuring the contemplative

[32] "Putto" is the Italian term for a winged angelic child while "Telemon" is a reference to an architectural feature of a weight bearing figure seen in antiquity. Cerasuolo, Piscitello, and Santucci, *Raffaello: La Madonna Del Divino Amore,* 53; 1. Naomi Blumberg, ed., "Putto," Encyclopædia Britannica, July 20, 1998, https://www.britannica.com/art/putto; Calder Loth, "Telamones and Atlantes," *Classicist.Org*, 2023, https://www.classicist.org/articles/classical-comments-telamones-and-atlantes/.

[33] Cerasuolo, Piscitello, and Santucci, *Raffaello: La Madonna Del Divino Amore,* 57.

[34] Cerasuolo, Piscitello, and Santucci, *Raffaello: La Madonna Del Divino Amore,* 68.

[35] Cerasuolo, Piscitello, and Santucci, *Raffaello: La Madonna Del Divino Amore,* 57.

Saint Joseph within the background, the figure grouping of Madonna and Child, Saint John, and Saint Elizabeth (though some interpret this to be Saint Anne) becomes the true focus by way of contrast. Perhaps this compositional redirection contributed to the piece's enduring veneration throughout time by imploring the viewer to contemplate a moment of tender reverence, rather than visually wandering off into an expansive pastoral abyss.

Furthermore, the resonance this artwork had with those privileged enough to behold it led to the creation of a multitude of copies. When considering how in demand Raphael's work was prior to his death, one can only imagine the insistence for his artwork postmortem. However, given his usual patronage, the original works were often in the possession of the papacy or high-level dignitaries and religious orders. This pressure certainly contributed to his work being copied with such avarice. Of course, the motivations for replicating a specific artwork varied, but for the most part, his paintings that spent the most time in Rome were copied most frequently.[36]

A painting's subject matter also greatly contributed to collectors' desire to replicate it. Compositions of a divine nature were highly favored; some even believed them to have apotropaic functions, as seen with the *Madonna of the Veil*. Interestingly, this Madonna is strongly associated with *The Madonna of Divine Love* due to their shared provenance. Both were owned by the Farnese, and both were adjacently displayed.[37] Cavazzini explains that "...the prestigious provenance of a picture could also have contributed to the desire to own a replica…some Roman collectors owned [copies of] both the Madonna of the Veil and that of Divine Love...following the example of the

[36] Patrizia Cavazzini, "The Madonna of the Peil and other Copies after Raphael in Seicento Roman Dwellings: Visibility, Faith and Vasari's Lives," in *Storia dell'Arte,* (Firenze: La Nuova Italia Editrice, 2021) 91.

[37] Cavazzini, "The Madonna of the Peil and other Copies," 92.

Farnese."[38] Giorgio Vasari's opinions on artwork also greatly influenced which pieces collectors wanted replicated to be held in their private collection. Specifically, his judgements on Raphael's quality and authenticity of a painting had the power to dictate replica preferences. Furthermore, it is known that Vasari speaks very highly of the *Madonna of Divine Love,* praising the artwork as being, "Most miraculous for its colors…" He continues, "...I don't think anyone can do better." [39] Clearly, *Madonna of Divine Love* was an excellent candidate for replication. Its contemplative reverence, prestigious provenance, and approval by Vasari all contributed to its desirability and, thus, extensive replication.

Cavazzini notes that Pope Urban VIII commissioned a copy to go along with its usual pairing with *The Madonna of the Veil*. She also mentions another commission for the pair from Marquis Cesare Capilupi prior to 1603.[40] Clearly there was a demand for this artwork by collectors of the 17th century. Getty images has a photograph of a copy found within the collection of Museo Diocesano, Jesi, and their website has an image of the museum space where the painting is hung.[41] A much later copy from the 19th century recently sold through an online marketplace called 1st Dibs for just under $3,500.00; a company called 1st-Art-Gallery.com offers the service of creating a handmade reproduction painted in oil for almost $900.00.[42] These modern examples of the practice of reproduction indicate a continued interest in this artwork throughout the centuries.

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[38] Cavazzini, "The Madonna of the Peil and other Copies," 91 & 97.

[39] Cavazzini, "The Madonna of the Peil and other Copies," 91 & 97.

[40] Cavazzini, "The Madonna of the Peil and other Copies," 97.

[41] Unfortunately I could not find addititional information on this work or its provenance. "Arte Antica e Moderna," Museo Diocesano Jesi, November 11, 2016, https://museodiocesanojesi.wordpress.com/museo/opere/arte-antica-e-moderna/, n.p.

[42] "Raphael (Raffaello Sanzio Da Urbino) - Madonna of the Divine Love Copy from Raffaello Sanzio,"

Another necessary caveat is the possibility of forgery. There is certainly a fine line between the tradition of creating copies and an act of forgery. Helstosky describes this distinction as a matter of intention. When an artwork is created with deceptive intention it is then characterized as forgery, though these ill intentions can have various motivations such as greed, egotism, or revenge.[43] Furthermore, forgeries can be directly correlated with the demands of the art market which, in nineteenth century Italy, was being flooded with, "unwitting and inexperienced customers," by way of foreigners newly discovering, "what they understood as Italian art."[44] Given the context at that time and the undoubted demand for Raphael's work, is there a chance that this copy was created much later with the intent to deceive buyers into thinking it was produced by his actual workshop? Both the tradition of copies and forgeries complicate the issue of how to date and understand the artwork under consideration here. Where exactly does the painting under analysis fit into the broader tradition of facsimiles? Was it produced by Gian Francesco Penni within the years following the death of Raphael as the current attribution would suggest? Or was it created much later in the 19th century for the American art market? These are some of the questions this analysis sets out to answer.

Raphael (Raffaello Sanzio da Urbino) - Madonna of the Divine Love Copy from Raffaello Sanzio at 1stDibs | raffaello sanzio da urbino, madonna of divine love, raffaello sanzio da urbino madonna, 2024, https://www.1stdibs.com/art/paintings/interior-paintings/raphael-raffaello-sanzio-da-urbino-madonna-divine-love-copy-from-raffaello-sanzio/id-a_4085361/, n.p; "Madonna of Divine Love (Copy from Rafaello)," 1st handmade portraits and reproductions, accessed June 26, 2024, https://www.1st-art-gallery.com/Anton-Raphael-Mengs/Madonna-Of-Divine-Love-Copy-From-Rafaello.html, n.p.

[43] Carol Helstosky, "Giovanni Bastianini, Art Forgery, and the Market in nineteenth-Century Italy," *The Journal of Modern History* 81, no. 4 (December 2009): 793–823, https://doi.org/10.1086/605486, 793.

[44] Helstosky, "Giovanni Bastianni," 795.

CHAPTER TWO

The analysis of this painting was executed in two phases. The first phase consisted of preliminary observation using noninvasive techniques including a close visual examination, the use of raking light, and UV induced visible fluorescence (UVIVF) for which a TATTU U3S 10-Watt Ultraviolet LED lamp was employed. The main goal for this initial phase was to identify areas of interest that could guide the subsequent more invasive techniques. For example, under the UV light it became clear what areas were overpainted in recent interventions, therefore guiding the selection of pXRF measurements to follow. A limitation of this method is its innate susceptibility to misinterpretation as it is solely based on empirical observation. For example, what one person might visually perceive as a pink fluorescence, the other may describe as peach. These observations are then compared to past scholarship that details the visual perception of those scholars observing a given material under UV radiation. What's more, when materials are mixed, which is often the case in paint media, it can be difficult to determine what is specifically causing the observed fluorescence.

In the second phase the painting was analyzed using X-ray Fluorescence (XRF) spectrometry and samples were taken. Given the size of the artwork (41 ¾ by 54 inches), a Bruker Tracer 5i portable XRF equipped with an 8mm collimator, rhodium thin window x-ray tube and silicone drift detector was employed which eliminated the need to transport the painting. Eighteen points on the canvas were selected for analysis and data was acquired using 40kV/11μA with no filter in air for 60 seconds (fig. F.1). These areas were chosen because they provided a representative sample of the painting's range of colors and hues with some identified as areas of interest after UVIVF examination. All samples were processed and analyzed using the ARTAX V. 8 software from Bruker AXS.

It is crucial to note the limitations of using pXRF for pigment analysis. This method can only provide information on inorganic materials heavier than magnesium found on the canvas.[45] Another limitation is that the X-ray energies of different elements could be similar and their peaks overlap in the spectrum acquired making identification of some elements difficult. Lastly, in heterogenous substrates such as a painting on canvas the instrument will detect the elements in the path of the beam and does not provide information for what depth a particular element was detected. This means that the user must determine which layer of the painting or which materials the detected elements correspond to.[46] Nevertheless it is a noninvasive analytical tool that does identify a range of elements making this technique worth utilizing for identifying possible metallic pigments present on the canvas. However, XRF alone cannot provide a complete picture on the materials used by the artist. It is for this reason more invasive techniques were necessary.

Using a scalpel, eleven samples were taken from the artwork, all located on the portion of the canvas that wraps around the stretcher bars hidden beneath the frame as these were the least invasive areas to take samples from. The painting first had to be removed from the frame to gain access to these discreet locations. Samples were chosen solely for the purpose of variety and ease of removal. Polarized light microscopy was used for identification of the blue pigment used in the sky. Two layers of canvas visible at the corner folds found when sampling indicated that the painting had

[45]Aaron Shugar, "Portable X-Ray Fluorescence and Archeology: Limitations of the Instrument and Suggested Methods To Achieve Desired Results," essay, in *Archeological Chemistry VIII* (Washington, DC: American Chemical Society, 2013), 173–93.

[46] Robert J. Speakman et al., "Sourcing Ceramics with Portable XRF Spectrometers? A Comparison with INAA Using Mimbres Pottery from the American Southwest," Journal of Archaeological Science, August 23, 2011, https://www.sciencedirect.com/science/article/pii/S0305440311002822, 181.

clearly been relined. This motivated the decision to take samples from both the old canvas and new to identify the material used to make the canvas and compare materials over periods of time.

To identify the material from both the canvas fibers and blue pigment, samples were analyzed using an AmScope PZ600T microscope under both plane and cross-polarized light. Preparation for fiber analysis was minimal, as fibers were simply separated from the fabric sample and mounted on glass with a drop of water while the blue pigment was mounted using Cargille Meltmount that has a refractive index of 1.66.

Lastly, two samples were taken from the blue sky for the purpose of creating cross sections to understand the stratigraphy of the paint layers, canvas preparation, and how colors were created. The samples were embedded in Struer's Epofix resin with a small rectangular mold made of silicone rubber. After curing, the embedded samples were polished with Buehler Carbimet 2 grinding paper (400-1200 grit) followed by Micromesh in the final stages of polishing. The final cross section serendipitously contained a fiber cross section as well. The cross-sections were then examined using a Nikon Epiphot metallographic microscope (10-40x) under both reflected and cross-polarized light. The images were captured using an AmScope microscope digital camera (MU1803) processed with the software AmScope Amlight (Appendix E).

CHAPTER THREE

The following chapter will discuss what was found through the analysis and what these findings may indicate, beginning with the most apparent observations and ending with more in-depth analyses. Following an overall visual analysis of the artwork, findings will be presented in the order in which the artist likely would have worked, starting with the support, then priming layer, followed by the pigments.

Visual Survey: the artwork hung precariously on a white wall in a room with sunlight filtering through from two windows and a door. It was held up by a single wire secured to the back of a wooden frame painted gold with a straight rabbet sloping upwards to a lobed decorative outer edge. On the bottom center of the frame a small metal plate was secured with two small nails on either side (fig. B.1). On it were the words, "Giovan Francesco Penni (Raphael School)." Dismounting the artwork from the wall and turning it over revealed various inscriptions on both the left and right sides of the painting's stretcher bars (figs B.2-B.5). Along with the writing was a nearly worn off label for a depository in Cheltenham, England called Barnby Bendall & Co. located on the left side of the back of the painting (fig. B.6). The inscriptions just above this label are almost entirely indecipherable, except for the year 1836. Given this company is said to have been established in 1839 and the label seems to ever so slightly overlap what has been written, the inscription on the left side of the stretcher bars likely came first and the label to follow a handful of years later.[47] Furthermore, since the company originated in England, this places the painting in the United Kingdom at some point in the 19th century. The writing on the opposite side does not appear to have been by the same hand. However, the inscription on the right side also seems to indicate

[47] Archives.trin.cam.ac.uk, accessed June 24, 2024, https://archives.trin.cam.ac.uk/index.php/barnby-bendall-and-co-ltd.

provenance. The words that can be deciphered are as follows: "Bought by George Maurice 1872, given to his daughter…Inherited by her sister 1894 Anna Bruce Pryce she framed it 1901." It is important to note that the entire inscription on this side of the stretcher bars seems to be in the same handwriting. It could have even been written by Anna Bruce Pryce herself, done so retroactively for her sister and her father, but contemporaneous to inheriting the painting. Furthermore, it informs us that the frame is not original to the artwork, therefore placing the attributive plaque secured to it into question.

Raking Light: following a visual analysis, the canvas' surface was observed using raking light. This made clear some of the prior conservation treatments. There had been a circular fracture located on the right side of the Christ child's buttocks, as well as regions of crackling elsewhere, all of which had been addressed. In so far as there are observable brush strokes, only the strokes from the varnish applied in its last conservation treatment were visible, and these strokes appeared to be running both horizontally and vertically. However, located on the Madonna's blouse just below her hands in prayer there was a region of cross hatching, most visible in person though the ultraviolet image does show it somewhat (fig. D.3). Scholarship confirms that Raphael would often use, "…dark hatched brushstrokes to reinforce an area of shadow…"[48] Perhaps this technique is being utilized by a follower here.

UVIVF: Due to the recently applied damar varnish, the entire surface of the canvas slightly fluoresced a nearly white color with a green cast which does correspond with the expected fluorescence.[49] Its presence deemed any form of interpretations of possible materials present

[48] Ashok Roy, Marika Spring, and Carol Plazzotta. "Raphael's Early Work in the National Gallery: Paintings before Rome." (United Kingdom: National Galleries, 2004) 8.

[49] 1. Danielle Measday, Walker Charlotte, and Briony Pemberton, "A Summary of Ultra-Violet Fluorescent

beneath this layer mere speculation. Areas that had been in-painted during prior treatment were the exception, as they did not fluoresce but appeared as dark patches in these regions (figs D.1-D.6). These areas were most prominent on the Madonna's face, hair, and the cheek of the Christ child (figs D.1 and D.2). When comparing these regions to images taken prior to the painting's conservation, it was clear that inpainting had been done to cover discoloration and scratches in these exact areas (Appendix B). These empirical observations acted as guiding forces that directed methods to follow.

Material support: the first material to now be discussed is the support chosen by the artist. Clearly the painting was done on a canvas wrapped around wooden stretcher bars. This alone possibly indicates a later work than those seen at the height of Raphael's career, as most of his portable paintings were wooden panels rather than stretched canvas. However, both his father Giovanni Santi and mentor Perugino were known to produce on canvas, so it was not unfamiliar to him .[50] Microscopic fiber analysis of both the old canvas and new canvas from a previous relining reveal that the fabrics are made of the same materials (figs E.1-E.4). Though the ply and twist of the fibers were not visible, they were made using a plain weave. X-shaped nodes located perpendicularly along the fiber strands as well as the presence of a thin lumen in the center of the strands are indicative of a bast fiber. All bast fibers come from the stem of a plant; these include hemp, flax, nettle, jute, and ramie.[51] Though distinguishing between these fibers can be a challenge,

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Materials Relevant to Conservation," Australian Institute for the Conservation of Cultural Material, November 21, 2023, https://aiccm.org.au/network-news/summary-ultra-violet-fluorescent-materials-relevant-conservation/, n.p.

[50] Roy, Spring, and Plazzotta. "Raphael's Early," 5.

[51] T. Editors of Encyclopaedia Britannica, "Bast Fibre," Encyclopædia Britannica, 2021, https://www.britannica.com/technology/bast-fiber, n.p.

the cross section most closely resembles flax due to its overall clumping pattern and polygonal shape (fig. E.5). [52] The presence of a flax fiber would indicate that the support used by the artist was likely linen, as was the material used for relining.

Given that examples of the use of both hemp and linen supports can be found from as early as the ancient Egyptians, this material selection is not out of the ordinary for the decades after Raphael's death.[53] In fact, scholarship confirms that Raphael's father painted on both plainly woven and herringbone linen.[54] The use of a plain weave linen support would thus have been possible during the artist's lifetime, and exposure of this material to Raphael and his workshop by way of his father is completely feasible.

Priming Layer: Having narrowed down the support material to a plainly woven linen fiber, how would this canvas have been prepared prior to the artwork being created? Part of this process would have entailed applying a priming layer onto the canvas. Technical analyses executed on various paintings by Raphael reveal the use of a gypsum (calcium sulfate dihydrate) layer of gesso followed by a layer of *imprimitura* consisting of lead white and trace amounts of lead-tin yellow all bound in oil.[55] To this mixture, there is also evidence of the addition of colorless glass particulates likely used as a siccative, or drying agent, within the paint. This type of canvas preparation is

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[52] Bergfjord and Holst, "A Procedure for Identifying Textile Bast Fibres…" 1192; 1. "Linen Traits," Ulster Linen, May 4, 2018, https://ulsterlinen.com/linen-traits/.

[53] Nicholas Mander, "Painted Cloths: History, Craftsmen and Techniques," *Textile History* 28, no. 2 (Philadelphia: Maney Publishing, 1997) 128.

[54] Gianluca Poldi, G. Poldi, M.L. Amadori, V. Mengacci, "Technical Peculiarities in Giovanni Santi's Paintings on Canvas", in *Materia: Journal of Technical Art History,* Vol. 1, Issue 1, (Massachusetts: Academia Publishing, 2021) 30.

[55] Roy, Spring, and Plazzotta. "Raphael's Early Work in the National Gallery," 5.

described as having been, "often used by Raphael and his entourage."[56] What's more, the technique was extremely common within Italy at this time, though cases elsewhere also do exist.[57]

Comparing this information with the painting being analyzed, pXRF measurements revealed considerable amounts of lead throughout the canvas (fig. F.3). Its consistency in the measurements was so prevalent that, given the thickness of the painting, the wall on which the canvas was hung was also tested to be certain that the beam was not traveling through the canvas and picking up lead on the wall behind it (no lead was found there). Along with the presence of lead on the canvas, there was also a consistency in the presence of several trace elements. These include tin, aluminum, silica, sulfur, manganese, calcium, potassium, titanium, and iron. Marika Spring lists the elements typically present in glass as follows: "…silicon is of course the major component; also present are sodium, magnesium, aluminum, potassium, calcium, titanium, manganese and iron." [58] The presence of these elements in all the areas measured indicates the use of such a glass siccative. Furthermore, there are particulates visible in cross-section samples, which are likely pieces of powdered glass suspended within the mixture. Cross section examination also reveals a white priming layer located below the colored paint and above the canvas material (figs E.6 and E.7). Tin is present due to the use of lead tin yellow to produce an off-white priming layer. It is important to note that, though this technique was certainly used by Raphael's workshop, scholarship claims that

[56] Henry, Joannides, González Mozo, and Martín, *Late Raphael,* 357.

[57] Roy, Spring, and Plazzotta. "Raphael's Early Work in the National Gallery," 5.

[58] Marika Spring, *Raphael's Materials: Some New Discoveries and Their Context*, (London: National Gallery, 2004) 79.

these layers took on a much more saturated hue nearing the end of the sixteenth century, while the *imprimatura* under analysis appears to be rather light.[59]

Pigments: After the canvas preparation, powdered pigments would have been selected and mixed with a binding medium. The white, brown, red, and blue pigments visible on the canvas will be discussed here. Due to the obvious tonal variations seen within the artwork, the artist clearly needed a white paint to be mixed with the selected colors creating the highlights that produce depth and form within the painting. Based on the high levels of lead, one can assume the white pigment chosen for this purpose was a lead white. This can also be inferred when comparing the pXRF measurements taken from areas of contrast such as from Madonna's shaded skirt (fig F.10). These areas of contrast show fluctuations in lead concentrations; darker regions have a lower concentration, while the lighter areas show an increased amount. It is important to note that, in areas where UV fluorescence revealed modern intervention, the concentration of titanium substantially increases, shifting from a trace amount seen in non-retouched areas to higher concentrations where there is inpainting (fig F.24). This suggests that conservators used titanium white for their in-painting while the original white paint was lead based. Given the widespread use of lead white pigment from antiquity even up until the 20th century, this material would have been readily available and in use over a long time span.[60] However, the titanium white is certainly of modern intervention as its production only began during the first world war.[61]

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[59] Henry, Joannides, González Mozo, and Martín, *Late Raphael,* 362.

[60] Victor Gonzalez et al., "Revealing the Origin and History of Lead-White Pigments by Their Photoluminescence Properties," *Analytical Chemistry* 89, no. 5 (February 21, 2017), 2909.

