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# A multi-disciplinary analysis of the *Portrait of Philip the Good* in Dijon

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**Abstract**
One of the finest fifteenth-century portraits of the Burgundian Duke Philip the Good resides in the Musée des Beaux-Arts in Dijon. This small yet exceptionally crafted panel holds significance for both historians and art historians alike. Surprisingly, prior to this study, the context, the dating and the authorship of the piece remained obscure, and the widely circulated hypothesis of it being "a copy of a lost portrait by Rogier van der Weyden" has never been corroborated by convincing arguments. Clarifying the context, dating and authorship of the painting were the primary objectives of the investigations discussed in the article. Therefore, this painting underwent a multidisciplinary investigation spanning both the positive and human sciences. Macro-XRF scans were conducted alongside hyperspectral reflectance scans, multispectral imaging in the visible and infrared range, and optical coherence tomography. These analyses were complemented by an art historical study. As a result, a precise delineation between authentic and retouched sections was achieved. This article does not merely present the various perspectives separately but constructs a coherent narrative based on all these foundations. This holistic multidisciplinary research methodology produced a clear account, albeit with some scope for future inquiry. The involvement of the painter Pieter Cristus was conclusively demonstrated. This painter, whether himself personally, an assistant in the workshop or a contemporary follower, is attributed to the genesis of this work, which is presumed to be not the original portrait but a contemporaneous copy, possibly commissioned by the Burgundian Duke himself. While we no longer remain in the dark and have lifted some veils, this study also paves the way for further investigation into this panel and the numerous other portraits of Philip the Good.

**Keywords** Philip the Good, MA-XRF, Optical coherence tomography, Reflectance imaging spectroscopy, Multispectral reflectography, Patronage of the Burgundian court, Holistic multi-disciplinarity

## Introduction

The Musée des Beaux-Arts in Dijon houses a portrait of the Burgundian duke Philip the Good (1396–1467) in its collection. Under his rule, the Duchy of Burgundy united nearly all the territories in the Low Countries under a single administration. Although the capital was Dijon, located in Burgundy, the economic and cultural heart lay in the many prosperous cities of Flanders and Brabant. The portrait from Dijon presents us with the man who led this flourishing, opulent European state from 1419 to 1467. The small panel, measuring approximately 22 by 31 cm, depicts the Burgundian ruler entirely dressed in black against a dark blue-green background (Fig. 1).

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**Fig. 1** Portrait of Philip the Good. Dijon, Musée des Beaux-Arts, inv. nr. 3782. Photo: Marco Raffaelli

The duke wears a black turbanlike hat, a bourrelet, with a draped cloth over it, the cornette, hanging over his right shoulder. Attention is drawn to the large gold necklace of the Order of the Golden Fleece. At the bottom edge, his right arm appears, the sleeve edged with marten fur, the right hand with four extended fingers while the invisible thumb clasps a scroll of paper or parchment. The inventory of the collection of Margaret of Austria, the great-granddaughter of Philip the Good and the regent of the Burgundian Netherlands from 1507 to 1530, mentions a panel with a portrait of Philip the Good, dressed in black, sporting a bourrelet and a Golden Fleece chain, with a scroll in his hand [1]. The portrait in Dijon, which closely corresponds to this description from 1516, is however not the only version. In an age when copying techniques were increasingly common, the Burgundian ruler apparently allowed his portrait to be distributed in multiples. There are more than ten versions, including those in the Groeninge Museum in Bruges, the Kunsthistorisches Museum in Vienna, Windsor Castle, the Louvre Museum in Paris, two different versions in the Musée de l'Hospice Comtesse in Lille, and in the Royal Museum of Fine Arts in Antwerp.

Much literature has been published on all these versions [1–4]. These various copies, replicas, or imitations vary greatly in quality. Undoubtedly, there were already multiple copies circulating during the lifetime of Philip the Good. Many (often inferior) copies were also made in later centuries.

We do not know the painter of any of these paintings, although the art historical literature often proposed unfounded tentative attributions. The most cited assessment, "copy after a lost work by Rogier van der Weyden", lacks any stylistic, technical, or archival support. Comblen-Sonkes does not believe the Dijon portrait is a work from Rogier van der Weyden's workshop [4] and Campbell suggested that it might be a painted copy after a drawing by Rogier van der Weyden [1]. Many scholars consider the Dijon portrait the finest rendition, or one of the finest renditions, suggesting a close affinity with the original portrait [1, 3, p. 20–21].

The presence of numerous versions of the work, coupled with unresolved scholarly debates, has led to a notably deficient comprehension of its contextual origins. Consequently, we deemed it imperative to subject this panel painting to a comprehensive multidisciplinary investigation.

The initiative, "Multi-disciplinary Analysis of the Portrait of Philip the Good", generously supported by IPERION HS and Illuminare, the Centre for Medieval and Renaissance Art (at KU Leuven), and facilitated by the Musée des Beaux-Arts in Dijon, was designed to employ a methodology referred to as a holistic interdisciplinary approach [5, 6]. This approach seeks to integrate diverse but complementary analytical techniques from both the humanities (such as history and art history) and heritage sciences (based on chemistry and physics) into an interdisciplinary technical art history [7, 8]. By synthesizing these various strands of inquiry, we aimed to construct a cohesive narrative elucidating the genesis and significance of the artwork.

Through this multifaceted examination, a coherent image of the panel painting compellingly emerged. The recent phases of restoration have been elucidated, thereby clarifying the distinction between authentic and non-authentic components. The painting could be attributed to a painter closely related to Pieter Cristus, shedding new light on the artistic patronage of Philip the Good. The painter Pieter Cristus is the immediate successor of Jan van Eyck in Bruges and is mostly known in literature as Petrus Christus, a name he himself never used. As suggested by the recent literature, this article uses his original name [9].