[61] Raymond B Seymour, "History of Colorants in Polymers" in *History of Polymeric Composites* (The Netherlands: VNU Science Press,1987) 3.

Having established the pigment used for creating highlights within the artwork, the clear next step is to address what was likely used for the lowlights and shadows. Just as areas of contrast exhibit a stark difference in lead concentration, the amount of iron in these regions also fluctuates. In the darkest region of the painting located at the bottom right corner of the image (spot 1551), there is a higher concentration of iron, manganese, and calcium when compared to the milky white color located on the Madonna's shawl (figs F.18 and F.22). The presence of iron and manganese is indicative of the use of either a raw or burnt umber for creating the shadows.[62] Though this pigment has been known for thousands of years, Vasari describes it as a relatively new addition to the artistic repertoire, implying its renewed popularity during the fifteenth century.[63]

The pigments mentioned thus far can be understood as vectors for creating tints and shades of color within the painting. Turning to the hues evident in the artwork we can see mainly a red color lightened to a shade of pink (likely using the afore-mentioned lead white) used on the blouse of the Madonna, and a vibrant blue for her skirt, as well as the sky. PXRF analysis of the highlights and shadows of both the Madonna's blouse and hem show the presence of mercury indicating the red pigment vermillion (HgS) was mixed with the lead white to produce the varying shades of pink (fig. F.21).

Finally, the blue pigment used was of particular interest. PXRF analysis revealed that the same pigment used for Madonna's skirt was also used in the blue of the sky due to their measurements being nearly identical (fig. F.13). Even after analysis, however, its identification is

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[62] Randolph Larsen, Nicolette Coluzzi and Antonino Cosentino, "Free XRF Spectroscopy Database of Pigments Checker," in *International Journal of Conservation Science* 7, no. 3 (2016): 659–68, https://chsopensource.org/free-xrf-spectroscopy-database-of-pigments-checker-2/, 661.

[63] George O'Hanlon, "The Versatility and Sustainability of Umber: Exploring the Natural Brown Earth Pigment," Natural Pigments, March 18, 2024, https://www.naturalpigments.com/artist-materials/umber-exploring-natural-brown-earth-pigment#mcetoc_1gra4ls4b0.

mostly based on eliminating other possible options. Copper was not present in these areas. This eliminates the use of azurite, Egyptian blue, phthalo blue, and blue bice. There is also no evidence of cobalt, which then eliminates the use of smalt, cobalt blue, and cobalt violet. Another possible blue pigment is ultramarine a sodium-aluminum-silicate pigment. Sodium falls outside of the range of elements detectable using XRF; recalling that the *imprimtura* layer already contains both aluminum and silica due to contaminates in the siccative, these elements are ubiquitously present across the canvas. According to Larsen et. Al. XRF measurements of ultramarine should detect trace amounts of both iron and copper, but no copper is present.[70] Iron was found in all the areas analyzed so its presence alone would not indicate the use of ultramarine (fig. F.13). However, polarized light microscopy did help with identification of the pigment. Under plane polarized light the particles are bright blue and seem to vary in size (fig. E.8). Under cross polarized light the particles disappear and are isotropic (fig. E.9). This characteristic narrows down the identification to either Ultramarine or Prussian blue.[71] Given that Prussian blue is an iron-hexacyanoferrate, one would expect that the iron concentration would increase in this area rather than having the same peak height as some non-blue areas such as flesh tones (spot 1555).[72] All of these combined observations lead to the conclusion that this pigment is most likely ultramarine.

There are both natural and synthetic versions of ultramarine. The synthetic version, called French Ultramarine, was not invented until 1828 while the natural pigment, derived from the semi-

[70] Larsen, Coluzzi, and Cosentino, "Free XRF Spectroscopy Database," 661.

[71] W.C McCrone, "The microscopical identification of artists' pigments," in *Journal of the International Institute for Conservation-Canadian Group (Canada:* 1982)11-34.

[72] Randolph Larsen and Nicolette Coluzzi, "Free XRF Spectroscopy Database of Pigments Checker," 663.

precious stone lapis lazuli, is considered one of the oldest blue pigments in history.[73] Though it can be difficult to distinguish between the two, the synthetic pigment has finer, more uniform particles while the natural ultramarine particles are more irregular in size.[74] From the sample examined, the particles do appear to vary in size, lending credence to the conclusion that this is natural ultramarine, which is consistent with the pigments that would have been available to the Raphael workshop and to artists in the century following Raphael's death (fig. E.8).

It was initially a challenge to even locate a particle of the colored blue pigment when under magnification, as it seemed to be within a brown substance, likely the binding medium (fig. E.8). If, in fact, this is the binding medium, then its prevalence when compared to the pigment particles would indicate a rich paint mixture rather than lean, meaning there is a higher amount of oil than powdered pigment within the mixture . Ruhemann describes such a consistency thus: "Rich paint is glossy and smooth. It is found in translucent glazes of some painting done with oil as a medium."[75] This technique aligns with what is known of Raphael, who "…applies the colors thinly in transparent glazes of great delicacy."[76]

[73] "Colour Story: Ultramarine," Winsor & Newton - North America, February 27, 2024, https://www.winsornewton.com/na/articles/colours/colour-story-ultramarine/, n.p.

[74] George O'Hanlon, "Ultramarine Blue Pigment and Oil Paint for Artists - Explore Its Rich History and Application," Natural Pigments, January 16, 2024, https://www.naturalpigments.com/artist-materials/ultramarine-blue-color-notes, n.p.

[75] Ruhemann, "The Cleaning of Paintings" in *Anatomy of a Painting*, 19-22, May 2000, IA 30006, BOX 2011. IA.41-05, GCI Training Manuals, The Getty Research Institute, Los Angeles, CA, 100.

[76] Shearman, and Hall, "The Princeton Raphael Symposium," xviii.

CONCLUSION

Though attribution and period-specificity cannot be proven with certainty, it can be said that technical aspects of the painting revealed through analysis are consistent with those used within the sixteenth century and in the atelier of Raphael. Given that even the priming layer, something not visible to the eye of the patron, appears to have been executed using traditional materials, a forgery seems unlikely, though certainly possible. Atop a linen canvas primed with lead white and lead tin yellow mixed with powdered glass, figures were given form using colors like vermillion and ultramarine that were lightened with lead white or darkened using umber. Further analysis that lands outside of the scope of this thesis could be executed using methods such as Infrared Reflectography to look for stippled outlines, indicative of a traditional pouncing technique for transferring underdrawings onto the canvas.[78] A scanning electron microscope could be employed to identify each particulate visible within the paint layers. Gas Chromatography Mass Spectrometry would be a useful tool for identifying the organic compounds present such as the binding medium. Of course, these further inquiries may also prove inconclusive. Nonetheless, what started as a friend's painting hanging in her studio that was bought by her father many years ago has begun to take its place within the broader tradition of copies and, thus, in history. If this painting was, in fact, produced by Gian Francesco Penni, who could have commissioned it? Was it merely an artistic exercise emulating his master? Was the artist simply fulfilling his administrative duties by visually recording a finished workshop commission? As with any form of inquiry, asking questions of the past often stirs up more questions than answers.

[78] Marcia B. Hall, "Introduction: The Art History of Renaissance Rome," essay, in *Rome* (Cambridge, MA: Cambridge University Press, 2005), 15–26, 24.

APPENDIX A. IMAGES OF MADONNA OF DIVINE LOVE, NAPLES

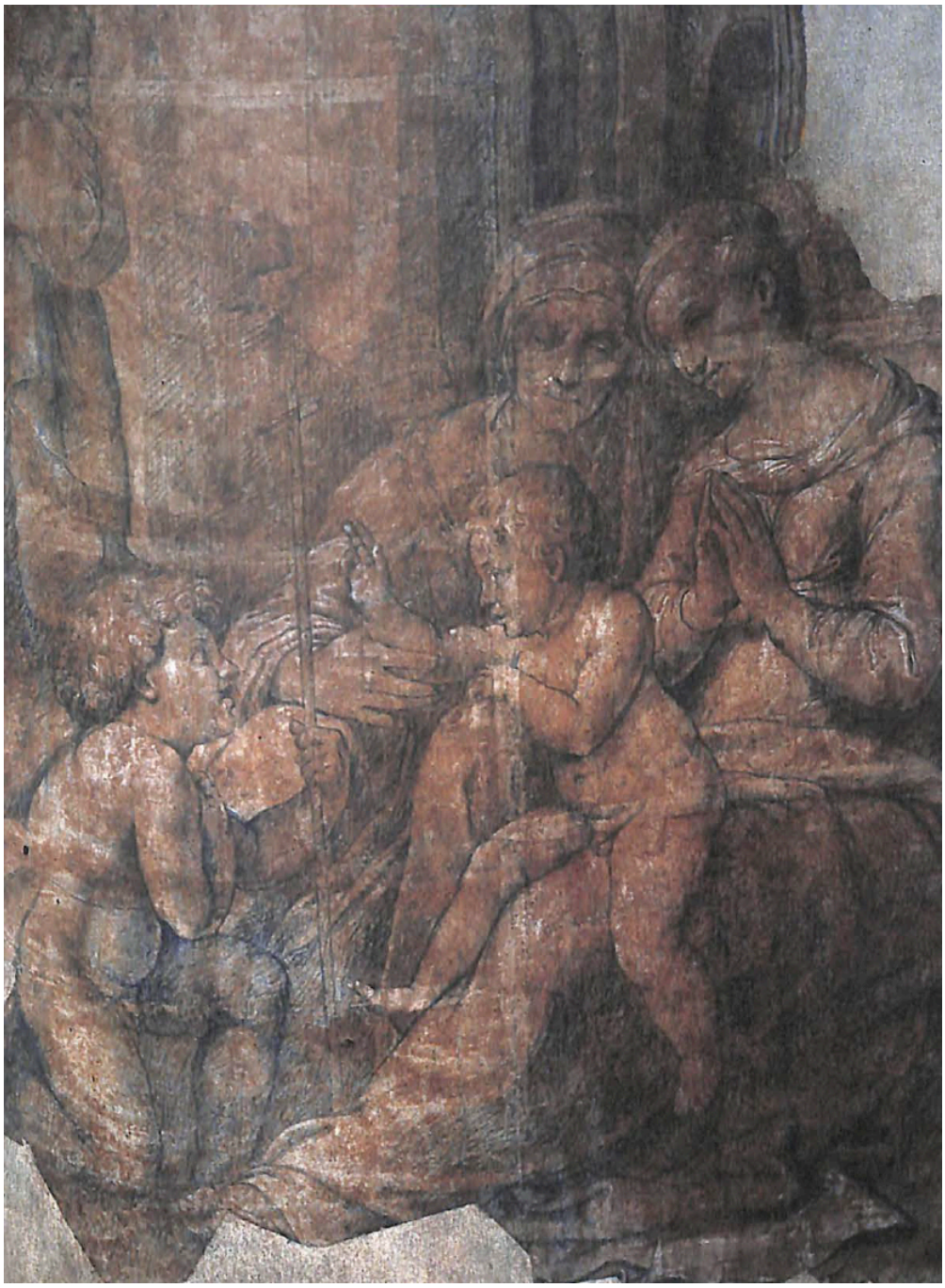

Figure A.1. Large scale drawing of the Madonna of Divine Love, attributed to Gian Francesco Penni (image taken from *Raffaelo: la Madonna del Divino Amore* by Angela Cerasuolo, Patrizia Piscitello, and Marina Santucci accessed July 19, 2024).

Figure A.2. Infrared Reflectogram of the *Madonna of Divine Love* panel in Naples, Italy. (image taken from Raffaelo*: la Madonna del Divino Amore* by Angela Cerasuolo, Patrizia Piscitello, and Marina Santucci accessed July 19, 2024).

Figure A.3. Infrared reflectogram of the *Madonna of Divine Love* panel in Naples, Italy. Detailed view showing balustrade beneath the figure of Joseph (image taken from *Raffaelo: la Madonna del Divino Amore* by Angela Cerasuolo, Patrizia Piscitello, and Marina Santucci accessed July 19, 2024).

Figure A.4. *Madonna under a Palm Tree*, engraving by Marcantonio Raimondi in the collection of the National Gallery of Art (image taken from Wikimedia Commons, July 19, 2024).

Figure A.5. Detailed comparison of Saint Elizabeth (or Anne) *pentimenti* beneath the *Madonna of Divine Love*, Naples and *Madonna Under a Palm Tree* engraving (image taken from *Raffaelo: la Madonna del Divino Amore* by Angela Cerasuolo, Patrizia Piscitello, and Marina Santucci accessed July 19, 2024).

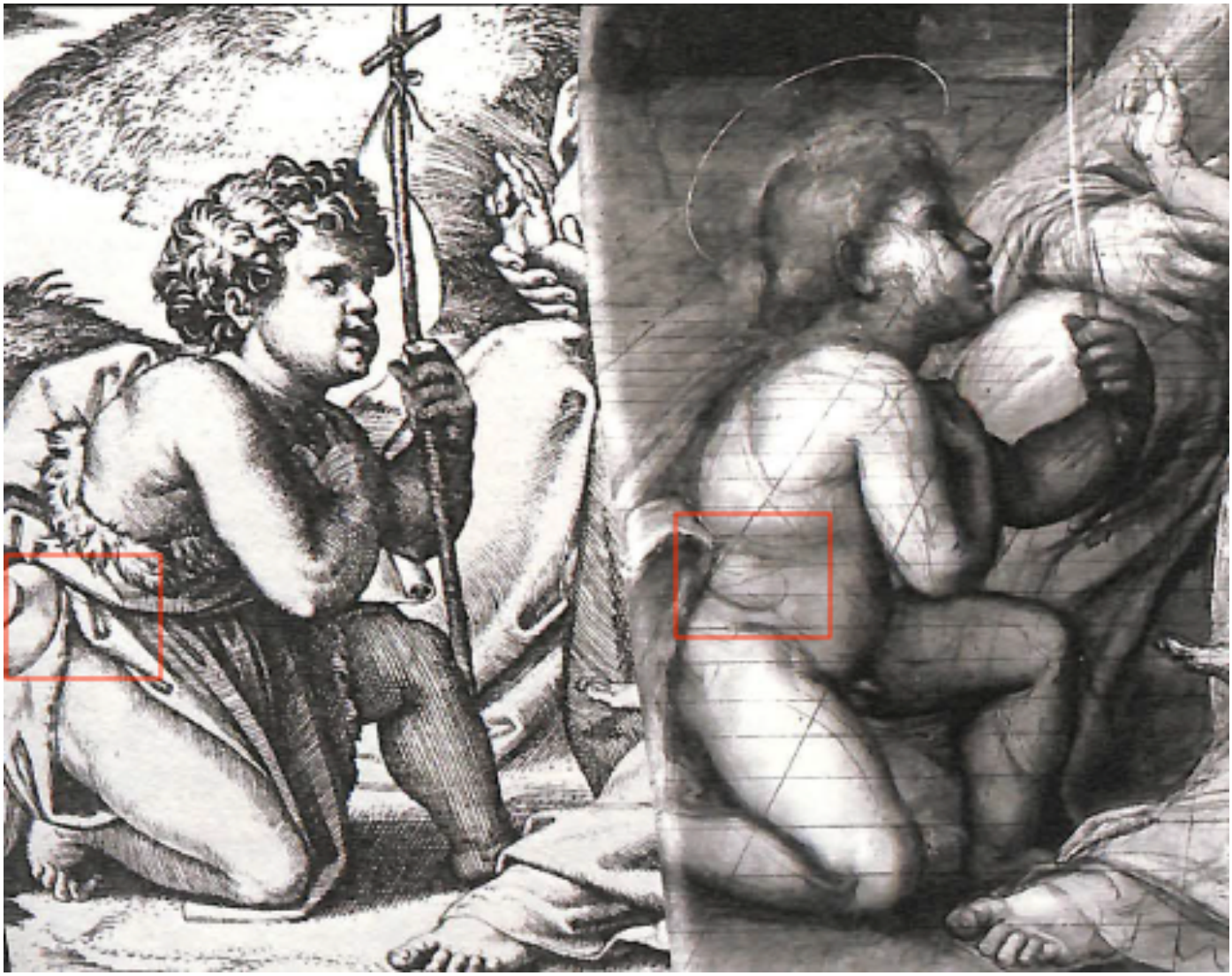

Figure A.6. Detailed comparison of Saint John *pentimenti* beneath the *Madonna of Divine Love*, Naples and *Madonna Under a Palm Tree* engraving (image taken from *Raffaelo: la Madonna del Divino Amore* by Angela Cerasuolo, Patrizia Piscitello, and Marina Santucci, red square added for emphasis, accessed July 19, 2024).

Figure A.7. Chalk drawing of Joseph, believed to be a preparatory sketch for the original Madonna of Divine Love engraving (image taken from *Raffaelo: la Madonna del Divino Amore* by Angela Cerasuolo, Patrizia Piscitello, and Marina Santucci accessed July 19, 2024).

APPENDIX B. IMAGES FROM VISUAL SURVEY

Figure B.1. A detailed image of the artwork's frame and attributive plaque (photo taken on site during phase one of analysis)

Figure B.2. Inscription located on the left side of the canvas stretcher bars (photo taken on site during phase one of analysis).

Figure B.3. Inscription located on top right corner of the stretcher bars (photo taken on site during phase one of analysis).

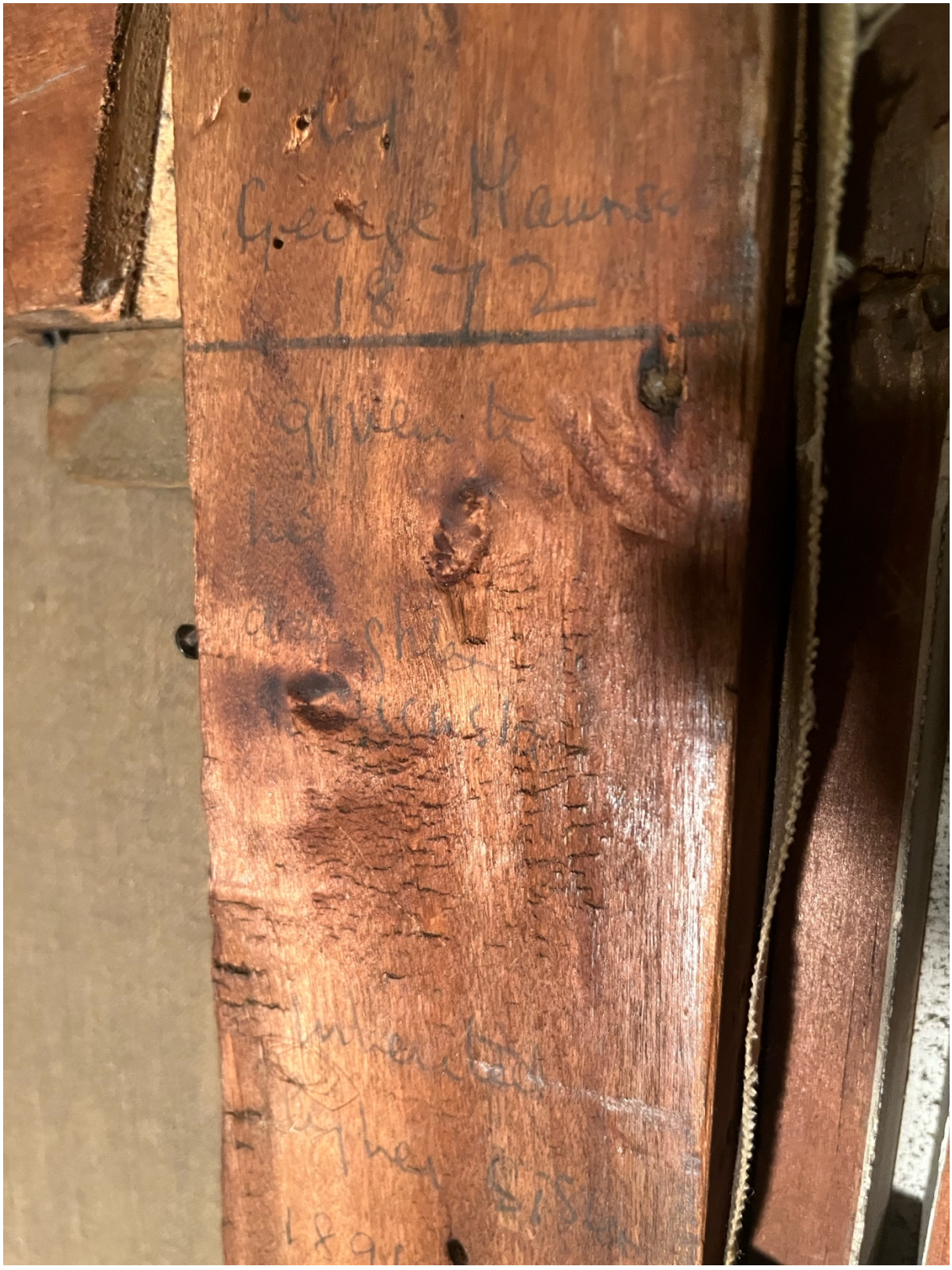

Figure B.4. Inscription just below top right corner of stretcher bars (photo taken on site during phase one of analysis).