## Prior work and condition

In 1975 technical analyses were executed by the Centre for the Study of Flemish Primitives, Brussels, and the results were published in 1986 by Comblen-Sonkes

[4]. In addition to a precise technical description of the support and pictorial layers, radiographic and infrared images were taken, and a cross-section analysis of a sample (from the background) was conducted. The sample revealed a ground layer consisting of chalk, covered with a layer of oil paint consisting of azurite and lead white. In the infrared image, a sharply defined underdrawing without hatching was visible on the face. This was interpreted as an indication of a copying method based on a traced sketch. However, hesitant, even clumsy lines were observed in the underdrawing of the hand. The work was in poor condition in 1975: it displayed four large vertical cracks, and strips with a roughly painted surface were attached to the four sides of the panel, enlarging the painted surface, but the different colouration betrayed its non-authentic nature (Fig. 2).

The portrait is painted on an oak panel with a complicated history. In 1946, the panel was described as a panel measuring 22.0 by 30.5 cm. Two years later, it was offered on loan to the Musée des Beaux-Arts in Dijon (its present location), where the enlarged frame was made “in the style of the fifteenth century” [10]. Around that time, the panel was enlarged with added pieces on all four sides, probably to stabilize the cracking panel. In the process, the original panel was trimmed by a few millimetres on all four sides. In 1975, it was described as a painted panel measuring 27.4 cm by 35.6 cm, whereas the inserted original panel measures only 21.3 cm by 29.6 cm (Fig. 2) [4]. Because of its poor state of preservation, a major restoration was carried out by SRMCC (Service de Restauration des Musées Classés et Contrôlés) in Paris in 1983–1984 [10]. The non-authentic wood was largely sawn off. Since then, the panel measures 22.4 cm by 31.3 cm, with edges of added, partly unpainted wood (left and right 5 mm, top 11 mm, bottom 6 mm).

Fig. 2 Portrait of Philip the Good. Dijon, Musée des Beaux-Arts. Photograph from 1975 before the restoration. Photo: CC-BY KIK-IRPA, Brussels

## Methods

Thanks to the MOLAB access granted by the EU project IPERION HS [11], the Portrait of Philip the Good has been recently subjected to multiple technical analyses in its location at the Musée des Beaux-Arts in Dijon. First, the panel had been stripped of its protective frame and glass plate. Then it was subjected to several complementary in-situ analyses by non-invasive techniques, described below. The planned dendrochronological analysis had to be cancelled once it became clear that the composite construction of the panel had rendered the original wood inaccessible (Fig. 3). All the research data and imagery, discussed below, can be consulted in an online data repository of KU Leuven [12].

### VIS–NIR multispectral reflectography

The multispectral scanner developed at CNR-INO produces 16 images in the visible (395–765 nm) and 16 images in the near-infrared range (750–2500 nm). The lighting (two current-stabilized halogen lamps and two white LEDs) and light collecting (a catoptric objective made of two off-axis parabolic mirrors) systems are placed in a 45°/0° lighting/detection configuration and moved jointly in the XY-plane in a boustrophedon

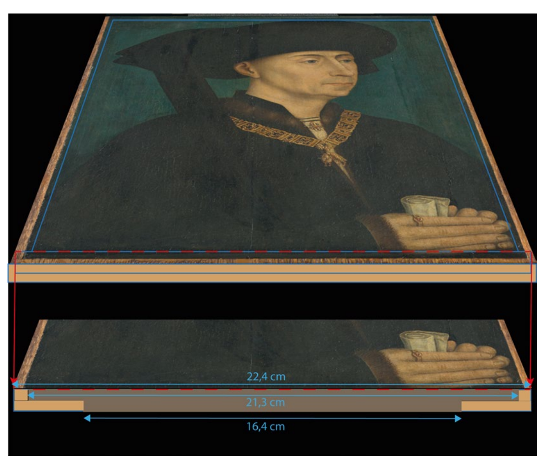


Fig. 3 Composition of the panel with original (dark) and non-original (light) parts

movement with a spot size of 250 μm. The device acquires 1 square meter in less than 3 h, with a 250 μm sampling step. The output is the so-called multispectral cube, which consists of 32 superimposing images that are processed by either Principal Component Analysis or false colour images to highlight the areas with deviating spectral properties not visible to the naked eye, allowing for the identification of retouching zones [13, 14]. This mobile device was brought to the museum location to scan the painting, vertically positioned on an easel.

Principal Component Analysis (PCA) is an orthogonal projection of the data onto a lower dimensional linear space such that the variance of the projected data is maximized. The new uncorrelated variables are called principal components (PCs). Besides dimensionality reduction, PCA is widely used for applications such as lossy data compression, feature extraction and data visualization.

### Synchronous macro XRF and scanning reflectance imaging spectroscopy

Simultaneous scanning measurements of X-ray fluorescence (MA-XRF) and scanning Reflectance Imaging Spectroscopy (sRIS) in the visible-near-infrared (VNIR) and short-wave-infrared (SWIR) range (from 400 to 2500 nm) were carried out by IRIS, a mobile and reconfigurable scanner by Bruker. This novel device is described in [15]. In literature, the analytical technique is also known as hyperspectral reflectance imaging, or HRI. Combining the two techniques in one single measurement allows for enhanced and complementary information on the paint's chemical composition. MA-XRF measurements were carried out operating the X-ray tube at 40 kV and 200 μA. The painting was scanned using a 0,5 mm pinhole collimator with a linear speed of 11 mm/s and acquisition time of 30 ms per spectrum. In these operative conditions, light elements such as Al, Si, P and S are not very suitable for detection by XRF and exhibit very low, non-mappable signal intensities. XRF elemental maps, presented in the Results section, were produced by the PyMCa and Datamuncher software packages [16, 17]. In IRIS, hyperspectral data are obtained in the 400–2500 nm spectral range using an external tungsten halogen lamp as a source and a dedicated optical bundle of fibres (400 μm in diameter) to carry the illumination light onto the surface to a coincident spot with the XRF measurement (of approximately 7 mm in diameter at the focal distance) and to collect reflected light. Acquisitions are synchronized by means of a common trigger logic, and measurement conditions (time exposure and acquisition time) are automatically set by the software. Hyperspectral raw data were exported in the ENVI format for processing [18] and maps were produced using the Spectral Angle Mapper (SAM) algorithm.