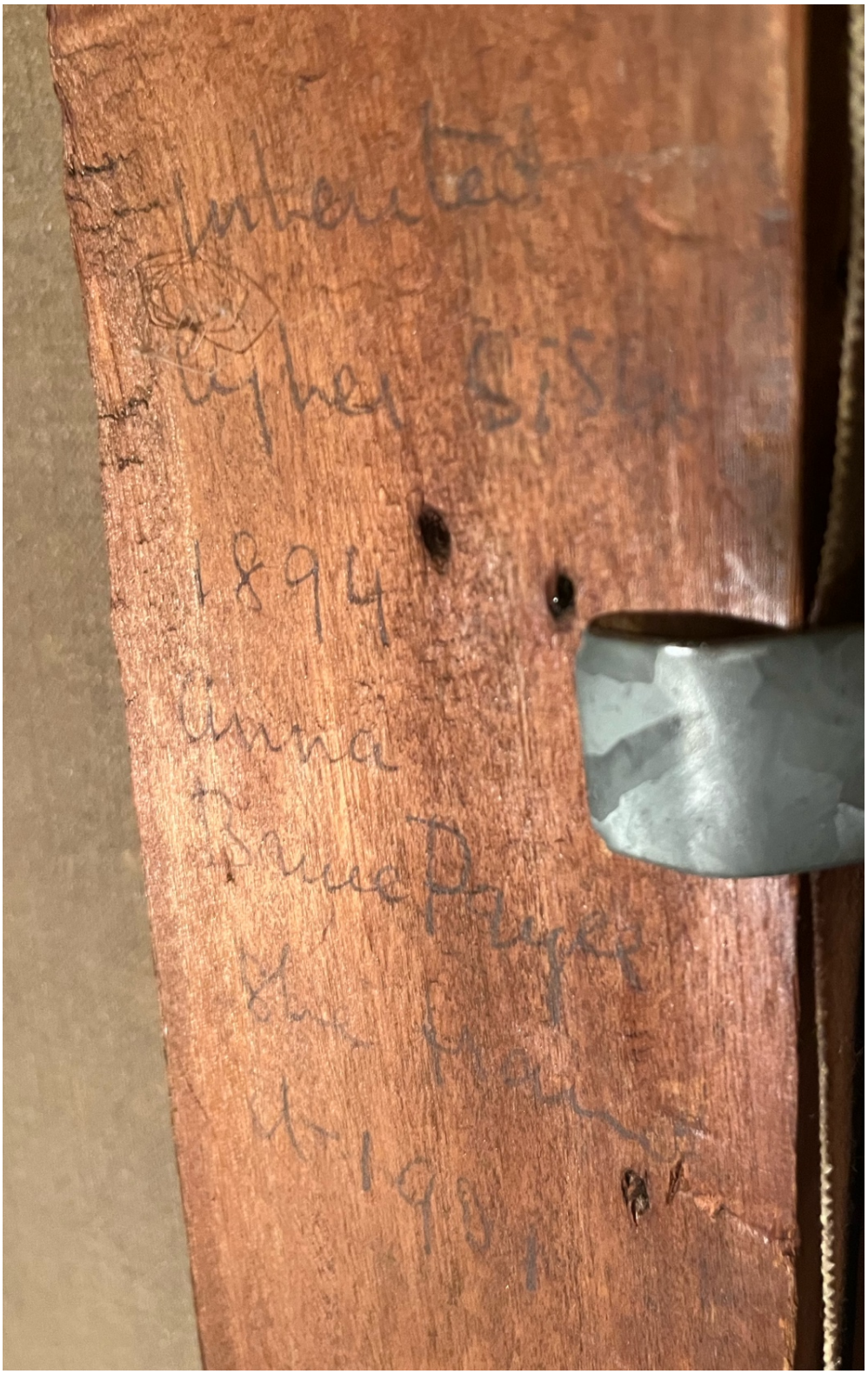

Figure B.5. End of inscription located on the right side of the canvas stretcher bars (photo taken on site during phase one of analysis).

Figure B.6 Photo of Barnby Bendall & Co. label. Notice where the label slightly overlaps the inscription above it.

APPENDIX C. IMAGES OF PAINTING PRIOR TO CONSERVATION

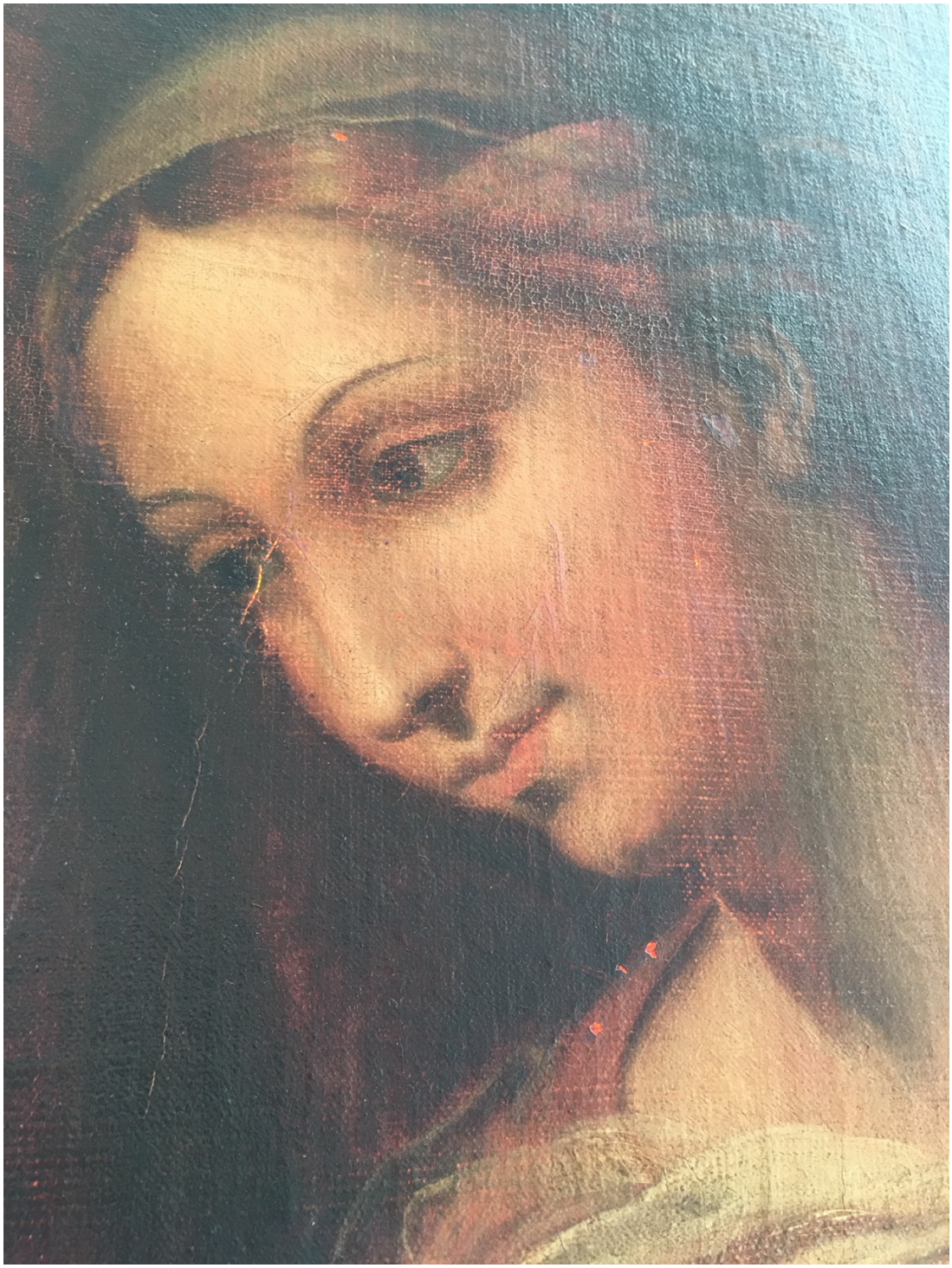

Figure C.1 Image of Mary's face prior to conservation. Note areas of discoloration and a large scratch extending downward from the figures eye (image from owner).

Figure C.2. Image of the face of baby Jesus prior to conservation. When observed under Ultraviolet light, discoloration on the figure's cheek was clearly painted over (image from owner).

APPENDIX D. IMAGES OF PAINTING UNDER ULTRAVIOLET FLUORESCENCE

Figure D.1. Madonna's face under Ultraviolet light revealing areas of painting from prior conservation (photo taken on site during phase one of analysis).

Figure D.2. Face of baby Jesus under UV light showing in painted areas. Note that even the profile and countenance of the figure look drastically different following treatment (photo taken on site during phase one of analysis).

Figure D.3. Hands of the Madonna under ultraviolet light. Notice the slight hatching marks located below her hands in prayer as well as the dark in-painting located on her left breast (photo taken on site during phase one of analysis).

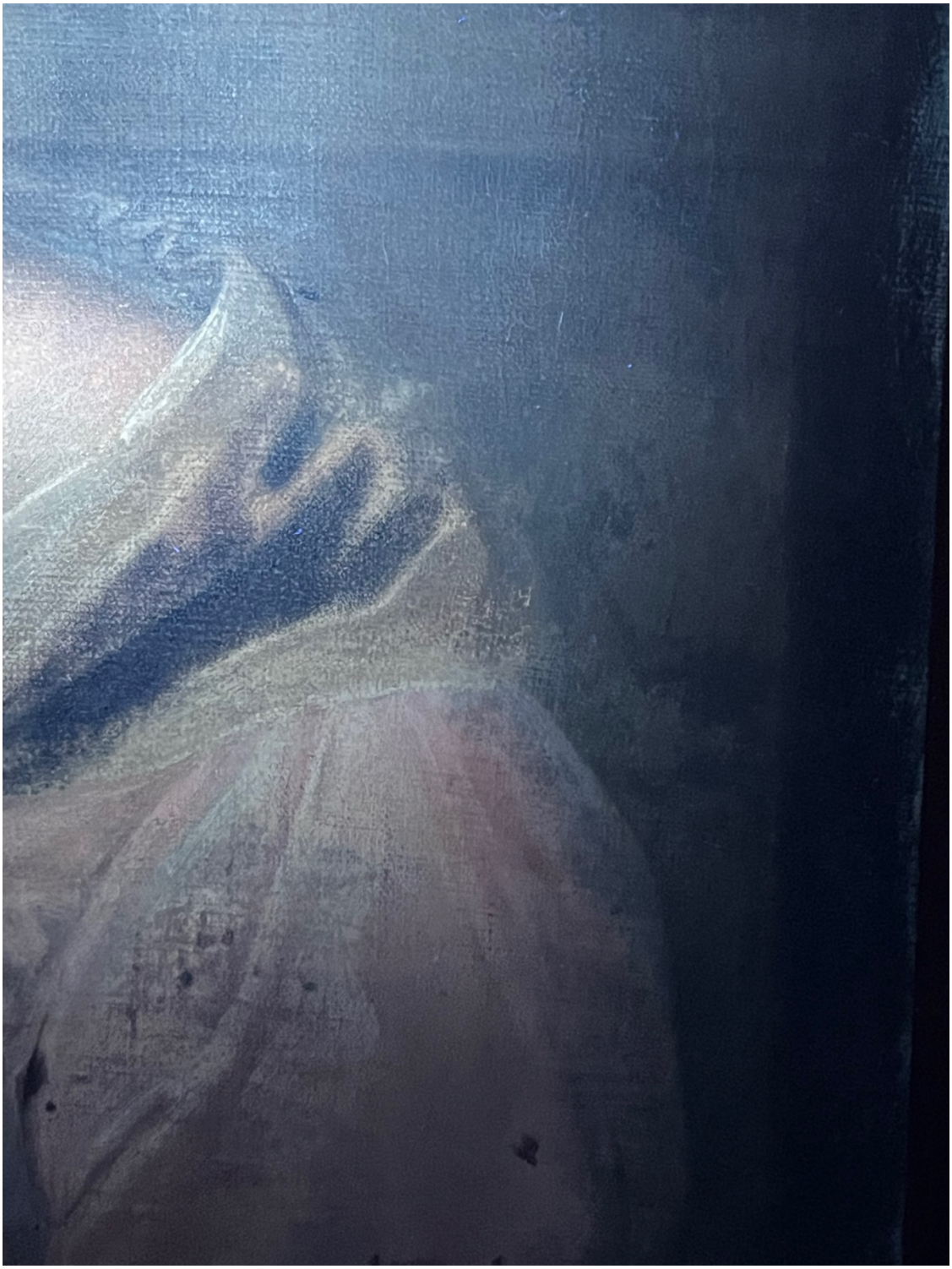

Figure D.4 Madonna's left shoulder under Ultraviolet Fluorescence (photo taken on site during phase one of analysis).

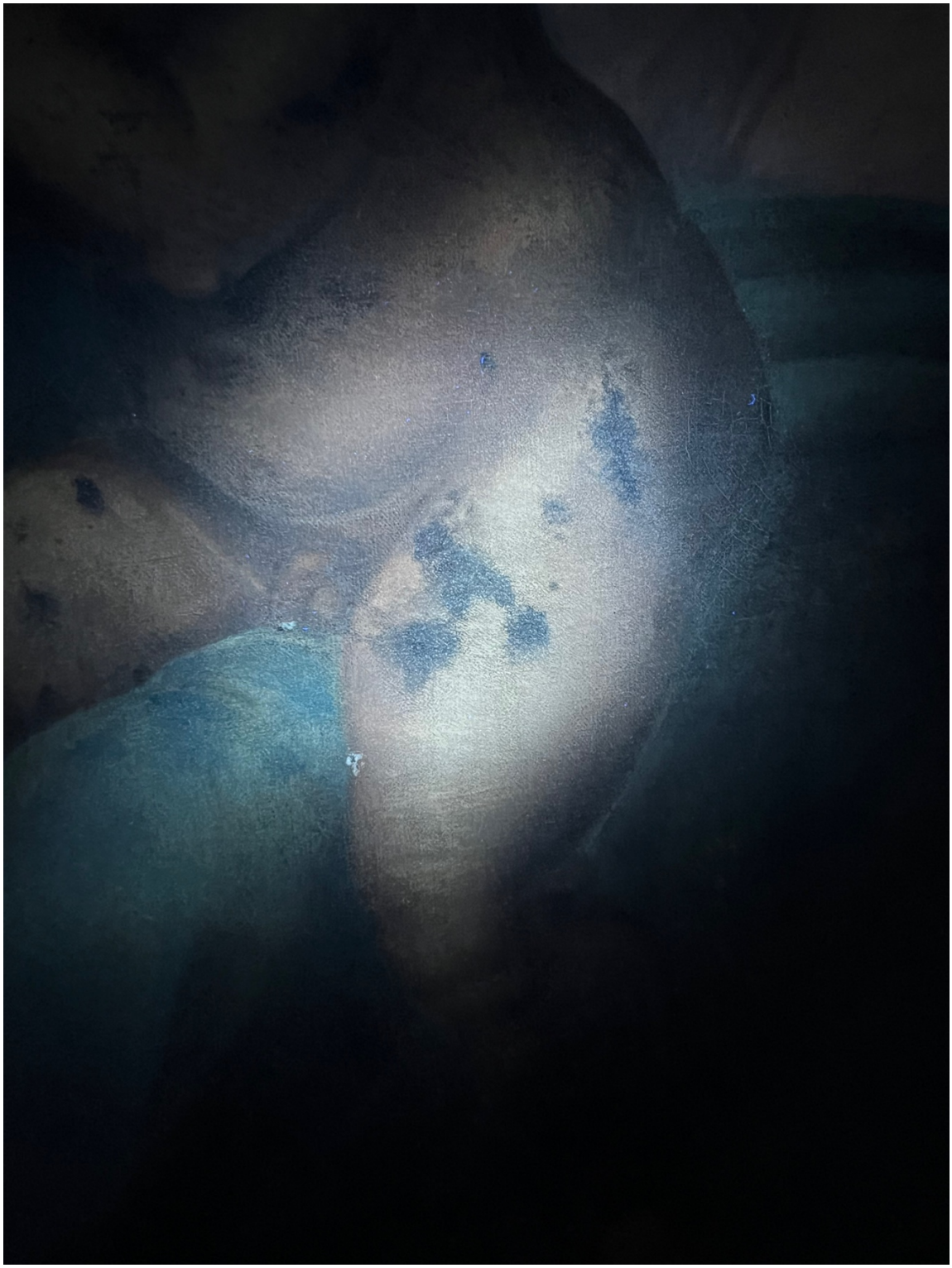

Figure D.5. Lower body of the Christ child under ultraviolet fluorescence (photo taken on site during phase one of analysis)

Figure D.6. Saint Joseph under ultraviolet fluorescence (photo taken on site during phase one of analysis).

Figure D.4. Inscription on top right corner of stretcher bars under UV fluorescence (photo taken on site during phase one of analysis).

Figure D.5. Inscription below top right corner of stretcher bars under UV fluorescence (photo taken on site during phase one of analysis).

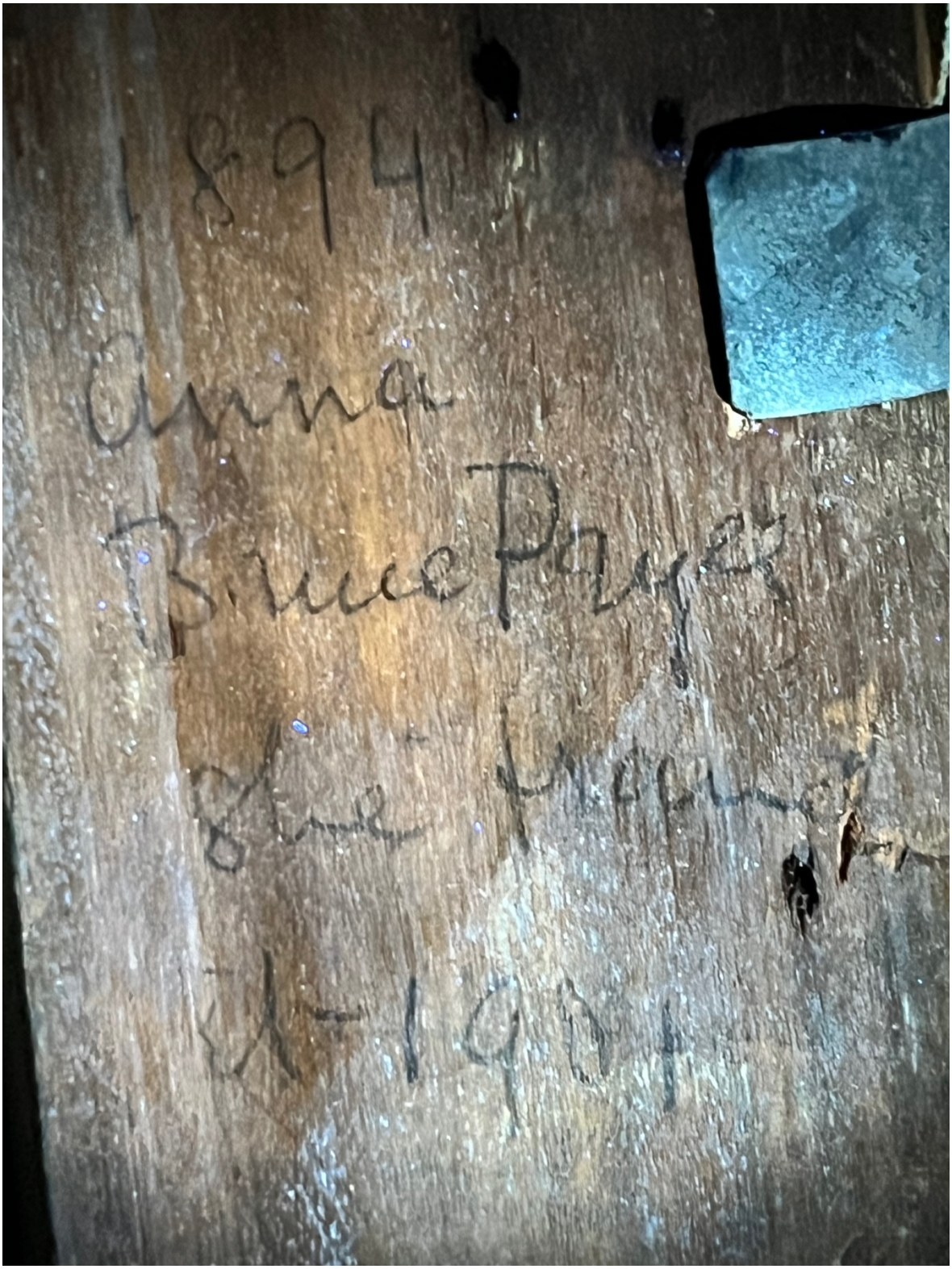

Figure D.6. Inscription below top right corner of stretcher bars under UV fluorescence (photo taken on site during phase one of analysis).

APPENDIX E. MICROSCOPY IMAGES

Figure E.1. Fiber from old canvas under 20x magnification (image taken at The Cotsen Institute of Archeology's Experimental and Archeological Sciences Lab at UCLA).

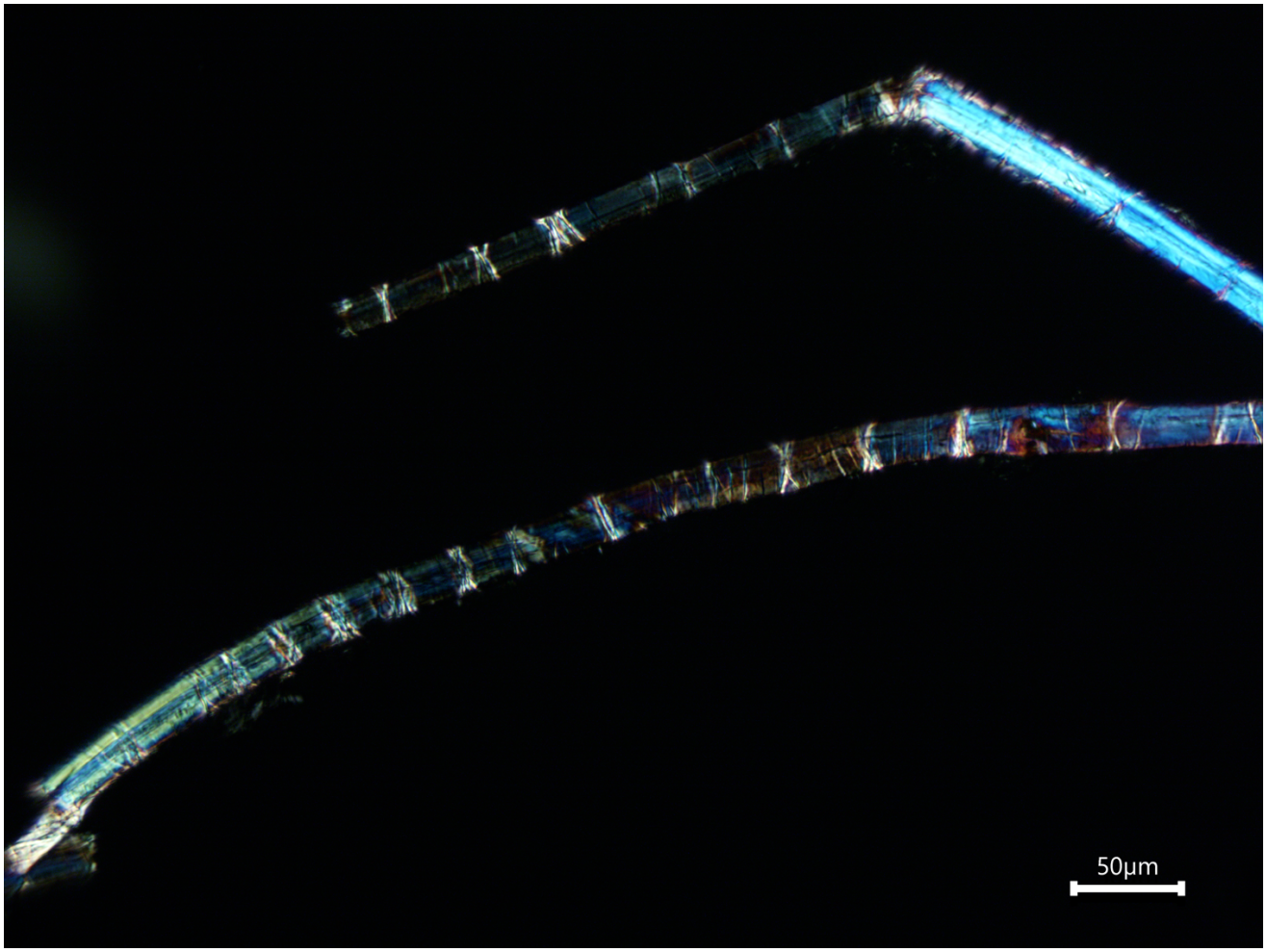

Figure E.2. Fiber from old canvas under 20x magnification with cross polarized light (image taken at The Cotsen Institute of Archeology's Experimental and Archeological Sciences Lab at UCLA).

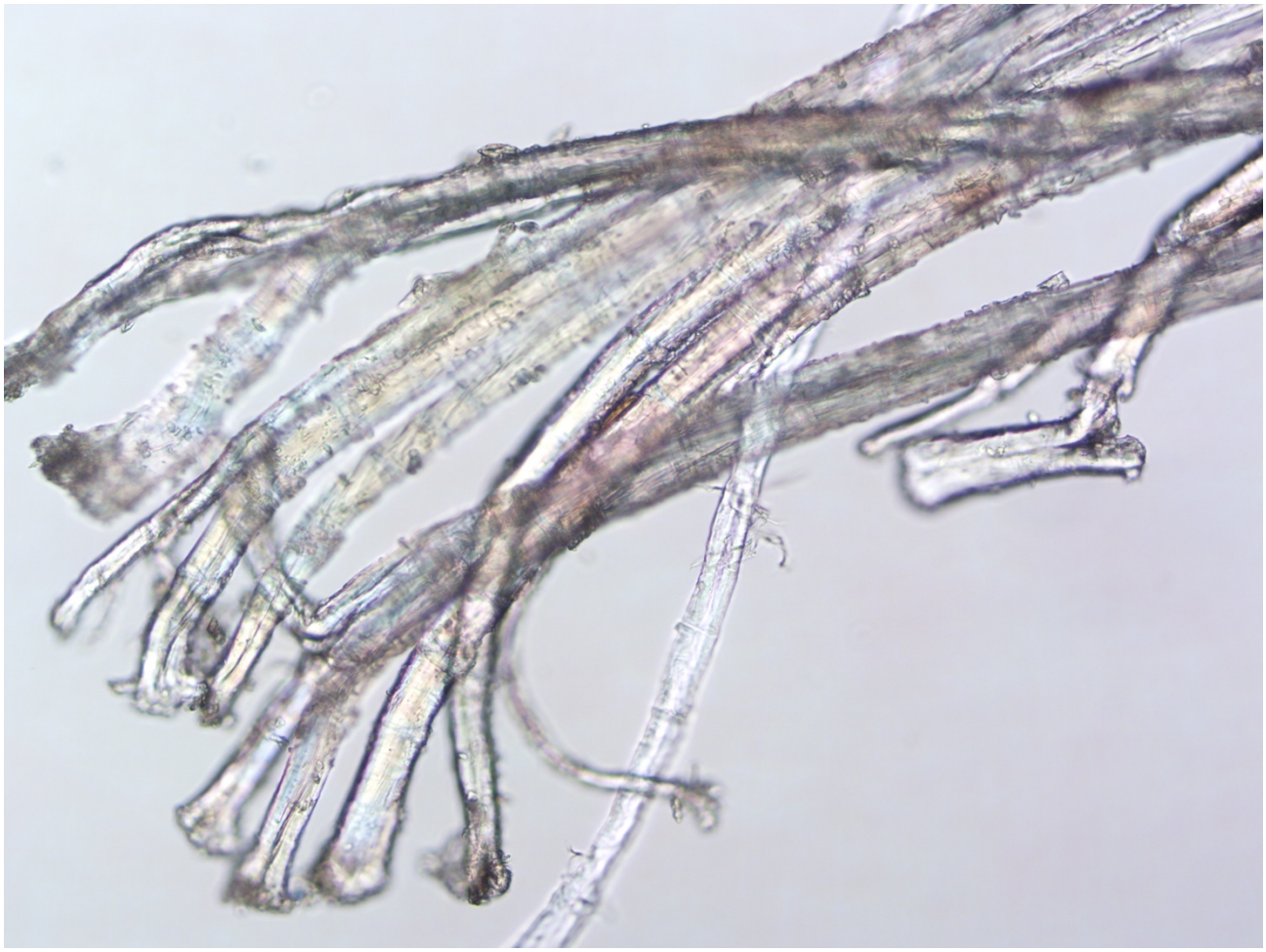

Figure E.3. Fiber from new canvas under 20x magnification (image taken at The Cotsen Institute of Archeology's Experimental and Archeological Sciences Lab at UCLA).

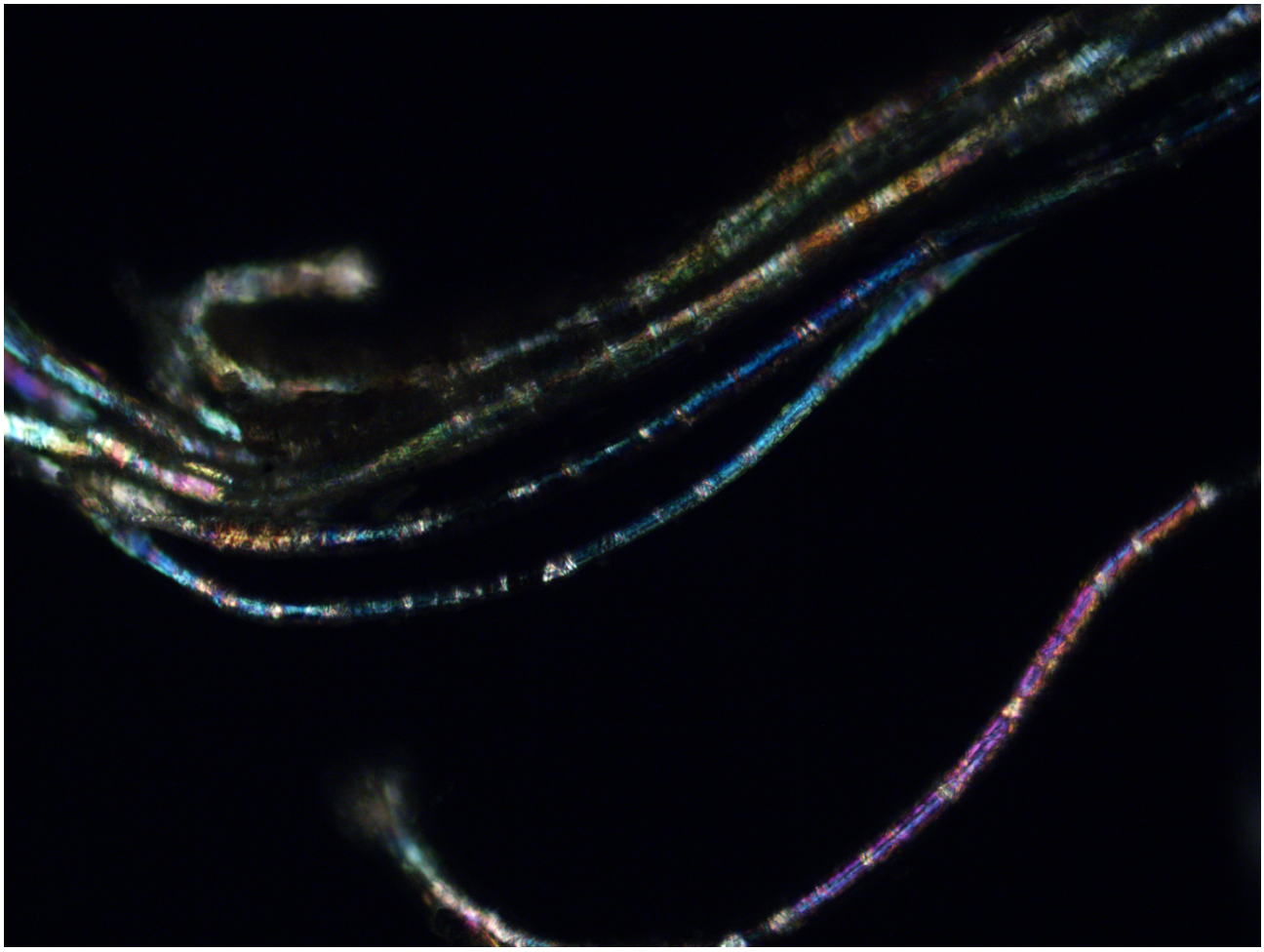

Figure E.4. Fiber from new canvas under 20x magnification with cross polarized light (image taken at The Cotsen Institute of Archeology's Experimental and Archeological Sciences Lab at UCLA).

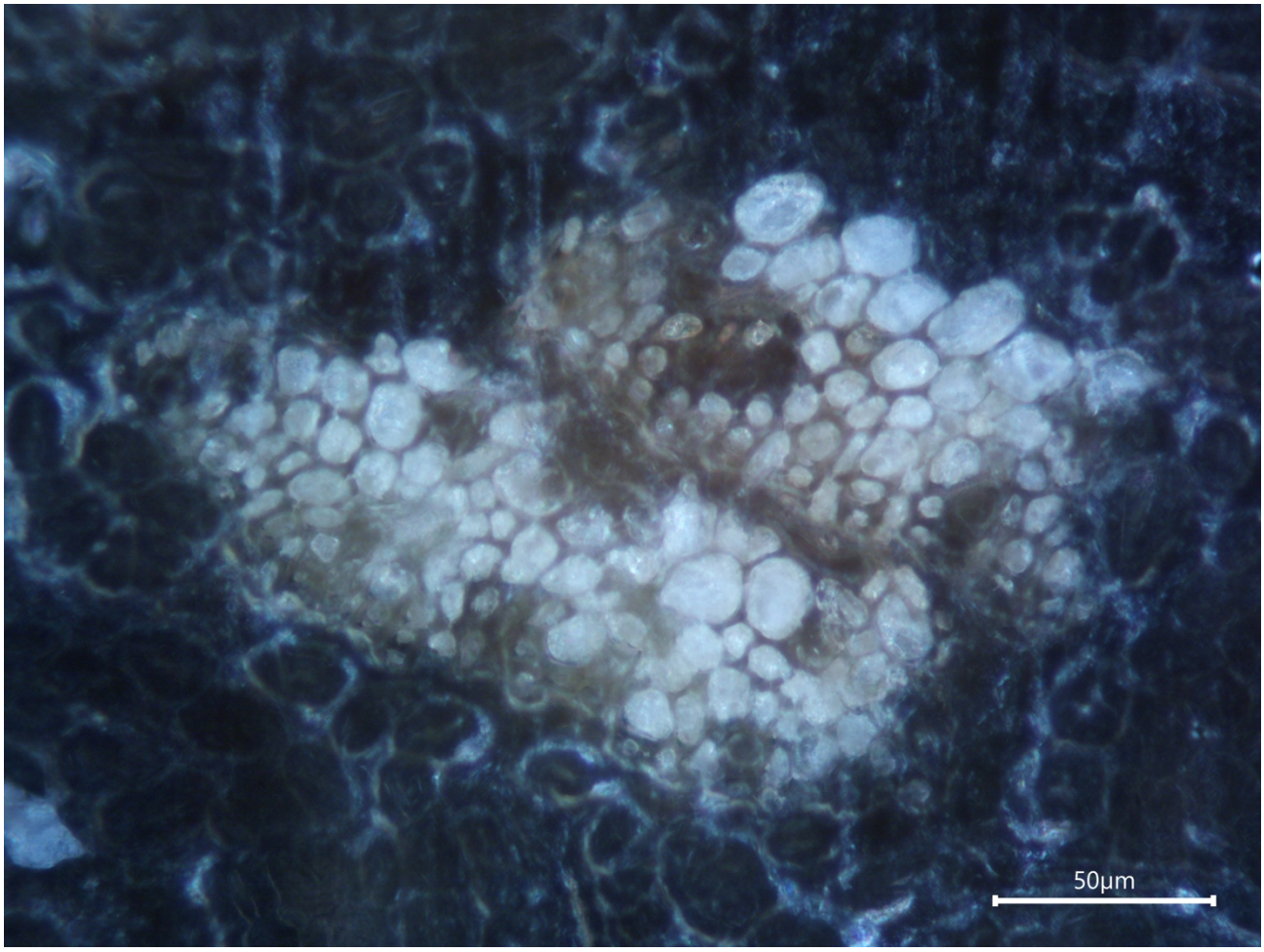

Figure E.5. Cross section of fiber from old canvas under 40x magnification (image taken at The Cotsen Institute of Archeology's Experimental and Archeological Sciences Lab at UCLA).

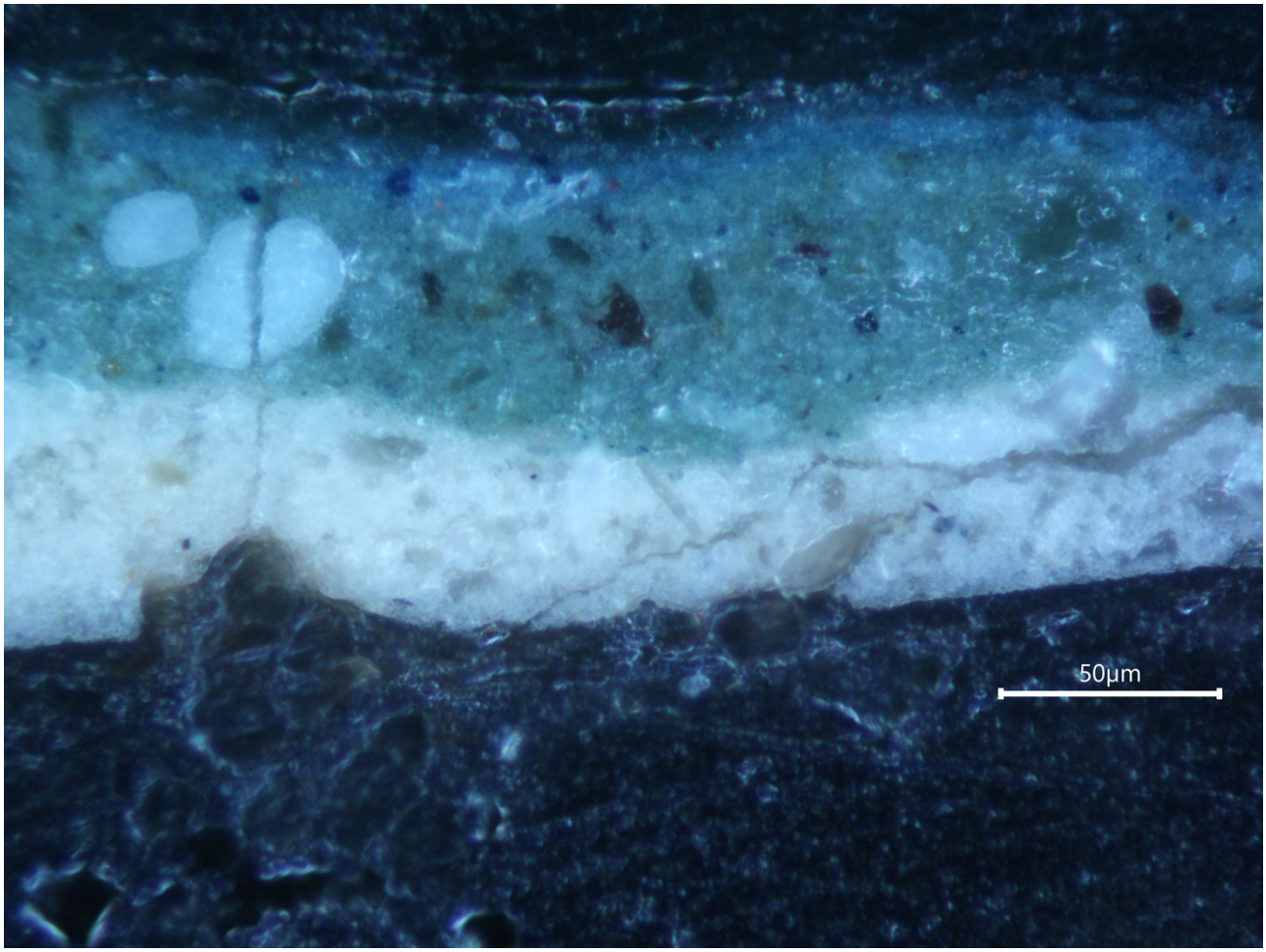

Figure E.6. Cross section of paint sample from the very edge of the distant sky magnified 40x. Observe the particles visible in both the white priming layer and colored region. Starting from bottom to top there is a white priming layer, teal blue section and thin richer blue layered atop (image taken at The Cotsen Institute of Archeology's Experimental and Archeological Sciences Lab at UCLA)..