### Optical coherence tomography

This non-invasive, non-contact imaging technique gives in-depth information on the painting's sub-surface structures. The technique is described in detail in [19, 20]. In short, the technique is based on analysing the back-reflected or back-scattered radiation after the object is subjected to broadband near-infrared radiation (in this case, 780–980 nm). Despite its major disadvantage of being capable of imaging semi-transparent, subsurface structures only, it is characterised by a superb in-depth resolution—in a range of single micrometres (in this case 2.2 μm in varnish or glazes). A version of the technique utilised here uses a narrow beam of probing light scanned over a selected area of the surface of the painting ($12 \times 12$ mm$^2$ in this case) as a set of parallel, adjacent linear trajectories (in this case, 100 trajectories, 120 μm apart). Radiation scattered back is collected by the same optics and brought to interference with the reference beam from the same source. The single linear scan is then converted into a cross-sectional image. Thus, a single study results in a set of 100 cross-section images, representative examples of which are presented in the Results section. The tomograms are presented here in a false colour composite: warm colours (yellow to green) indicate high scattering/reflecting regions, cold colours (light and dark blue) low scattering regions, whereas non-scattering/reflecting structures like varnish or air above the structure of the painting are shown black. Black are also regions that are not accessible by probing light due to the opacity of the paint above.

This non-invasive, non-contact imaging technique gives in-depth information on the painting's sub-surface structures. The technique is based on analysing the back-reflected or back-scattered radiation after the object is subjected to near-infrared light (in this case, 780–980 nm). Although this technique penetrates only semi-transparent structures at a depth up to 1.8 mm, its in-depth resolution is in a range of single micrometres (in this case 2.2 μm in varnish and glazes). Images are usually presented as cross-sectional views and can be used to distinguish the varnishes, glaze layers, and paint layers. The technique is described in [19, 20].

## Results and discussion

### VIS–NIR multispectral reflectography

When analysing the multispectral cube, particular attention was drawn to the composition of the dark blue-green background, which consists of various zones painted at different times and with different pigments. Immediately around the face and the headdress, the background becomes translucent at 1050 nm, while the outer parts only become visible at higher wavelengths (Fig. 4). The various optical properties were visualised in a colour

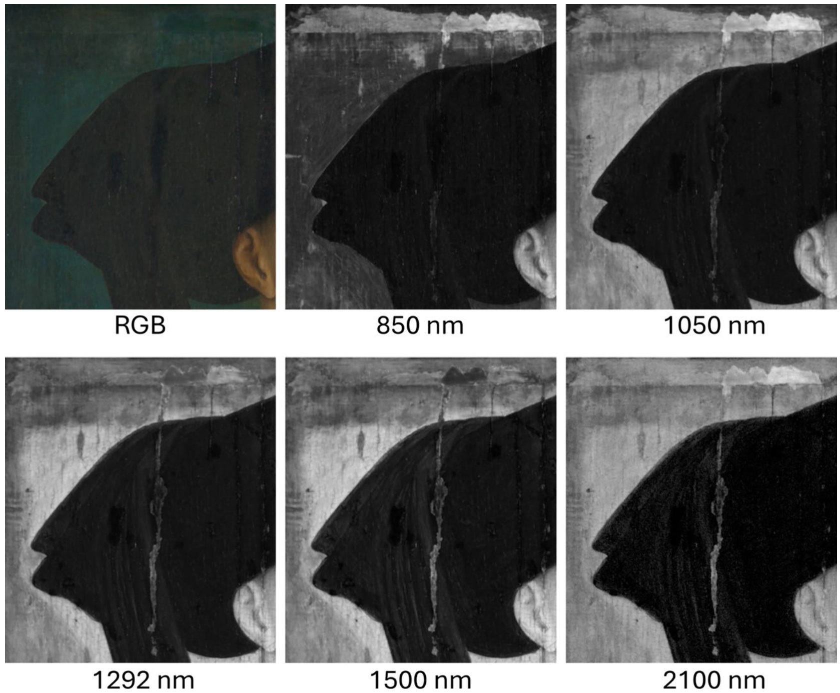


**Fig. 4** The background of the portrait, in different infrared wavelengths

composite image based on principal component analysis (Fig. 5), suggesting that a seemingly untouched original background is only present in the immediate vicinity of the figure. The (presumed) overpainting was executed from the edges inward. At the top, left of the centre, there is a spot with a different composition, most probably a retouching. This retouching only became translucent at wavelengths between 1830 and 1940 nm. The original or non-original character of the different paint passages in the background will be clarified by the pigment analysis based on the MA-XRF scans (see below). In contrast to the troubled background, the figure itself, particularly the facial features, appears conspicuously unaffected by retouching. Comblen-Sonkes noted in 1986 that the delicate modelling of the face had been well preserved [4]. In older restoration practices background areas, however, were considered suitable for radical overpainting. A well-known example is Rogier van der Weyden's *Virgin and Child* in Tournai, which was treated by a controversial restoration by Jozef Van der Veken around 1924 [21].

Infrared reflectography at a wavelength of 1600 nm has rendered the paint layers of the face and the immediate background completely transparent. In this image, we see the underdrawing of the face, consisting of remarkably sharp, confident lines. The neck and tip of the cornette (the cowl) are also outlined (Fig. 6a). This linear sketch, without hatching and with a continuous line free of hesitations, is characteristic of a copied sketch [4, 22, 23].