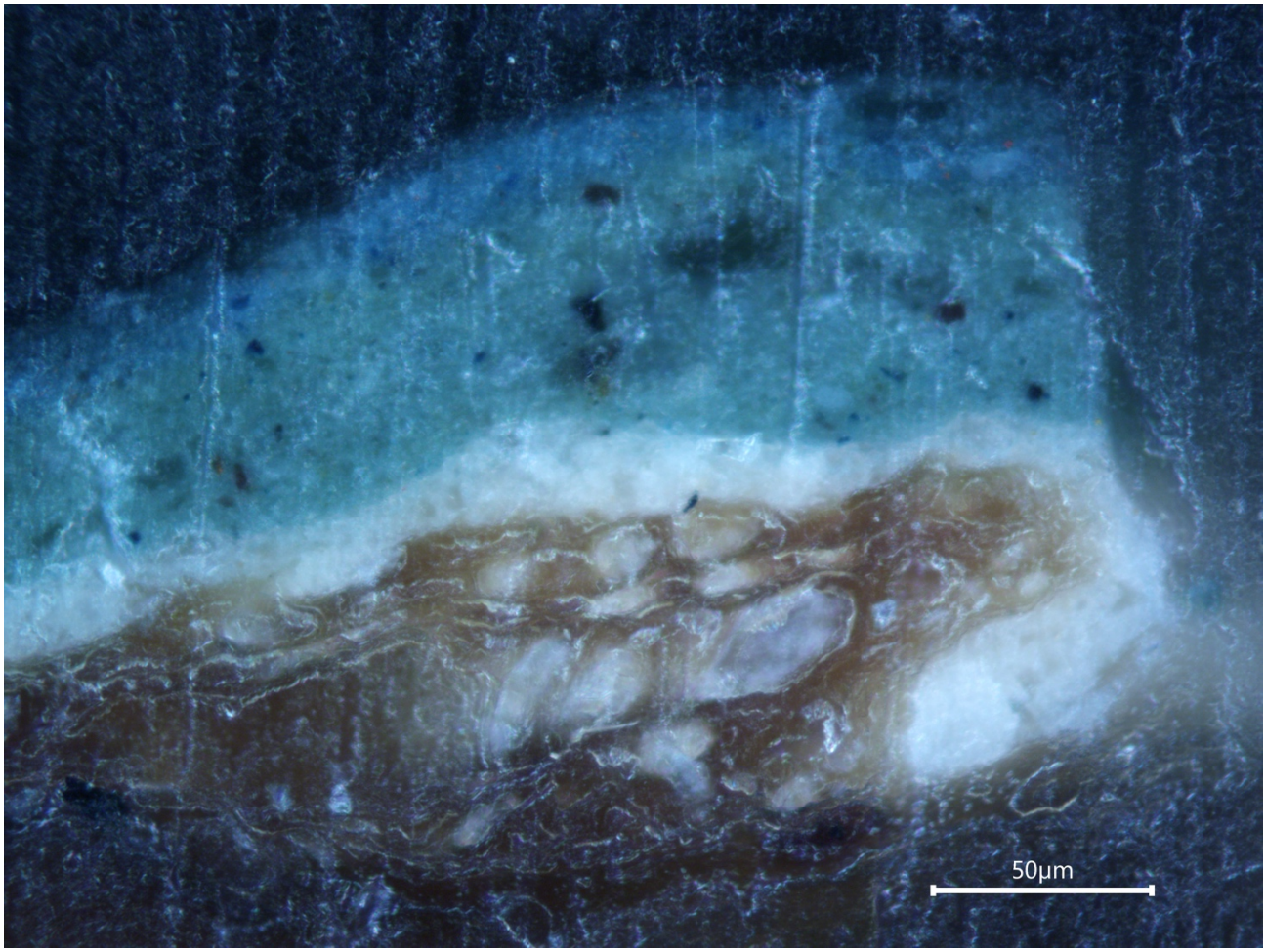

Figure E.7. Cross section of paint sample from the very edge of the distant sky magnified 40x. This image was taken from a different area of the cross section and includes the canvas layer just below the white priming layer (image taken at The Cotsen Institute of Archeology's Experimental and Archeological Sciences Lab at UCLA).

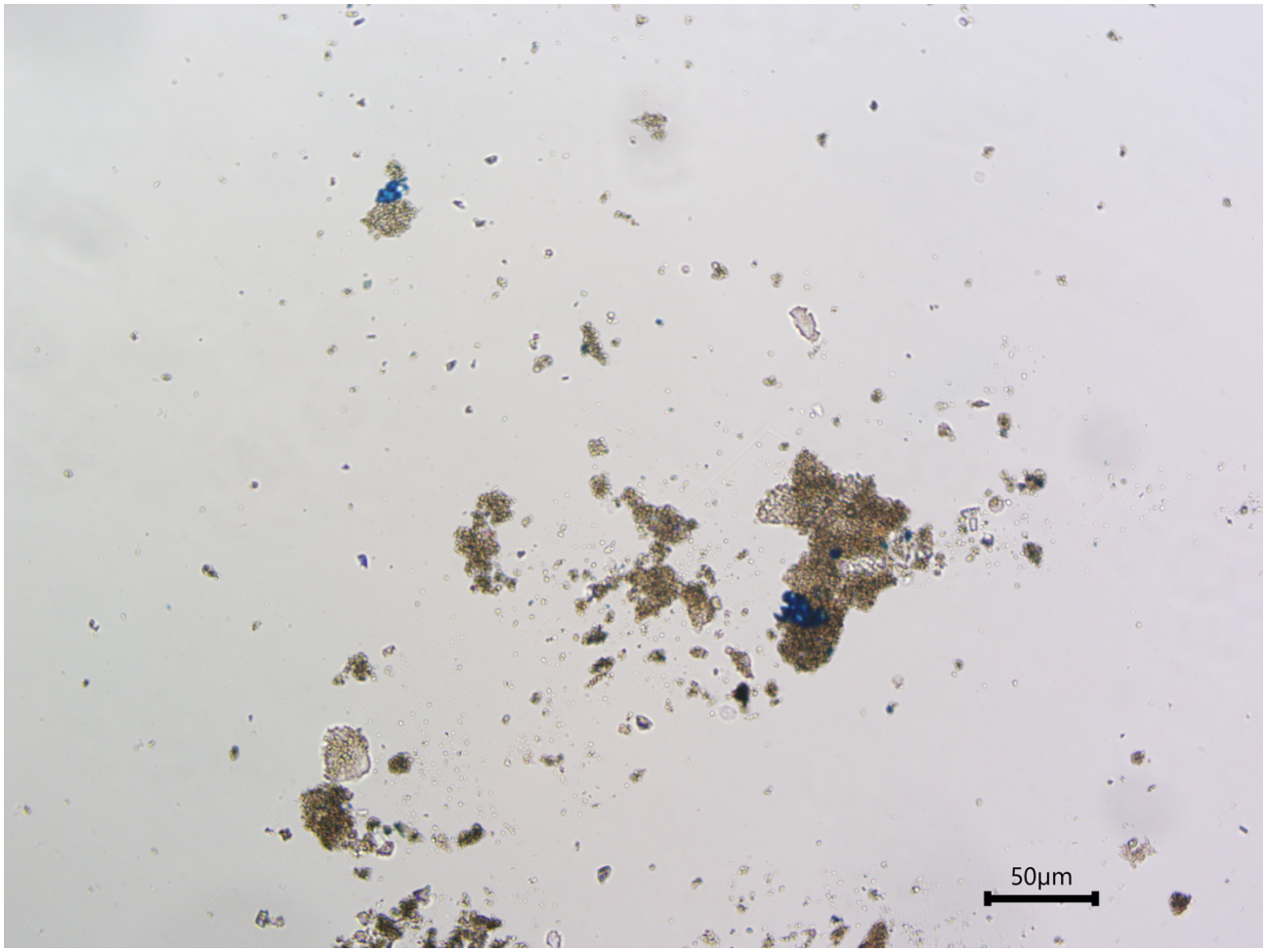

Figure E.8. Blue pigment and binding medium magnified to 20x (image taken at The Cotsen Institute of Archeology's Experimental and Archeological Sciences Lab at UCLA).

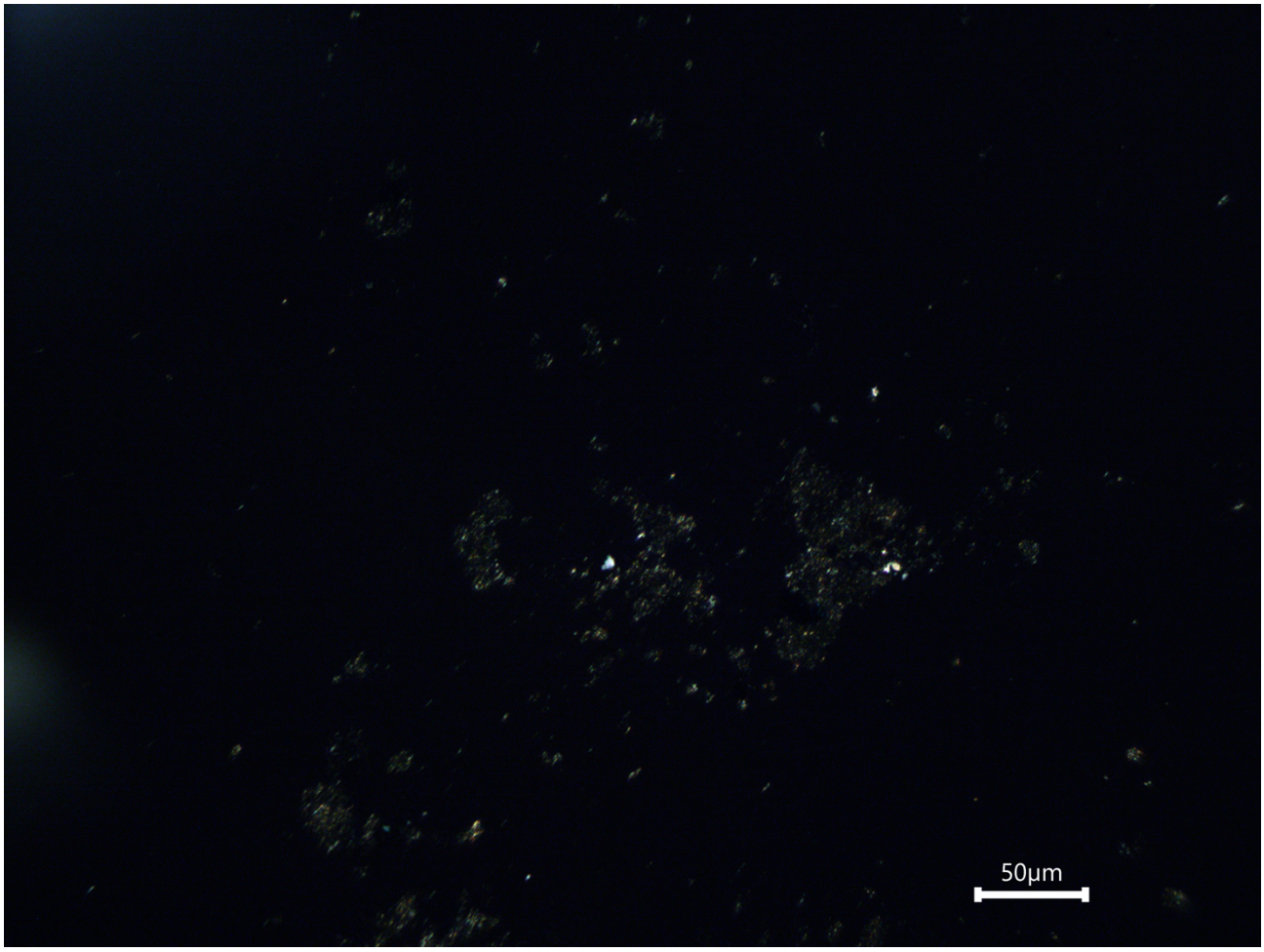

Figure E.9. Blue pigment and binding medium magnified to 20x under cross polarized light. Notice the blue pigment disappears indicating an isotropic pigment (image taken at The Cotsen Institute of Archeology's Experimental and Archeological Sciences Lab at UCLA).

Figure F.1. *Madonna of Divine Love* copy annotated with pXRF points of measurement (image taken on site and annotations added later).

February 17 2024 sample collection

PXRF points:
1539: Joseph's halo
1540: V-shaped mark between Mary and Anne/Elizabeth
1541: Mary's halo
1542: blue skirt in the area around Mary's knee
1543: wall in room (testing for lead)
1544: dark V-shaped mark left of Jesus' knee
1545: inner section of cross
1546: sky blue (visible in top right corner of window)
1547: Jesus's cheek, under his eye
1548: dark area under Jesus' right elbow
1549: pink dress left of Mary's right hand
1550: dark area on Mary's left breast
1551: right corner of painting
1552: hem of Mary's dress, between the two main folds
1553: dark pink inside biggest fold in hem of Mary's dress
1554: whiter part of Mary's scarf/shawl
1555: Jesus' left thigh
1556: Anne/Elizabeth's left cheek

Painting sample numbers:
1: original canvas, light brown coating/varnish, lower left corner of canvas edge
2: lower left corner of canvas, new canvas sample
3: center of left edge of canvas, yellow-ish tan/ochre color
4: center of left edge of canvas, yellow/orange (maybe the same as sample 3)
5: left edge of canvas towards the top left corner, dark brown in color, close to Joseph's lower body
6: blue of the sky, upper edge of canvas
7: same as sample 1 but for Vanessa
8: same as sample 2 but for Vanessa
9: same as sample 6 but for Vanessa

Figure F.2. Description of pXRF measurement points and samples taken (written by committee member, Luiza Osorio G. Silva).

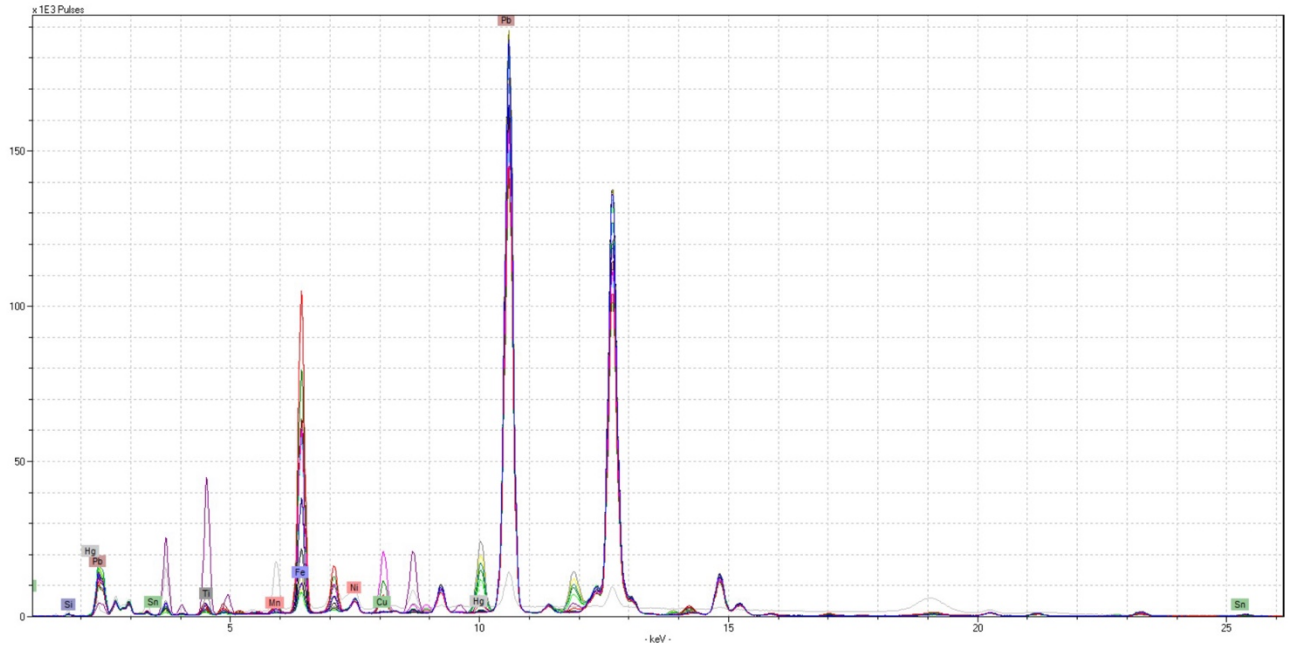

Figure F.3. An overlay of all measurements (graph created with Artax V.8 software).

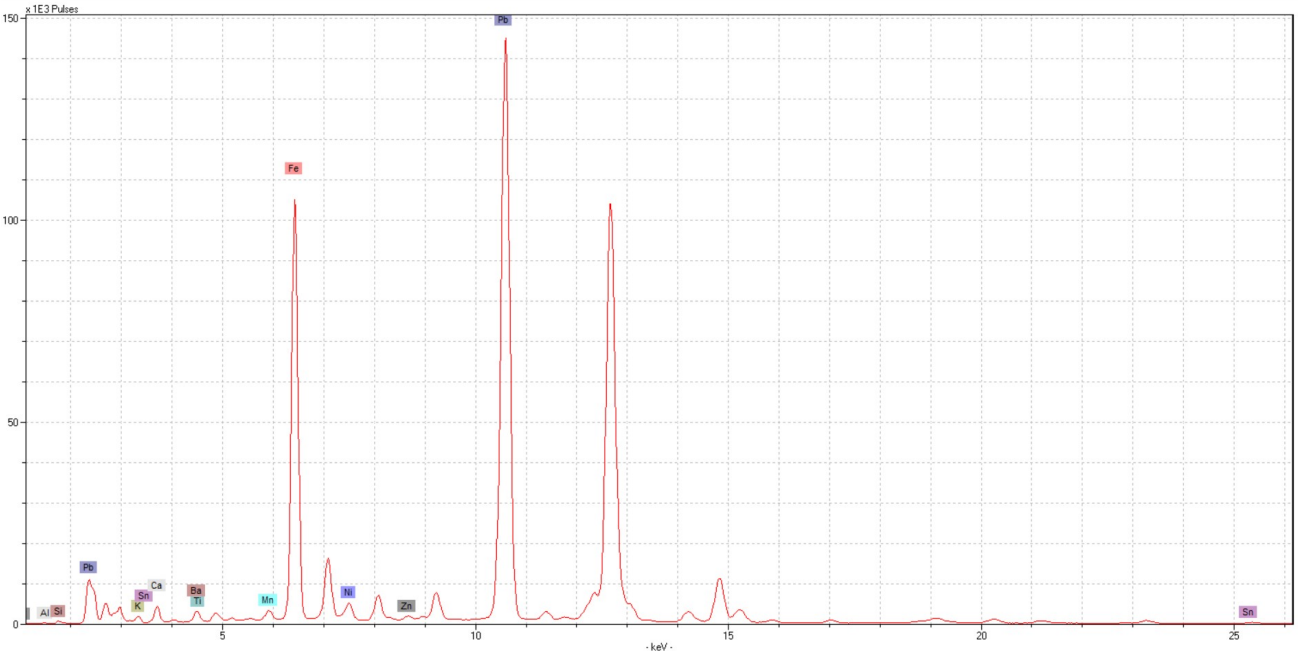

Figure F.4. pXRF measurement number 1539, Saint Joseph's halo (graph created with Artax V.8 software).

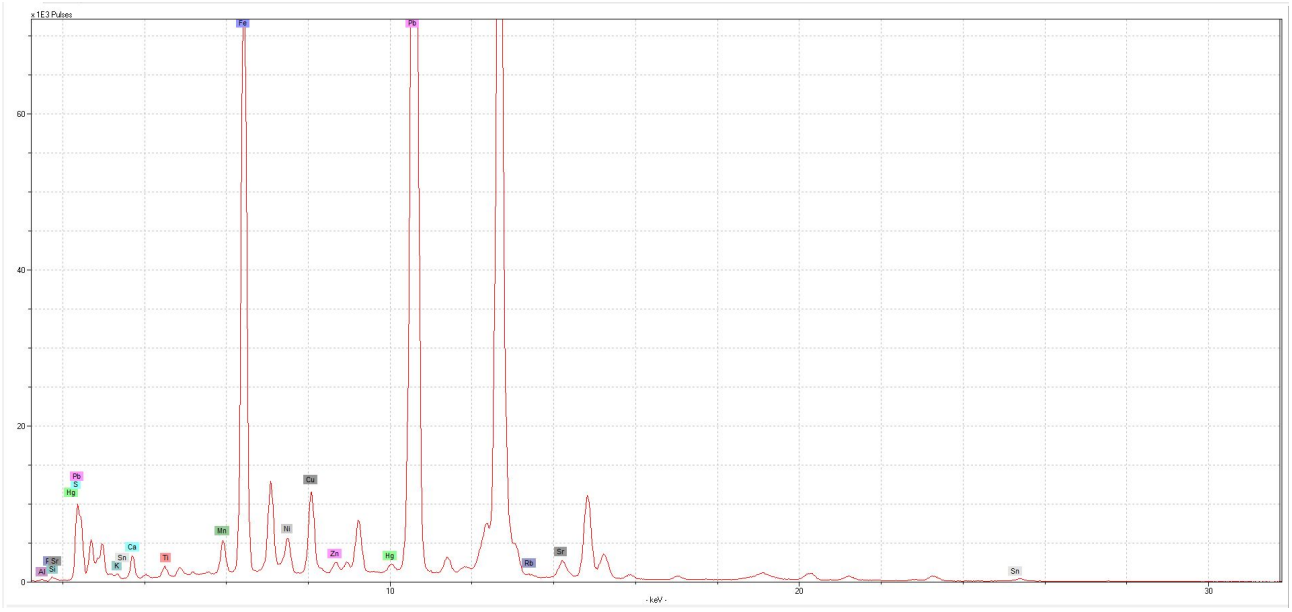

Figure F.5. pXRF measurement number 1540, Jesus' halo (graph created with Artax V.8 software).