**Fig. 5** Colour composite representation of the spectral differences in the background area, based on the PCA (2-3-4) technique

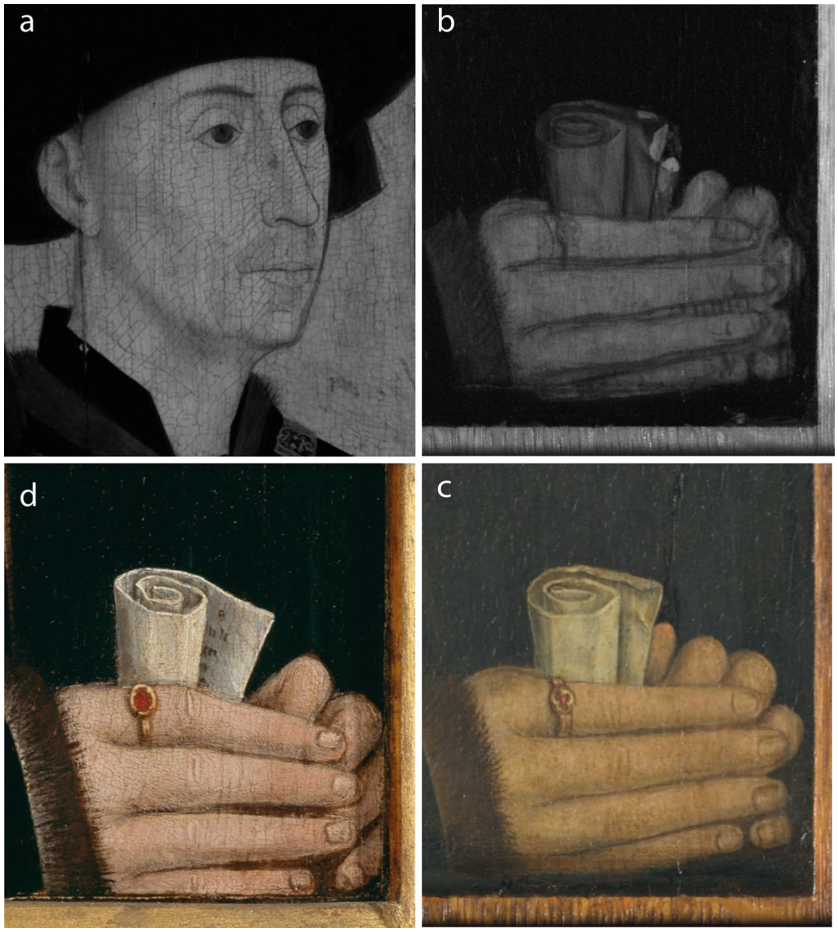


**Fig. 6** **a** Infrared reflectography at 1600 nm, detail (face). **b** Infrared reflectography at 1705 nm, detail (hand). **(c)** RGB image obtained from the 16 visible channels combined with the standard D65 illuminant and 1931 observer, detail (hand). **d** Portrait of Philip the Good. Bruges, Groeninge Museum, detail (hand). Photo: Public domain

Where the face appears as a confident, almost mechanical copy, we see a very different image in the hands. The underdrawing indicates hesitation and adjustment by the painter, both in the drawing and in the painting. Initially, the fingers were narrower towards the tips, and the nail of the index finger pointed upwards: two anatomical errors that were corrected during painting. The ring around the index finger was initially shifted further towards the palm and was only provided with a gemstone during painting (Fig. 6b). The fingers, initially too short, were lengthened during painting, and the space between them was reduced to a line, resulting in a more realistic depiction of the fingers (compare Fig. 6b and c). Three parallel fingers with a V-shaped space between them, only visible in the inferior underdrawing here, are also seen with the painted hand in the Vienna portrait of Philip the Good. The upward-pointing nail and the too short fingers are mistakes also observable in the Bruges Philip the Good (Fig. 6d). These observations seem to suggest that the painter carried out a copying process while improving the inferior execution in his version.

## Synchronous macro XRF and reflectance imaging spectroscopy

The original colour palette consists of a limited number of hues. Where the presence of tin correlates with that of lead, lead–tin yellow pigment was used, notably conspicuous in the Order of the Golden Fleece chain and, very faintly, in the cross-shaped pendant and the ring (see the Sn-L and Pb-L maps in Fig. 7). The most frequent form of lead–tin yellow consists of lead stannate, $Pb_2SnO_4$, and is known as type I. A second variety, lead–tin yellow type II, also contains silicon. Both types of this pigment have been documented since the fourteenth century but have not been identified after 1750 [24]. Considering our MA-XRF results, where we have not good sensitivity to the element Si, we have no possibility to discriminate between pigments type I and type II without Raman or


**Fig. 7** MA-XRF scans of the *Portrait of Philip the Good* (Dijon, Musée des Beaux-Arts). The original images are adjusted for brightness and contrast to improve the readability of the image

XRD techniques. Other lead-based yellows, like Naples yellow and lead tin antimony yellow, both containing Sb, were also used in the eighteenth and nineteenth centuries. These pigments can be excluded since we have no evidence for Sb [25]. Lead–tin yellow was a frequently used pigment in Netherlandish art in the fifteenth and sixteenth centuries and we know from a treatise by Van Mander, dated 1604, that the pigment was particularly recommended for depicting golden jewellery [26]. The presence of lead–tin yellow provides a *terminus ante quem* (before 1750) for the panel and convincingly eliminates the possibility of a modern copy or falsification.

The original blue mostly consists of copper-containing pigment (Cu-K map in Fig. 7), identified as azurite by HR scanning (Fig. 8), predominantly found in areas of the background closely surrounding the head and chaperon of Philip the Good. On the peripheries of the panel, the original blue has been overpainted with modern cobalt-based (blue) and chromium-based (green) pigments (Co-K and Cr-K maps in Fig. 7). The distribution of azurite based on its NIR spectral features (combination bands at 2351 and 2390 nm, and OH overtone bands at 1496 nm, [27]) is reported in Fig. 8 and matches the distribution of Cu in the MA-XRF map.

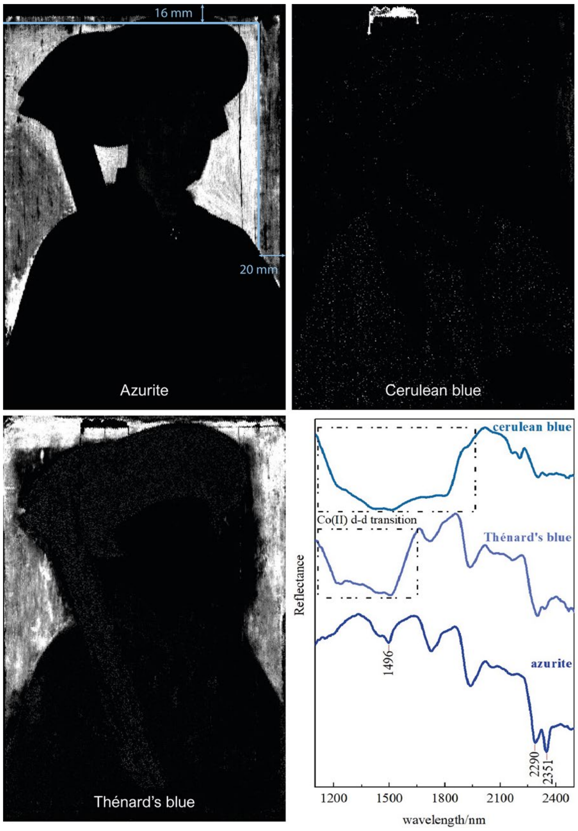


**Fig. 8** Pigments identified by hyperspectral imaging. On the azurite scan, the boundary line between zones with higher and lower azurite concentration is marked in blue

The red pigment used is vermilion, based on mercury sulphide (HgS) [24]. It was observed in the flesh tones but particularly vibrant in the gold of the Order of the Golden Fleece chain, the central ruby in the cruciform pendant, and the ring (See the Hg-L map in Fig. 7). In the face and hands, extensive use of lead white is observed with a minimal amount of vermilion, containing mercury, which is exactly according the recipes for flesh colour, described in fifteenth-century textbooks on painting techniques. [28]. Recent research by MA-XRF revealed indeed this painting technique for rendering flesh tones on a painting by Rogier van der Weyden from 1460 [29].

Lead white was extensively used, both in white areas (for instance, in the shirt and the scroll) and mixed with other pigments to obtain different tonalities, such as in the face and hands, or even in the background where it was mixed with azurite (See the Cu-K and Pb-L maps in Fig. 7). We observe a minimal amount of lead over the entire surface of the painting (excluding the added strips), even in the black areas. A possible explanation for this could be the presence of a monochromous preparatory layer or *imprimatura*, based on lead white, which isolates the pictorial layers from the ground layer. This technique, also employed by Jan van Eyck, has been observed in many other Netherlandish panel paintings [30–32]. By comparing the Pb-image and the Ca-image, we can identify areas where lacunae were retouched: where the lead is locally absent, the calcium signal appears much brighter (Ca-K and Pb-L maps in Fig. 7).

The iron-containing ochre was not used in the flesh tones but rather in the brown marten fur of cuffs, fur collar, and mantle lining.

Since the presence of calcium characterises the black surfaces, it can be presumed that this involves the calcium-rich pigment bone black or ivory black, which contains hydroxyapatite, $Ca_5(PO_4)_3(OH)$. Similar to other calcium compounds, hydroxyapatite may also contain Sr as a trace element, acting as a vicariant ion for Ca. This is likely the explanation for the slight presence of strontium in correlation with the calcium in the black areas [33]. However, since XRF detection efficiency is rather low for phosphorus we cannot confirm conclusively the presence of bone black.

The original palette is thus composed of lead–tin yellow, azurite, vermilion, lead white, ochre, and (presumably) bone black, demonstrating a relatively limited range of pigments. Both the observed pigments and the observed painting techniques, like the lead white priming, the rendering of flesh tones and golden jewellery, are entirely in line with the known palette and techniques of fifteenth-century painters [31].

The MA-XRF images also provide a clear view of the retouched paint layers and restorations. The vertical cracks, two parallel lines (a short and a longer one) passing through the ear and a long line located to our right of the face, were filled with a barium-containing pigment after 1800 (Ba-K map in Fig. 7). A third crack, more towards the left, was restored at a later time, with the presence of titanium, iron and manganese detected here (See Ti-K and Fe-K in Fig. 7). Because of the presence of titanium, probably in the form of titanium white, this intervention must be dated after 1920. The co-presence of iron and manganese (elemental map not shown in Fig. 7) in this crack filling suggests the use of a burnt umber pigment or manganese black (a mixed Mn/Fe oxide). However, based only on elemental analysis we cannot give identification of the pigment.

Where locally elevated levels of calcium are detected in the black surfaces (the pourpoint and hood), this is accompanied by the presence of iron. It is likely that these local lacunae have been filled with retouches using mars black, a pigment containing magnetite ($Fe_3O_4$) that was only developed at the end of the nineteenth century and traditionally used with calcium carbonate as an extender [34–37].

However, the most notable are several overpaintings in the dark blue background, as already suggested by the VIS–NIR multispectral reflectography. These were executed when the panel was enlarged with additional edges, and a dark greenish blue was painted well beyond the old background from the new edges. The cobalt-containing pigment was identified by HR scanning to be cobalt blue, also known as Thénard's blue (Fig. 8) (near-infrared d-d transition of cobalt (II), [38]). The chromium-based pigment, instead, could be either viridian or chromium green. Although some spectral features in the visible range highlighted by HR scanning hinted at the usage of the first, a clear identification of the pigment cannot be achieved without further complementary analysis. Possibly the zinc comes from zinc white, which was used as a filler in a modern paint. These are pigments that were not used before the end of the eighteenth century [39, 40]. A notably distinct retouching in dark blue is situated to the left of the upper edge, which was seen translucent at wavelengths between 1830 and 1940 nm in reflectography. A small spot measuring 20 mm wide and 5 mm high consists of cobalt stannate, a compound of cobalt and tin (see the Co-K and Sn-L maps in Fig. 7) and a primary component of cerulean blue (near-infrared d-d transition of cobalt (II) as for the previously mentioned cobalt-based pigment, [38]). This pigment was introduced only after 1860. Lastly, the repainted lower edge also exhibits a markedly different chemical composition, with notably high concentrations of iron and calcium, possibly indicating the use of the modern pigment mars black (Fig. 7).