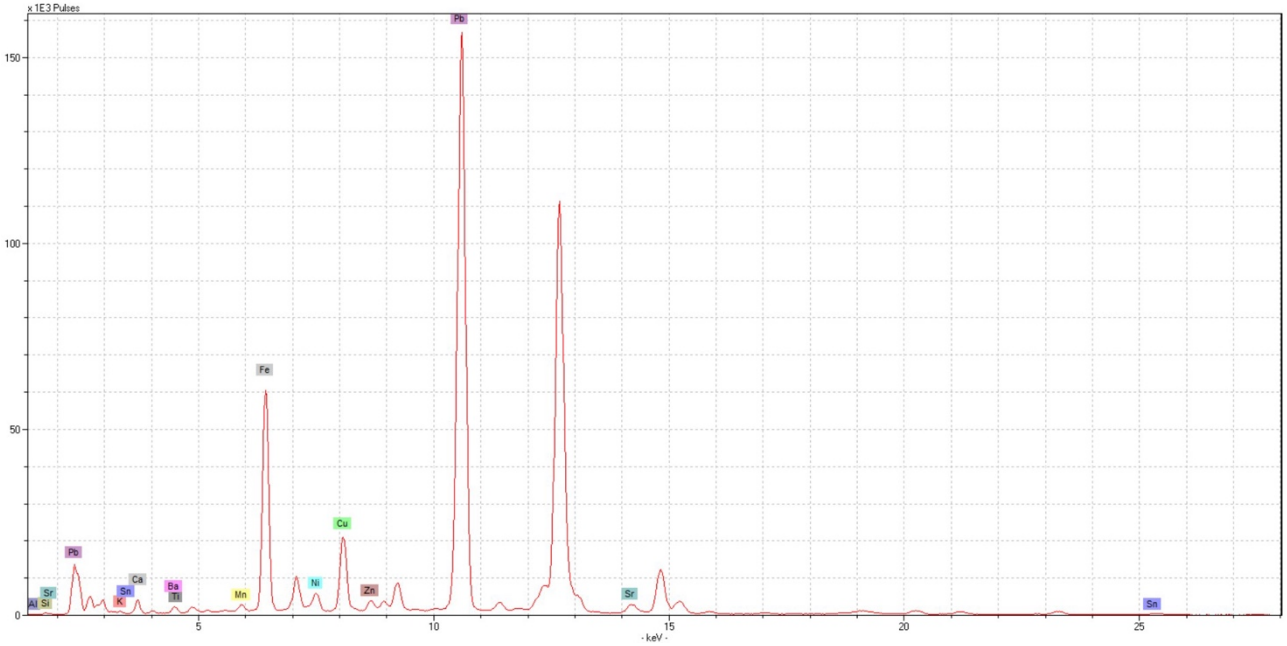

Figure F.6. pXRF measurement number 1541, Madonna's halo (graph created with Artax V.8 software).

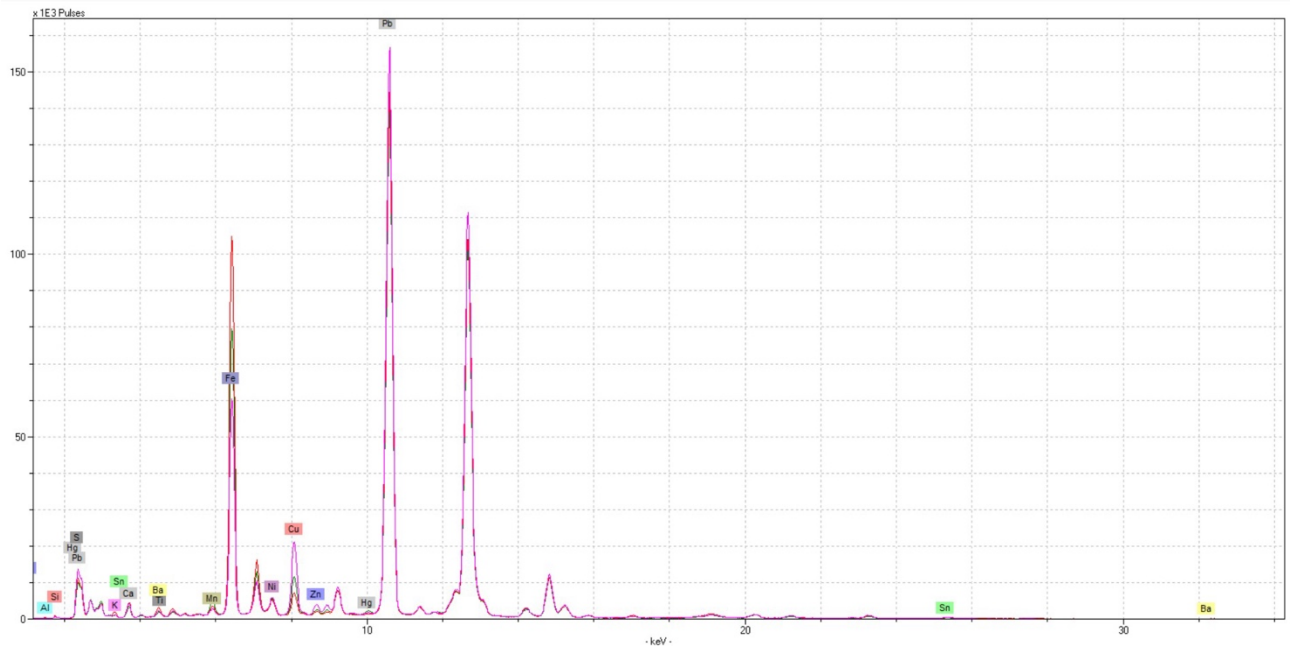

Figure F.7. pXRF measurement numbers 1539 (red), 1540 (green), and 1541(pink). Mary, Joseph, and Jesus' halos overlayed (graph created with Artax V.8 software).

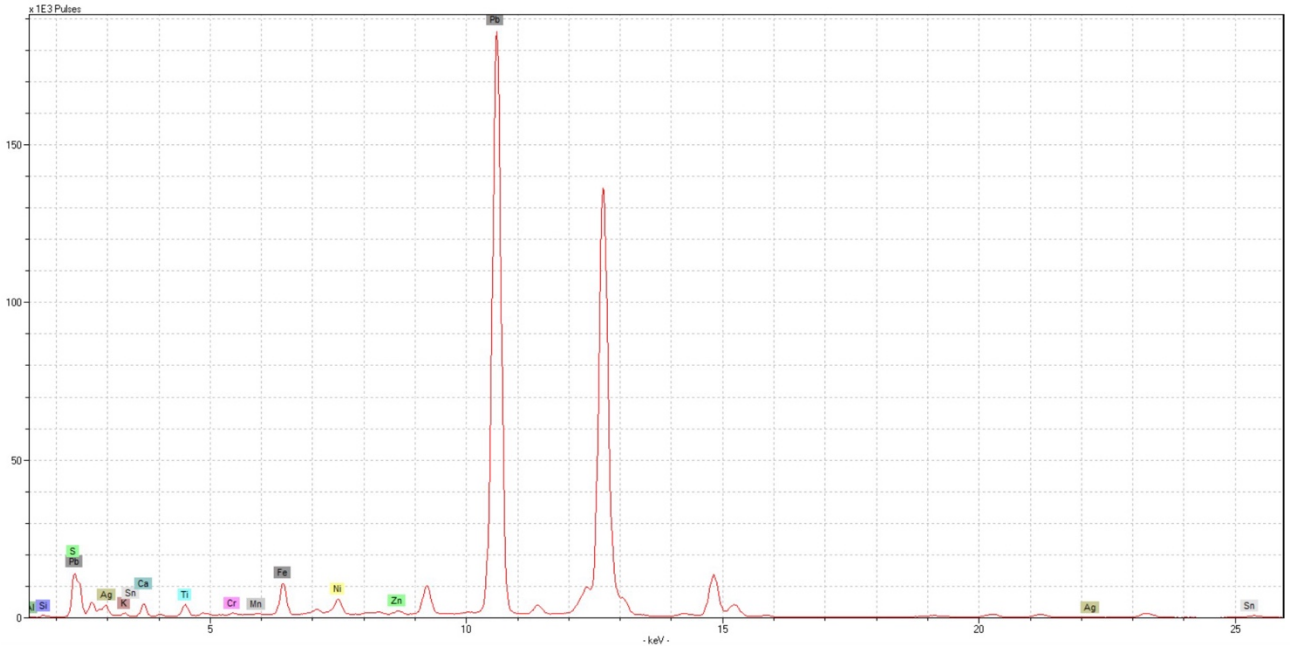

Figure F.8. pXRF measurement number 1542, the top of the Madonna's knee (graph created with Artax V.8 software).

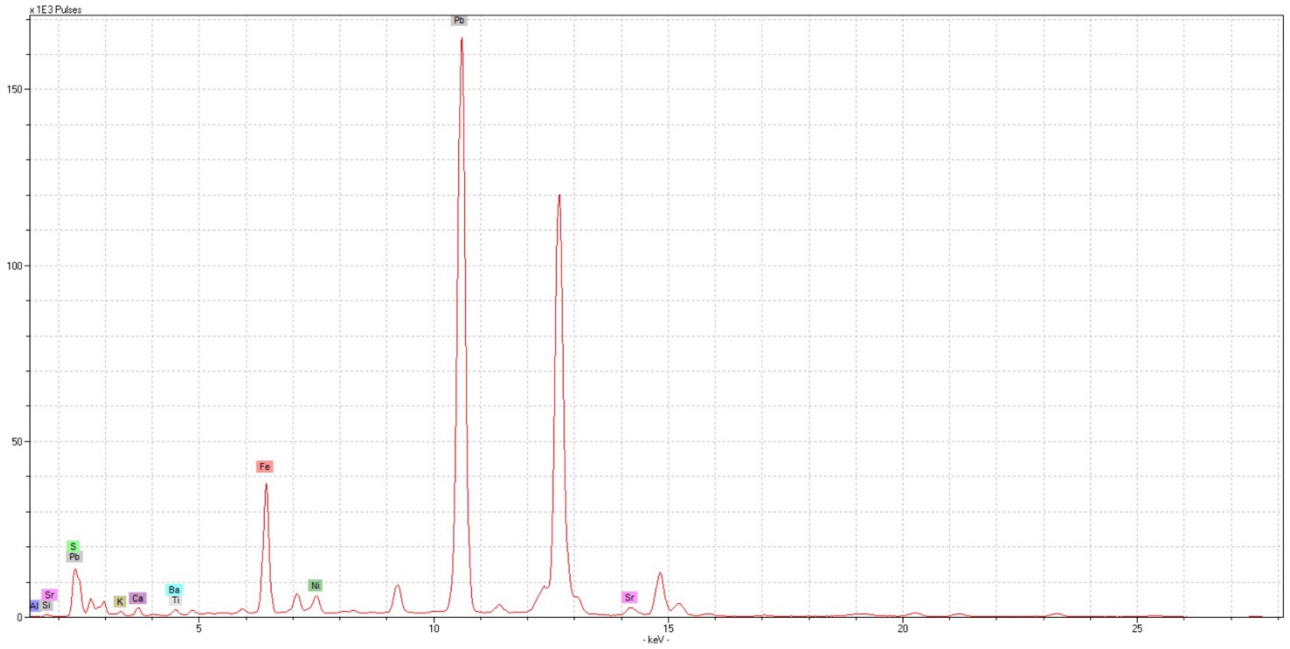

Figure F.9. pXRF measurement number 1544, shading along the side of the Madonna's knee (graph created with Artax V.8 software).

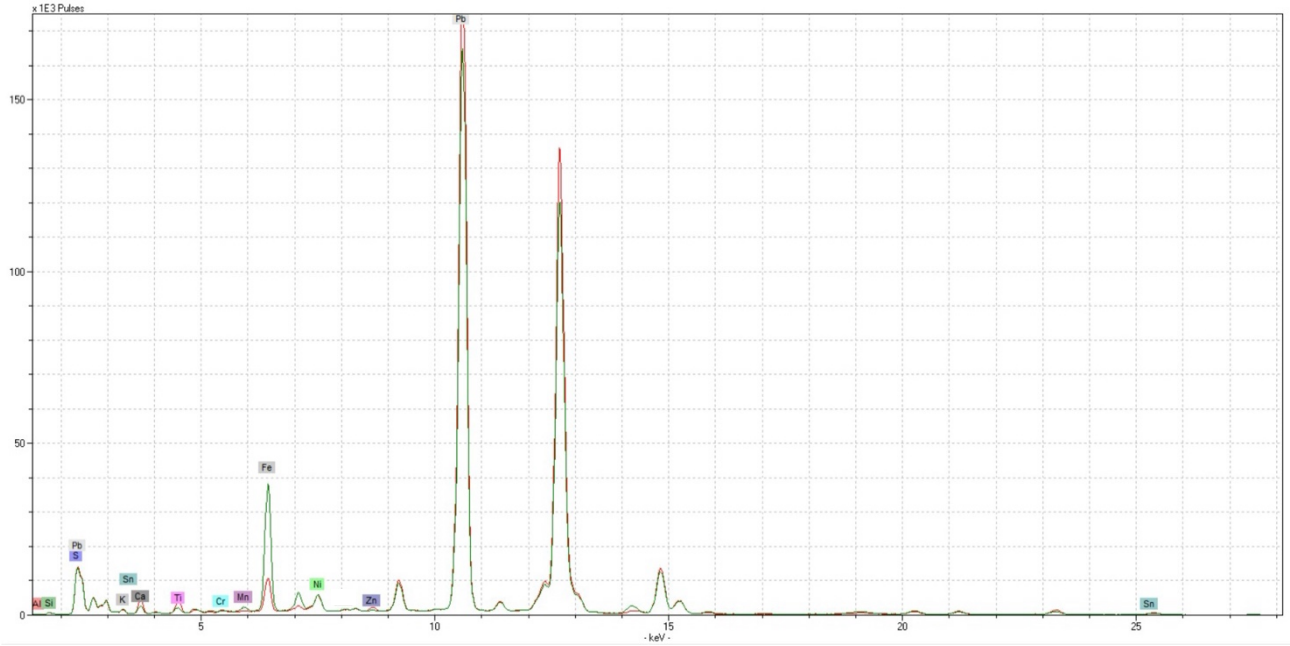

Figure F.10. pXRF measurement numbers 1542 (red) and 1544 (green), the highlight and shadow of the Madonna's skirt (graph created with Artax V.8 software). Notice the spike in iron seen in point 1544 (the area in shadow) suggesting the use of umber to darken the shade of blue.

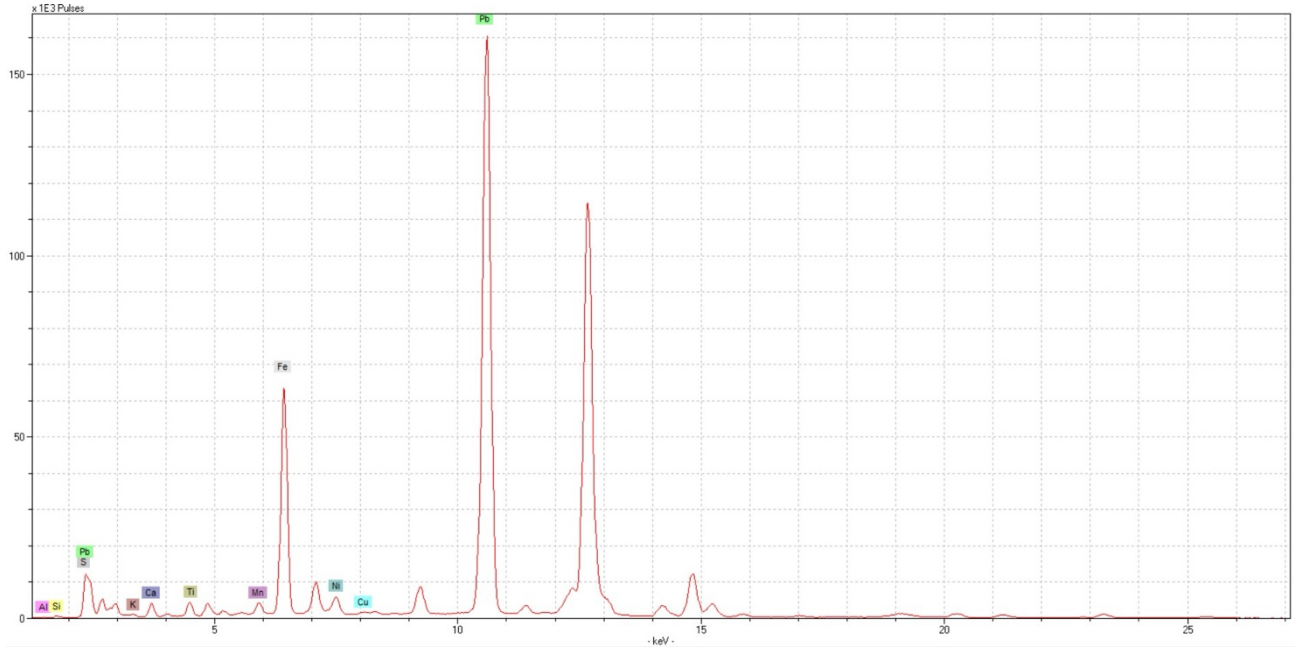

Figure F.11. pXRF measurement number 1545, small cross located atop the staff held by John the Baptist (graph created with Artax V.8 software).

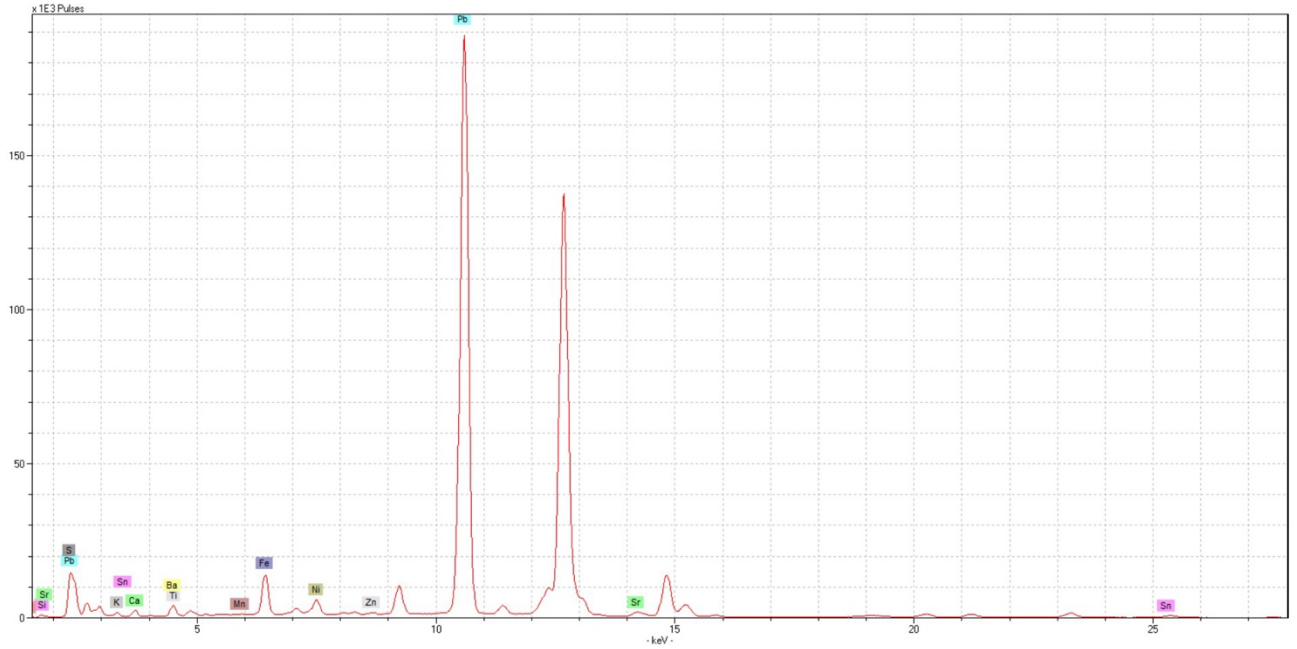

Figure F.12. pXRF measurement number 1546, distant blue sky (graph created with Artax V.8 software).