Furthermore, the scans in the elements lead, copper, and calcium provide insights into an intriguing line in the original, overpainted background. Approximately 20 mm from the right edge, we observe in the lead scan a vertical boundary line in the background. The area near the right edge clearly exhibits less lead, causing the calcium from the ground layer to appear brighter in that area. Additionally, a noticeable lacuna in the lead image, between Philip's left shoulder and the right edge of the image plane, highlights the underlying calcium. In the original background, now invisible because of the overpainted cobalt blue paint, there must have been a 20 mm strip with a lower concentration of lead. This is further corroborated by the copper image, which shows a discontinuity along the same line (Fig. 7). The vertical 20 mm strip certainly does not represent an added piece of panel. The added pieces are clearly discernible in the lead scan, where they create lead-free black edges. The strip where the presence of copper and lead is reduced must have been a distinct colour zone in the original background. We can claim with some confidence that the original, hidden background had a different colour effect in the areas left and right of the vertical boundary line (Fig. 8). Given that in Pieter Cristus's *Portrait of a Carthusian* (Fig. 9), dating from 1446, we see a similar vertical boundary between two colour zones in the background, positioned halfway between the face and the right edge of the image plane, creating the illusion of a corner in an interior, it is highly plausible that a similar corner effect was intended in the original background of Philip the Good's portrait. However, later overpainting of the background has obscured this subtle tonal difference to the naked eye. It is not inconceivable that originally there was also a horizontal zone at the top with a difference in colour, thus suggesting a ceiling plane. Indeed, we can distinguish a thin 16 mm strip where both the lead and copper concentrations are reduced and calcium is highlighted. However, the top 11 mm are not authentic, here, the lead scan is black because a lead-free modern oak strip has been added to the panel. A *Portrait of a Knight of the Golden Fleece*, attributed to a follower of Pieter Cristus and dated around 1455, has exactly the same division lines dividing the background in two colour zones (Fig. 10) [41, 42, p. 130–131]. It is very possible that the latter portrait was executed after an earlier model featuring Philip the Good against a similar background.

Finally, we were able to identify with reasonable certainty the areas where retouching was applied over the

**Fig. 9** Pieter Cristus, *Portrait of a Carthusian*, 1446. New York, The Metropolitan Museum, The Jules Bache Collection, 1949. Photo: Public domain

**Fig. 10** Pieter Cristus (or copy after), *Portrait of Jean de Bourgogne, Count of Estampes*, c. 1455. Collection Château de Beloeil. Photo: KU Leuven Libraries Special Collections, GP002148

**Fig. 11** Schematic representation of the original and non-original paint layers. Original and untouched paint (no colour manipulation), the old paint layers covered by modern retouching (transparent red) and the entirely repainted areas (red)

existing paint layers and the areas where the repaint was applied entirely from the ground layer up, due to paint loss. When the lead-map reveals gaps and the calcium-map highlights, the original paint layers have vanished, indicating that the entire present paint layer is a recent addition. Modern retouching areas are easily identifiable because they consistently contain zinc, chromium and/or titanium. The overpaint (transparent red) and repaint (opaque red) zones are illustrated in Fig. 11. This scheme clearly reaffirms what Comblen-Sonkes already claimed in 1986: the face and the hands are remarkably intact and untouched by restorations [4].

In summary, the MA-XRF scans have sharply delineated the retouched areas. These appear to originate from at least two restoration phases during the nineteenth and twentieth centuries and are located solely in the dark blue and black areas. The face and hands are nearly intact and, based on the usage of lead–tin yellow, were certainly painted before 1750 and, based on the observed painting techniques and pigments, probably in the fifteenth century. It appears that the original background on the right side of the image contained a 20 mm wide vertical strip with a distinct colour and a similar but narrower strip on the top edge of the panel.

### Optical coherence tomography

This technique can reveal subtle discrepancies in the surface texture. Twenty zones of 12 mm by 12 mm were selected on the front. Five of these will be discussed here.

The OCT tomograms presented in Fig. 12 show the paint layers, glaze layers, and varnish on the surface of the painting into a depth of approximately 60 to 100 µm. Scattering layers are shown in false colours from yellow to blue, while transparent layers and deep structures not accessible for light are presented as black. The surface of the painting is seen as the uppermost strong line. Images are ten-fold vertically stretched for better readability and corrected for refraction with the average refractive index $n_R = 1.5$. In every image, we observe a thin layer of varnish of approximately 10–15 µm, immediately below the reflective surface. Then, we observe at least two, but often three or four transparent layers interspaced by semi-transparent paint layers. On the left side of spots #6 and #8 (Fig. 12) it can be seen how these glaze layers are substantial in the flesh tones of the painting, while on the right side, we see much thinner glaze layers and more opaque paint layers when we move into the dark background or the black area of the headdress. The

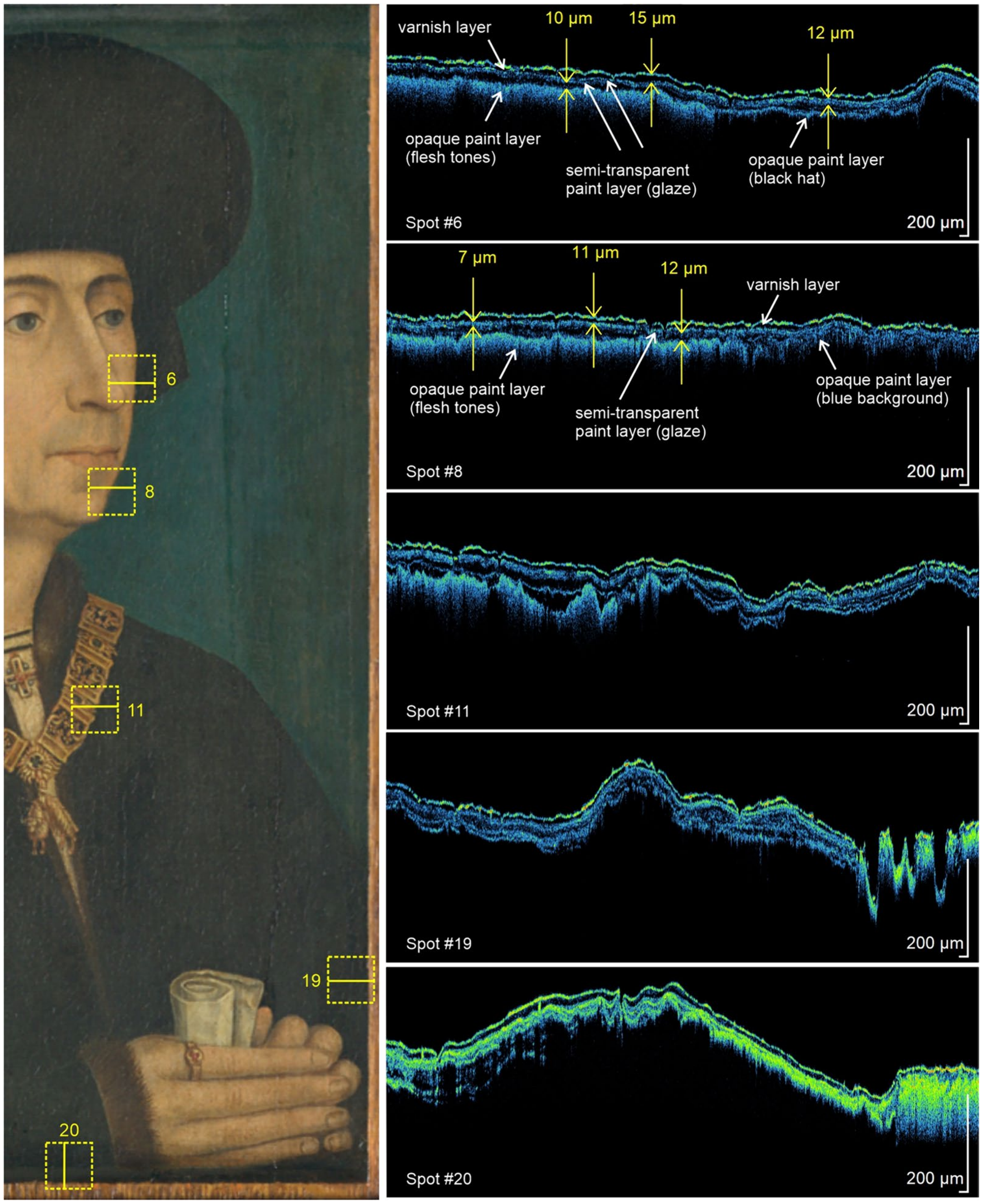


**Fig. 12** Selected locations of OCT examinations. Left: for each spot selection, a dashed line indicates the position of the tomogram chosen for presentation, shown to the right

most striking this effect can be seen in spot # 11 (Fig. 12) where the left part of the graphic corresponds to the gold of the Golden Fleece Chain, for which the painter has used relatively thick semi-transparent layers of paint in which glaze and paint alternate. Also, it can be observed how non-transparent textured paint is used as a preparation layer under the finishing golden colour glazes.

Finally, in location # 19, we observe a striking discontinuity at the point on the support where modern wood is adhered to the old panel. A similar effect is noted in spot # 20 (where the tomogram follows a vertical line). In the latter image, we see that the modern paint layer exhibits a distinctly different subsurface structure with more reflective paint with a smoother surface and without semi-transparent finishing layers.

#### Historical and art historical analysis

To confront the most important questions regarding this portrait, the technical results should be complemented with a historical and art historical analysis.

To ascertain the date of origin of this portrait, we can draw support from descriptions in the accounts of the Burgundian court revealing that the black chaperon with large bourrelet was first introduced by the Burgundian duke in 1442 and abruptly went out of fashion shortly after 1456 [43, p. 133]. One of the numerous versions of this portrait appears in the presentation miniature of the manuscript *Chroniques de Hainaut*, dated 1446–1447 [44, p. 90]. Therefore, it has been suggested that the first version of the portrait originated around 1445. [2, p. 187–188] [4, p. 229].

Who was the painter for whom Philip the Good posed? There was no exclusive court painter in the 1440s [45, 46]. Between 1444 and 1447, Philip the Good spent half of his time in Bruges and Brussels as his most frequented locations [47]. These were the cities where Pieter Cristus and Rogier van der Weyden were based, the most renowned painters at that time. However, the described period coincides with the onset of the copying tradition in the workshops of Flemish painters, situated around 1450 [48]. The portrait of a dignified, solemn Philip the Good represents a consciously chosen image intended for widespread dissemination through copied versions, simulating his omnipresence [49]. These different portraits were possibly executed by different painters. When a skilled painter executed a copy, it is nearly impossible to identify the painter's hand.

There were previous attribution attempts of the Dijon portrait. Seven portraits of "Philip the Good with black chaperon" were first assembled in 1907 for an exhibition in Bruges [50]. Conway believed they were copies and that Pieter Cristus was the most likely painter of the original portrait [45]. Friedländer, however, categorized all these portrait versions as copies or imitations after Rogier Van der Weyden [51]. In 1946 the Dijon museum changed the attribution of their portrait and considered it a copy after Van der Weyden [52]. Janssens de Bisthoven pointed to the lacking evidence for this attribution hypothesis [53] and Comblen-Sonkes did not believe that the Dijon portrait originated in Van der Weyden's workshop [4]. De Vos preferred Jan van Eyck or Pieter Cristus as the most plausible author of the original portrait [54].