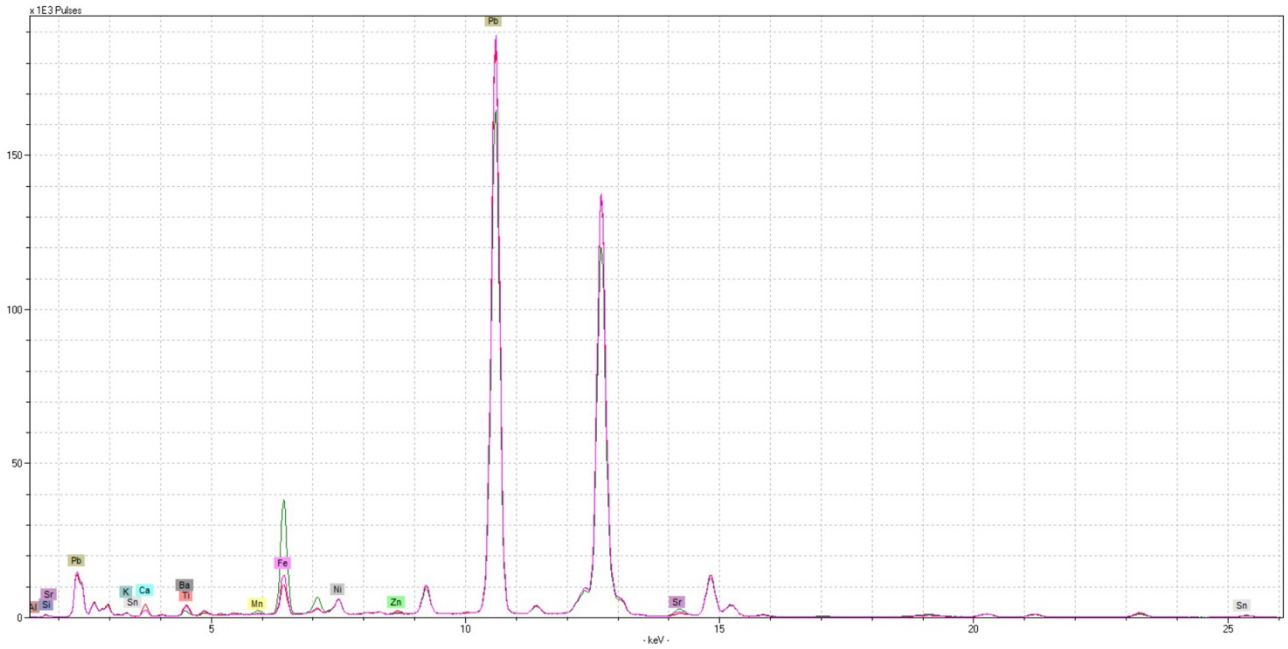

Figure F.13. pXRF measurement numbers 1542 (red), 1544 (green), and 1546 (pink), all blues on canvas. The same pigment appears to have been used for all areas but notice the spike in iron seen in the darkest area while both the distant blue sky and highlight of the skirt have a higher concentration of lead (graph created with Artax V.8 software).

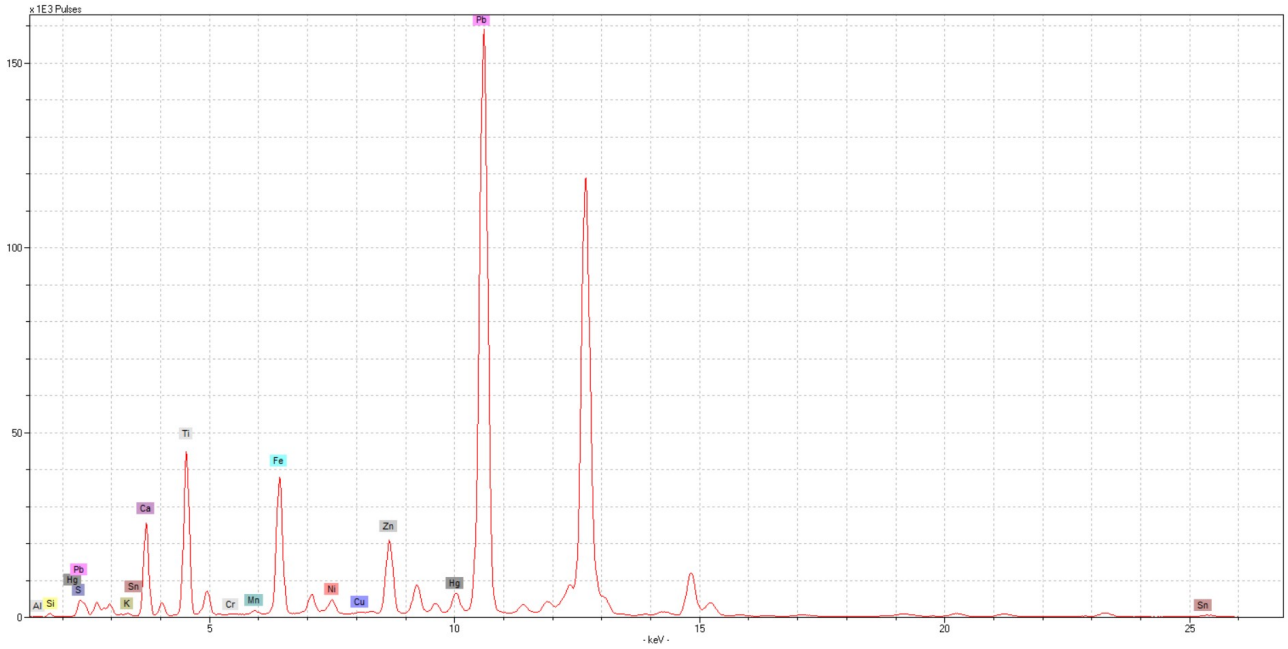

Figure F.14. pXRF measurement number 1547, cheek of baby Jesus that appears to have been heavily retouched (graph created with Artax V.8 software).

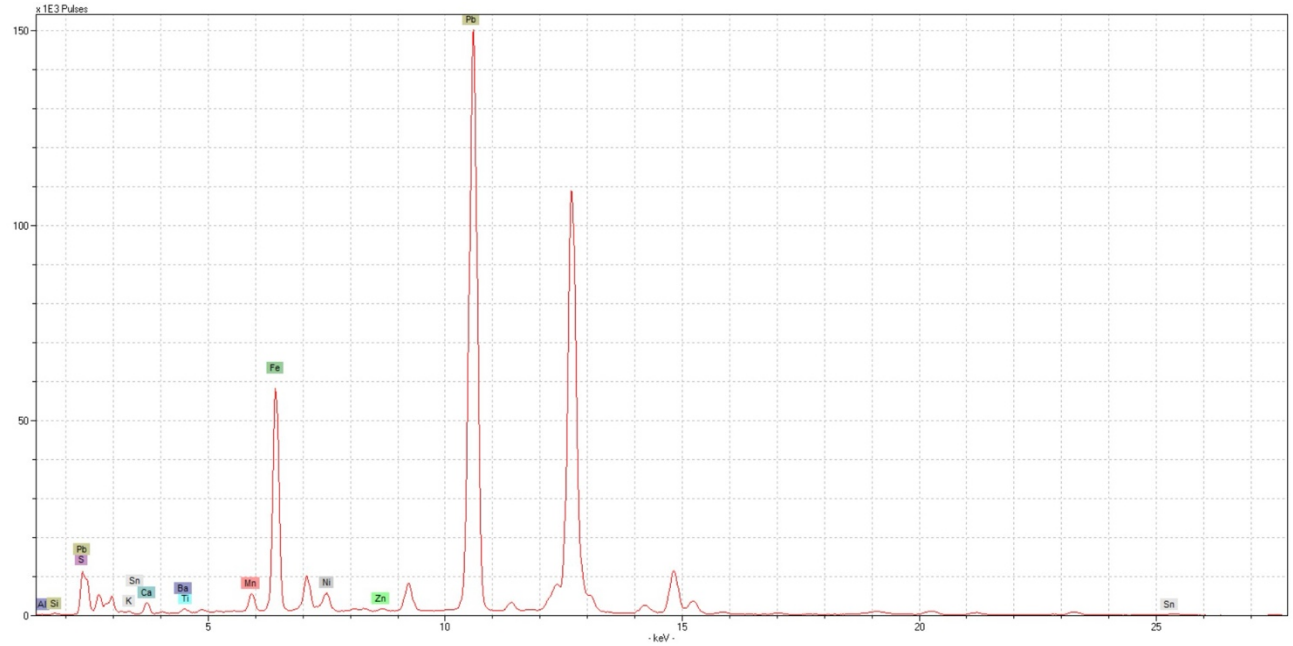

Figure F.15. pXRF measurement number 1548, dark area below Jesus' right elbow (graph created with Artax V.8 software).

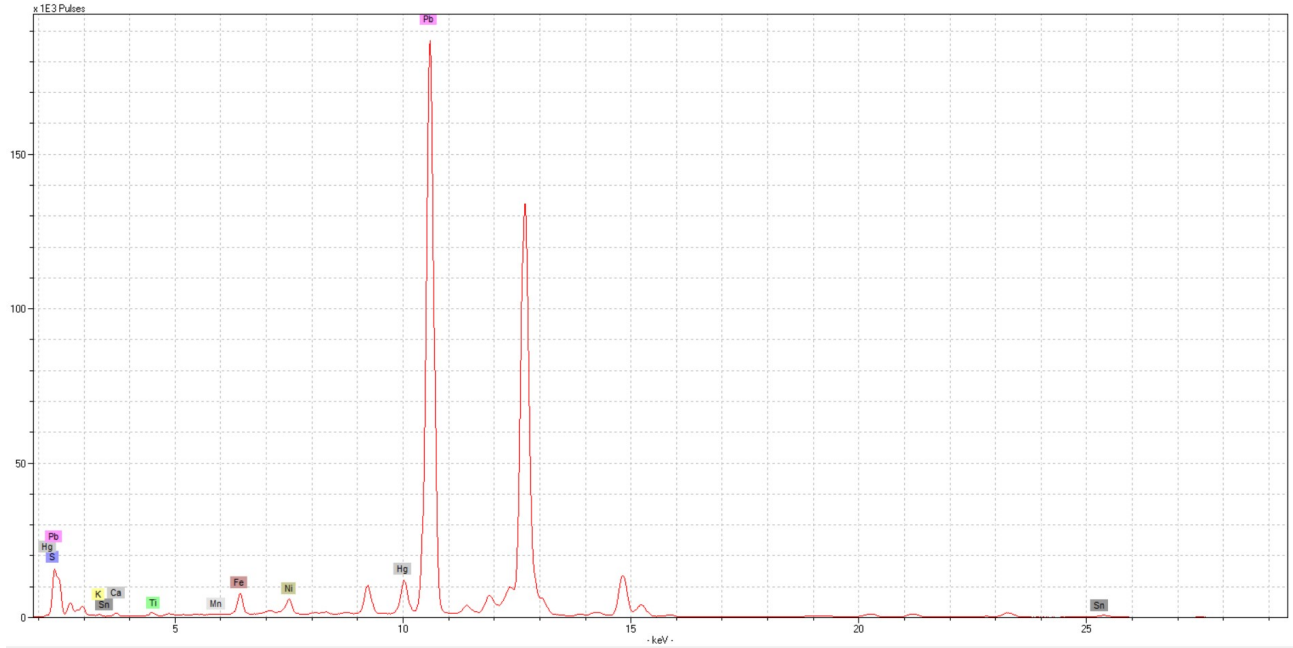

Figure F.16. pXRF measurement number 1549, Madonna's right sleeve (graph created with Artax V.8 software).

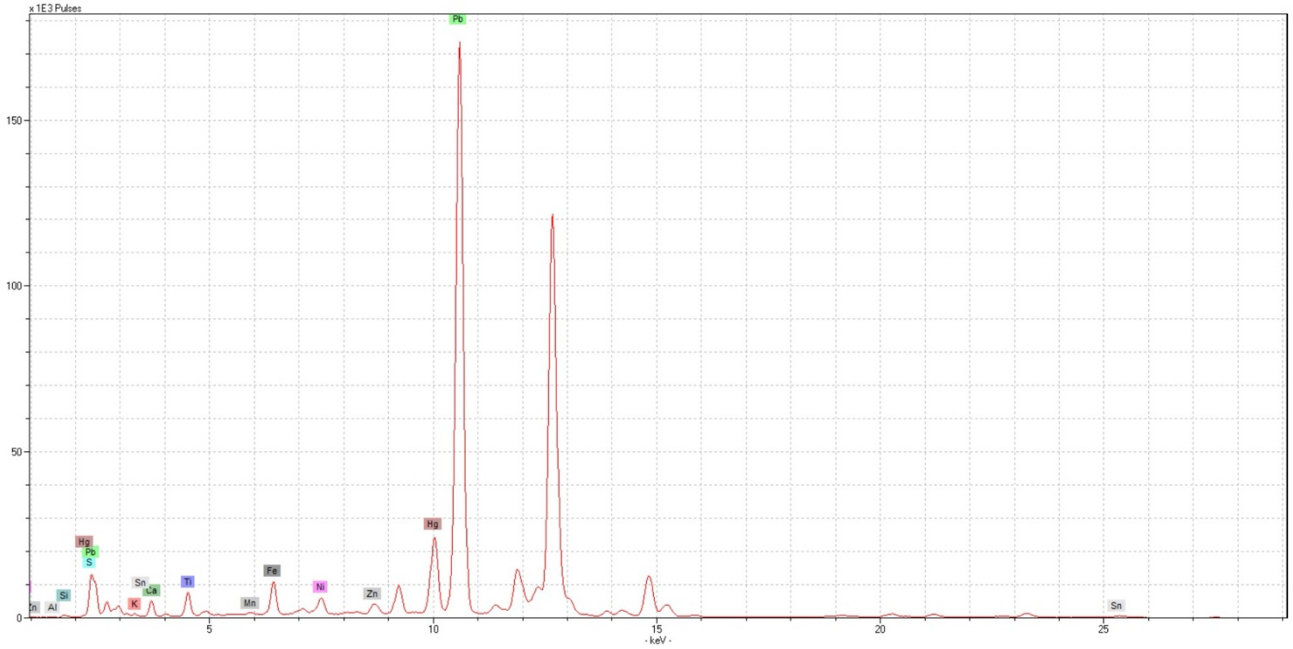

Figure F.17. pXRF measurement number 1550, shaded area on the Madonna's left breast. This are does appear to have been retouched, notice the increased concentration of titanium (graph created with Artax V.8 software).

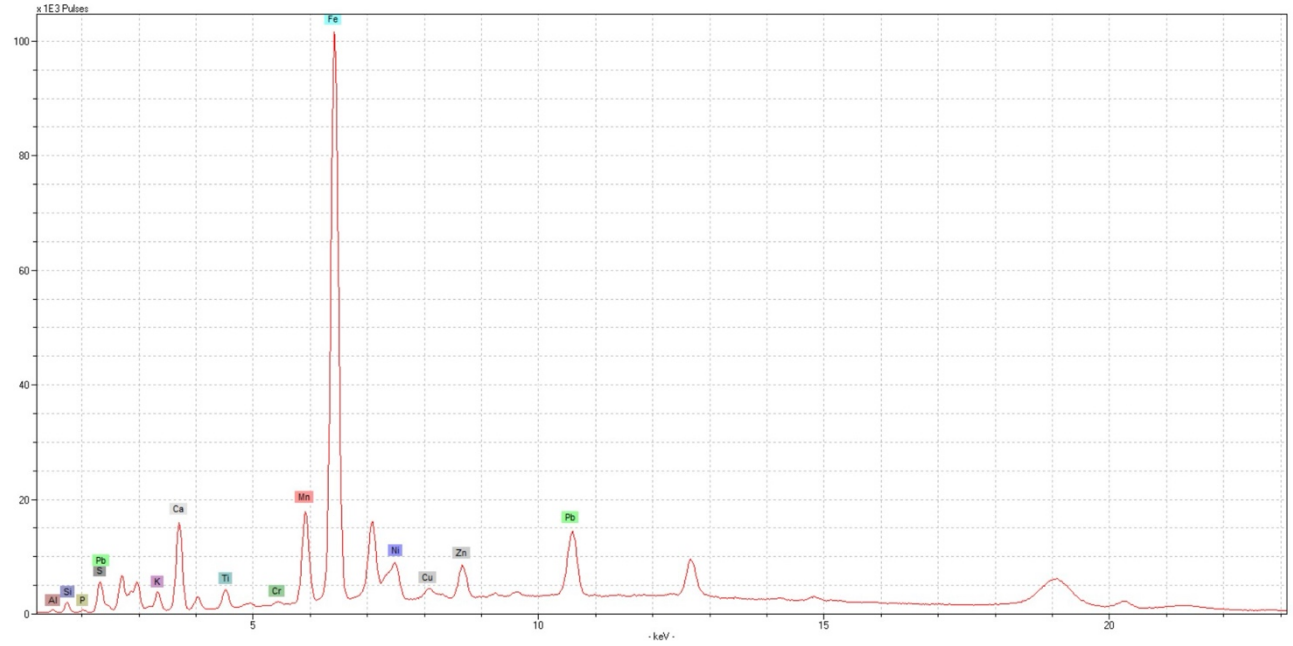

Figure F.18. pXRF measurement number 1551, dark shadow of picture right bottom corner. Here the lead concentration drops and iron spikes very high (graph created with Artax V.8 software).

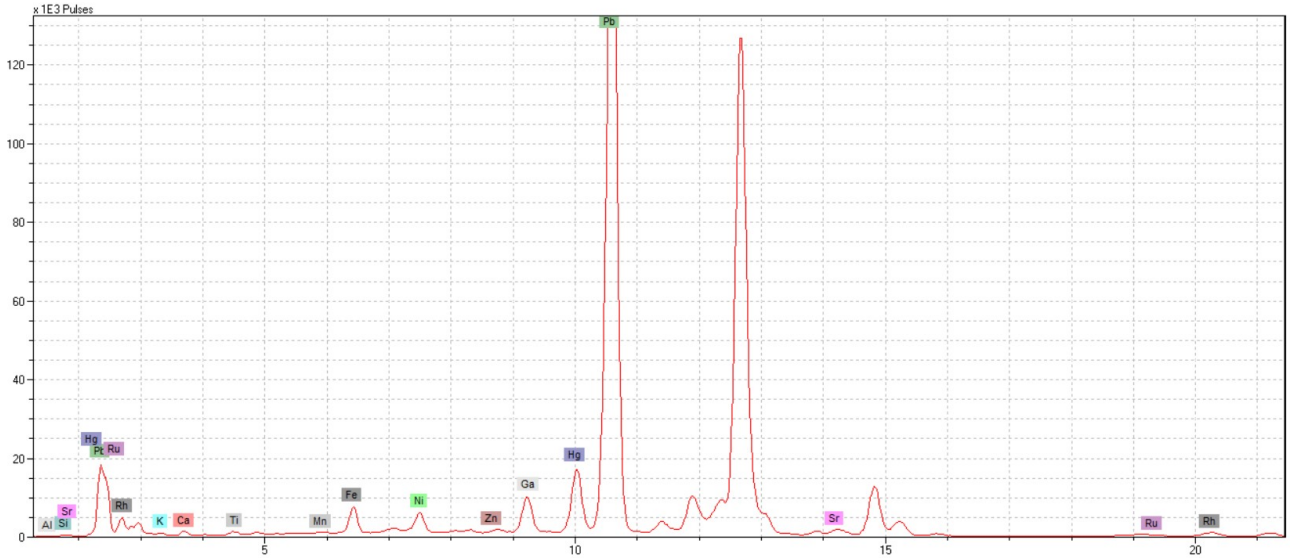

Figure F.19. pXRF measurement number 1552, highlight of Madonna's pink skirt hem (graph created with Artax V.8 software).