Thanks to the various technical analyses we are now much better armed to tackle this thorny attribution issue based on a stylistic analysis of the many previously hidden features. The author of the Dijon portrait demonstrates particular expertise in the subtle rendition of light and shadow within the flesh tones of his portraits. Particularly Pieter Cristus is known for this harmonious and carefully modelled tones. As we have seen on the OCT diagram of sample # 11, the painter of the Dijon portrait used the same technique of glaze layers as Pieter Cristus to achieve this effect [55, p. 169]. However, we find a much more striking stylistic feature in the revealed original background, initially formed with colour strips at the right and upper edges. This "corner-space effect", which is never observed with Rogier van der Weyden, is a distinctive characteristic of Pieter Cristus's portraits circa 1446 [56, p. 28], as in his *Portrait of a Knight of the Golden Fleece* (Fig. 10). Similarly, in the Dijon portrait the combination of the copper scan and the hyperspectral image of azurite reveals a notable colour difference precisely in the same corner of the image. The resemblance is too striking to dismiss. A third notable feature is the size of the original panel, 21.3 cm by 29.6 cm, which is very similar to the dimensions of Pieter Cristus's *Portrait of the Carthusian* in New York, 20.3 cm by 29.2 cm (Fig. 9).

In the time period under study, it is best to avoid name-fetishism in attributions because numerous painters—workshop assistants, copyists, and followers—worked in anonymity alongside the classical names, possibly at a high level of skill [57]. With this consideration in mind, it nonetheless appears reasonable to conclude that Pieter Cristus played at least an indirect role in the Dijon portrait. Perhaps a copyist painted it, incorporating a Cristus-style corner into the background. Alternatively, Pieter Cristus may have painted this after a model, interpreting the background in his own manner and exhibiting his talent in the modelling of the face. The possibility that two different hands were at work, as has already been suggested for works by Pieter Cristus, cannot be ruled out either [55, p. 151]. The differences in sketching qualities seem to suggest this, although the small size of this portrait makes this hypothesis less likely.

In summary, the traditional assessment as "copy after Rogier van der Weyden" has little or no factual support. The historical context, in combination with the stylistic features revealed by the recent technical analyses, clearly indicates that it was rather Pieter Cristus who played a significant role in the creative process of this particular portrait version.

## Conclusion

Regarding the complementarity and the advantages and disadvantages of different analytical methods, we can conclude the following. The VIS–NIR multispectral camera is a more sophisticated and optimized version of classical infrared reflectography, making it particularly suitable for imaging underdrawings. MA-XRF provides information solely about the present elements, but by interpreting correlations and combining this with data from other techniques, many pigments can be identified. The RIS technique, measured in this experiment using the same device, can identify the compounds used through their spectral properties, providing a significant complement to the elemental information. OCT has relatively limited diagnostic power on its own, but the technique is highly suitable for visualizing varnish and glaze layers, which can be crucial in authenticity discussions. Art-historical methods, such as the history of fashion and painting techniques, offer important and objective support in dating. The study of fifteenth-century painting techniques and their material-technical aspects, in particular, lends itself well to a holistic multidisciplinary analysis.

The technical examination of this portrait has revealed numerous hidden details concerning the restoration history of this panel. In the 1980s, it was seamlessly integrated into a larger, more recent oak panel with surgical precision. The overpainting, predominantly conducted during the nineteenth and early twentieth centuries, rather haphazardly covered the background with various blue and blue-green pigments, yet respectfully preserved the delicate facial areas. In the stratigraphy of the pictorial layers, we were able to identify the skilfully applied original glaze layers, particularly in the depiction of the Golden Fleece chain. Although dendrochronological dating was unfeasible, pigment analyses, infrared reflectography, multispectral scans, and optical coherence tomography, revealing the used pigments and painting techniques, suggest an authentic work, probably from the fifteenth century and certainly prior mid-eighteenth century, marred only by recent interventions in the background and at the edges.

As for the dating and authorship of the prototype, we can be fairly precise with some margin of error. The first version of this portrait must be painted between 1442 and 1447. The historical context strongly suggests that one of the most renowned Flemish or Brabantine painters of that moment must be engaged for the original, arguing for both Pieter Cristus and Rogier van der Weyden. The cold gaze of the Burgundian duke and the fine modelling of his face, points to the stylistic idiom of Pieter Cristus. The Dijon version, although of high quality and likely quasi-contemporaneous to the original portrait, is probably not the first, principal portrait. The mechanically prepared underdrawing of the face, in combination with the clumsy creation process of the hands, suggests the work of a copyist. Intriguing shared characteristic details in portraying the hands suggest a close association with the portrait versions in Bruges and Vienna, although further investigation is warranted to uncover the precise correlations. Nevertheless, there is an undeniable close relationship with Pieter Cristus's portraits, revealed by the distinctive colour zones in the overpainted background, a rudimentary reference to a corner in the room. Taking all aspects into account we can reasonably conclude that the Dijon portrait of Philip the Good is a high-quality, contemporaneous or near-contemporaneous copy of the first version, painted by Pieter Cristus, by a workshop assistant or by a copyist of Pieter Cristus.

However, this contribution is not an endpoint to the debate. Dendrochronological dating via X-ray CT scan should certainly be considered to corroborate further the present hypothesis. Furthermore, a thorough technical examination of other contemporaneous copies of this portrait will undoubtedly further enhance our understanding of the remarkable corpus of portraits of Philip the Good.

**Abbreviations**

| | |
|---|---|
| HRI | Hyperspectral reflectance imaging |
| NIR | Near-infrared (7,502,500 Nm) |
| OCT | Optical coherence tomography |
| sRIS | Scanning reflectance imaging spectroscopy |
| MA-XRF | Macro- X-ray fluorescence |
| SWIR | Short wave infrared (7,502,500 Nm) |
| VIS | Visible (395–765 nm) |
| VNIR | Visible and near infrared (4,001,000 Nm) |

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**Author contributions**
RF and MR did the executing, interpreting and reporting of the multispectral scanning. LC and DB did the executing, interpreting and reporting of the synchronous MA-XRF and hyperspectral reflectance scans MI and PT did the executing, interpreting and reporting of the OCT JV wrote the art historical part, and was a major contributor in writing the manuscript All authors read and approved the final manuscript.

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**Availability of data and materials**
The datasets generated and analysed during the current study are available in the RDR KU Leuven repository "Replication data for: MAP Philip the Good", https://doi.org/https://doi.org/10.48804/YZ51FF.

## Declarations

**Competing interests**
The authors declare no competing interests.

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