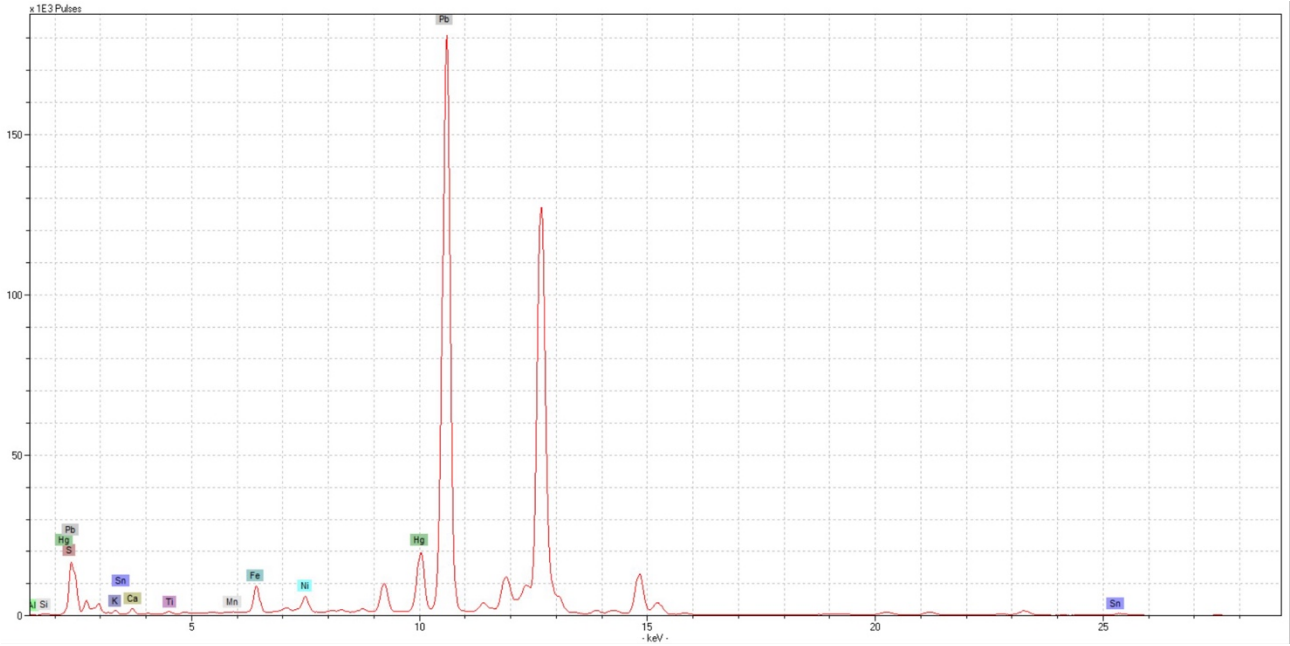

Figure F.20. pXRF measurement number 1553, shadow in fold of Madonna's pink skirt hem (graph created with Artax V.8 software).

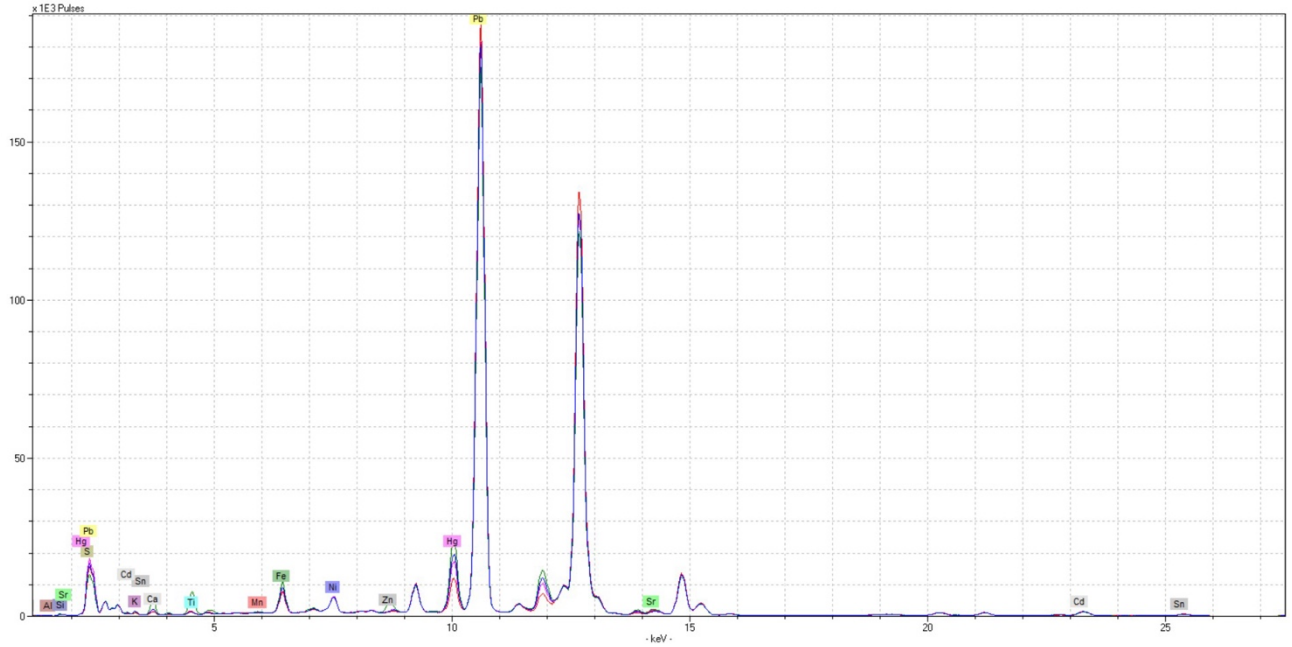

Figure F.21. pXRF measurement numbers 1549 (red), 1550 (green), 1552 (pink) and 1553 (blue), all pink regions (graph created with Artax V.8 software).

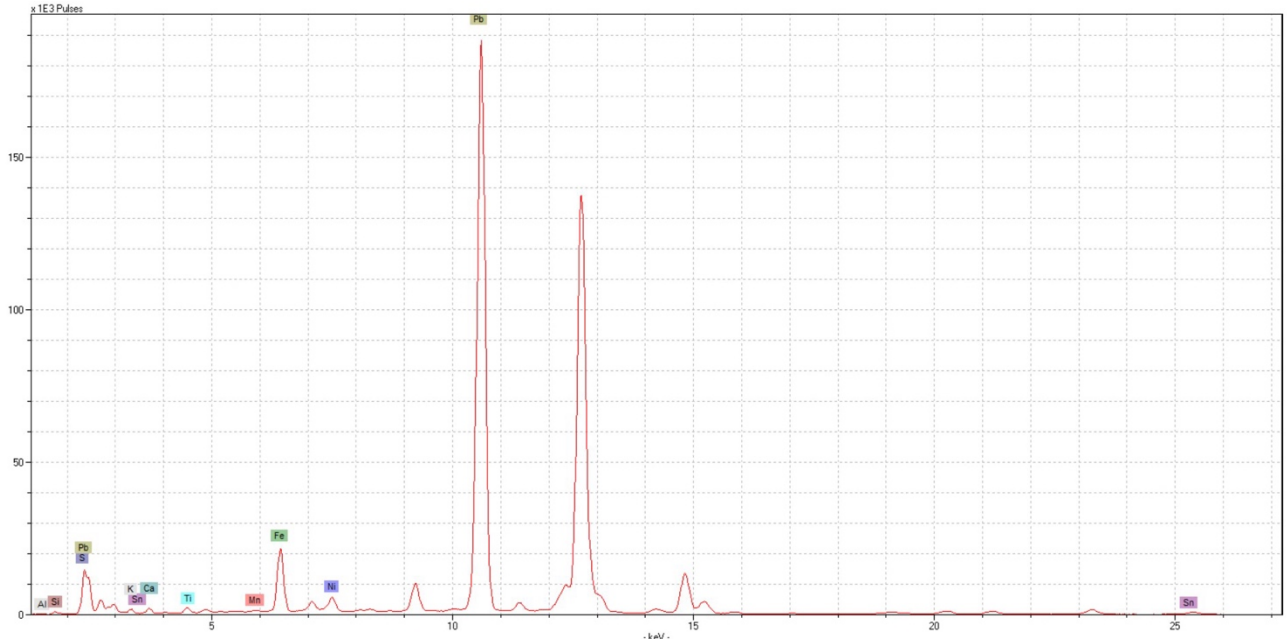

Figure F.22. pXRF measurement number 1554, Madonna's cream-colored shawl (graph created with Artax V.8 software).

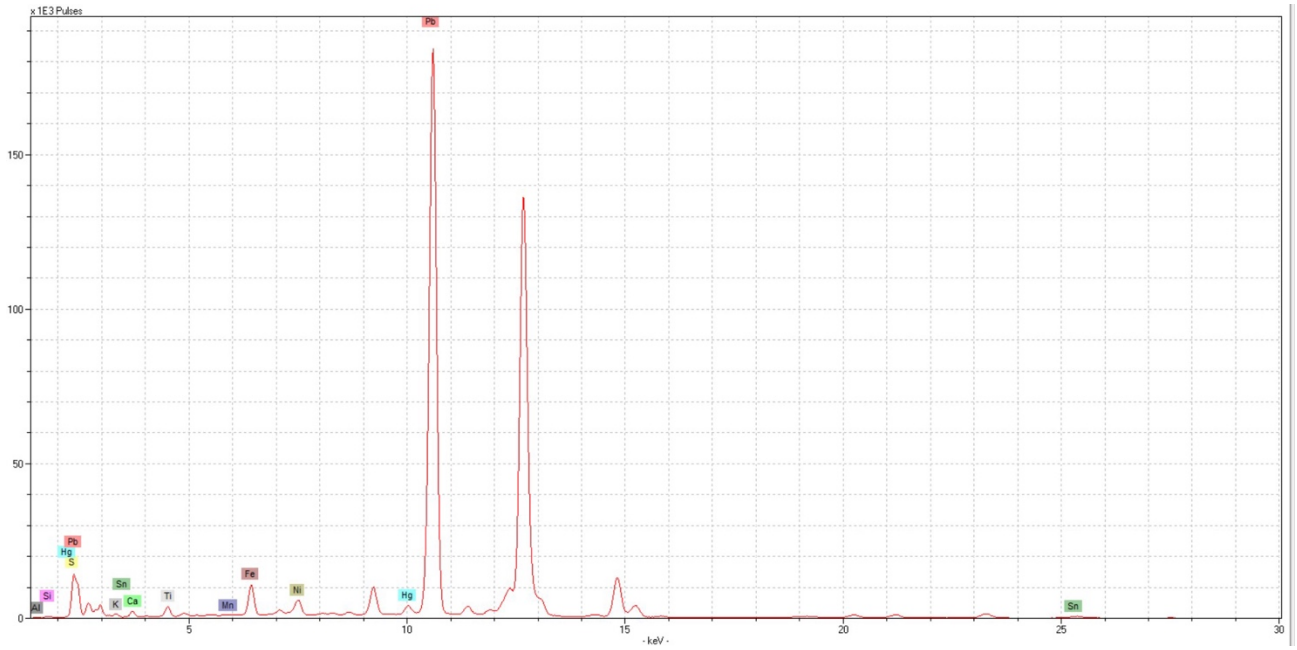

Figure F.23. pXRF measurement number 1555, the top of Jesus' left knee (graph created with Artax V.8 software).

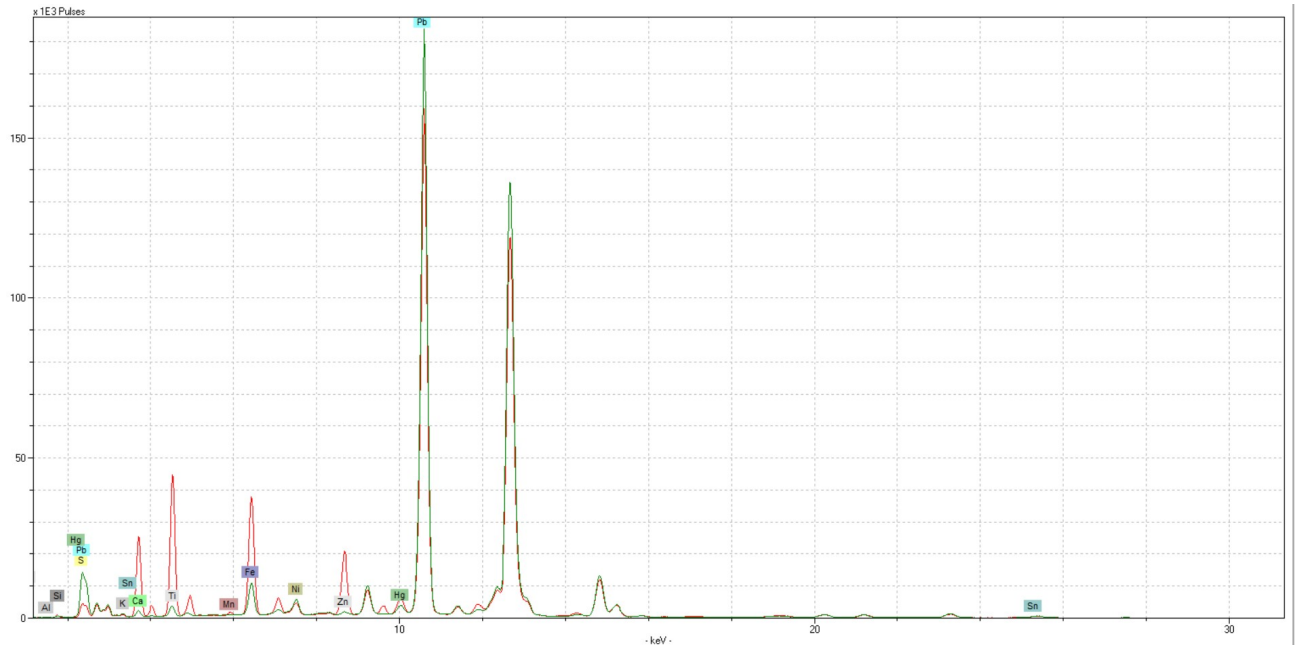

Figure F.24. pXRF measurement numbers 1547 (red) and 1555 (green), the retouched area of Jesus' cheek compared to likely original paint of his left knee. The modern intervention shows a spike in Calcium, Titanium, Iron, Zinc and Mercury, while the original paint contains more lead (graph created with Artax V.8 software).

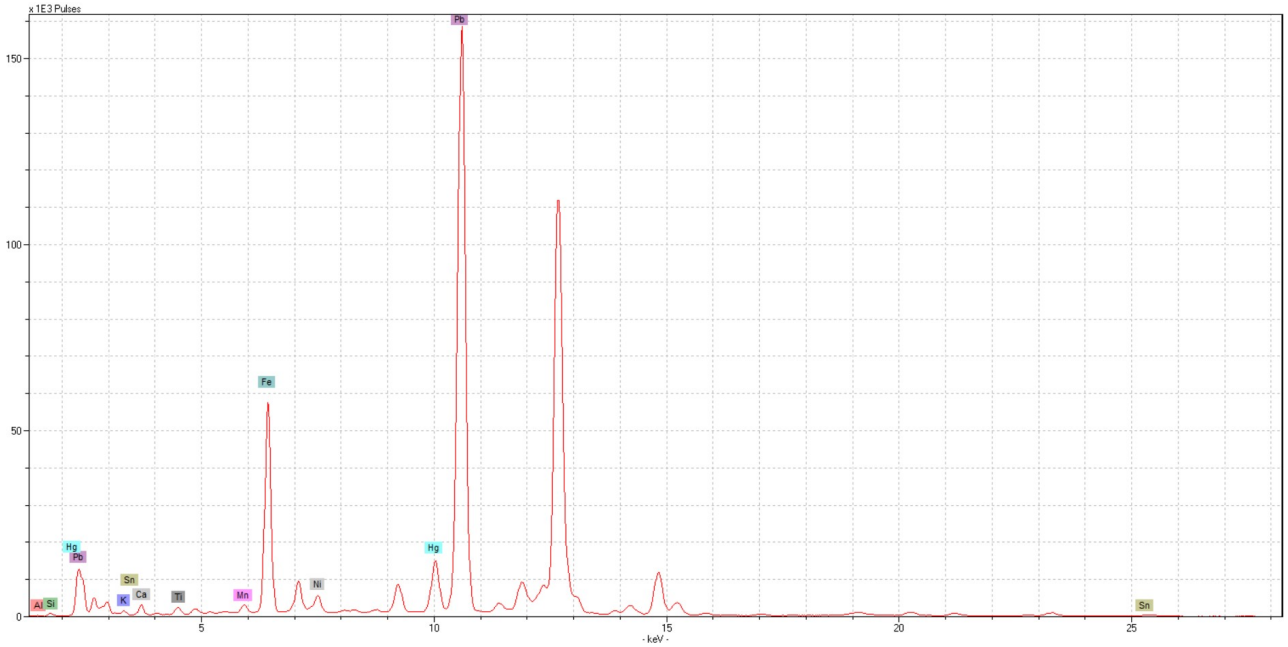

Figure F.25. pXRF measurement number 1556, Saint Anne's left cheek (graph created with Artax V.8 software).

Figure G.1. Preliminary evaluation of the painting (photo taken by Alvin Cuadra during phase two of analysis).

Figure G.2. Doctor Vanessa Muros operating the portable X-Ray Fluorescence device (photo taken by Alvin Cuadra during phase two of analysis).

Figure G.3. Annotating the various points being measured by pXRF (photo taken by Alvin Cuadra during phase two of analysis).

Figure G.4. Painting being removed from frame for the purpose of taking samples from the most discreet areas (photo taken by Alvin Cuadra during phase two of analysis).

Figure G.5. Samples taken from very edge of the canvas (photo taken by Alvin Cuadra during phase two of analysis).

Figure G.6. Samples 1, 2, 7, and 8 prior to their removal (photo taken by Alvin Cuadra on site during phase two of analysis).

Figure G.7. After image of 1, 2, 7, and 8 (photo taken by Alvin Cuadra on site during phase two of analysis).

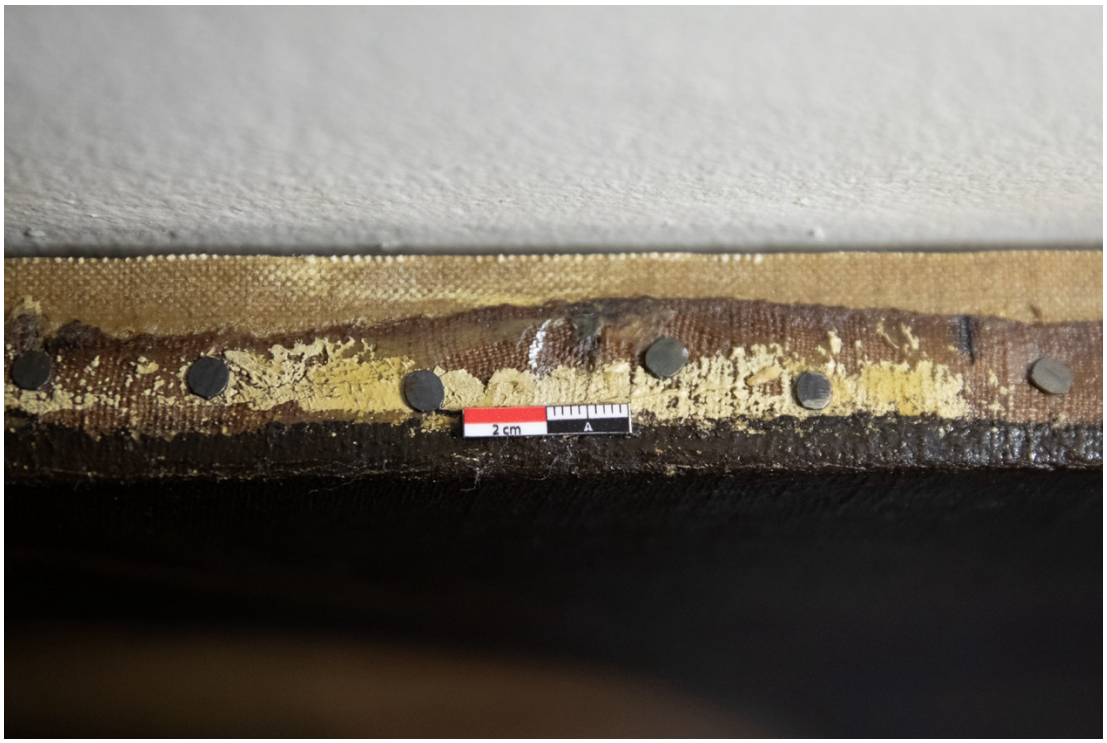

Figure G.8. Sample 3 prior to removal (photo taken by Alvin Cuadra on site during phase two of analysis).

Figure G.9. After image of sample 3 (photo taken by Alvin Cuadra on site during phase two of analysis).

Figure G.10. Sample number 4 and 5 prior to removal (photo taken by Alvin Cuadra on site during phase two of analysis).

Figure G.11. After image of samples 4 and 5 (photo taken by Alvin Cuadra on site during phase two of analysis).

Figure G.12. Samples 6 and 9 prior to removal (photo taken by Alvin Cuadra on site during phase two of analysis).

Figure G.13. After image of samples 6 and 9 (photo taken by Alvin Cuadra on site during phase two of analysis).

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