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EARLY MONDRIAN (1912-1914) PAINTING TECHNIQUE AND MATERIALS

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Abstract

One of the most intriguing periods of activity of Dutch painter Piet Mondrian (1872-1944) regards the transition between the early figurative works and the well-known neoplastic paintings. Three paintings from the collection of the Fondation Beyeler in Basel Switzerland made in this period were studied. In Eucalyptus (1912) and Composition No. XVI ('Arbres') (1912/13) the tree motif is still visible; Composition No. VI ('Blue Façade') (1914) refers to the side wall of a house, showing the traces of an adjoining building that had been demolished. For this paper, both the results of the in-depth examination by the conservators and the analyses of the heritage scientists were brought together. The goal was to compare the materials and techniques of these three early paintings and find trends of Mondrian's working process. All paintings were examined in detail, with the aid of stereomicroscopy, X-rays and technical imaging. Analyses of the canvas, pigments and binders were performed with non-invasive X-ray fluorescence (XRF) and Raman spectroscopy, and micro-invasive analysis of cross sections and loose material using optical microscopy, Raman and Fourier Transform Infrared (FTIR) spectroscopy, Scanning electron microscopy – energy dispersive x-ray fluorescence spectroscopy (SEM-EDX and Pyrolysis Gas chromatography mass spectrometry (PY-GC-MS). The three works have been executed on linen canvas with commercial grounds of different compositions. The pigments of all paint layers could be identified, as well as linseed oil, used as binding medium in all paints and grounds. Special attention was paid to the technique of the black lines and underdrawings.

Keywords*: Piet Mondrian; Paint; Pigments; Black lines; Analysis*

Introduction

In 1912 Piet Mondrian (1872-1944) moves to Paris, where he rents a studio in 26 Rue du Départ in Montparnasse. He starts to experiment with the stylistic features of Cubism in a very personal way. Just like in other cubist paintings, less intense colours such as brown, dark green and ochre, prevail. But where Picasso and Braque fragment their compositions showing different planes at the same time and maintaining the perspective, Mondrian introduces a revolutionary idea: the sense of depth and the difference between back- and foreground is abolished. The series of trees forms the start of this process and in a few years, he evolves from realism, via cubism, to geometrical abstraction [1-2].

Extensive research has been done on the artworks of Mondrian's well known neoplastic period (1920-1944) [3-6], whereas his earlier paintings have hardly been investigated [7-8].

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As to the works Mondrian painted during his first stay in Paris (1912-1914), a first solo exhibition was held at Kunsthandel W. Walrecht (The Hague) in 1914. Here sixteen paintings, which he unchronologically named *Composition no. I – XVI*, were shown to the Dutch public. Hundred years later, in 2014 this exhibition was carefully reconstructed in Kunstmuseum the Hague (formerly, Gemeentemuseum). The catalogue 'Mondrian and cubism' includes for each of the paintings a thorough description, as well as a summary of the few available technical and materials' analyses [7].

This paper presents the results of the study of three paintings in the collection of the Fondation Beyeler painted by Mondrian between 1912 and 1914: *Eucalyptus* (1912; B22), *Composition No. XVI ('Arbres')* (1912-1913; B26) and *Composition No. VI ('Blue Façade')* (1914; B50) (Figs. 1-3). The latter two were part of the historical Walrecht and the 'Mondrian and cubism' exhibitions. The three paintings are the first of a series of seven that were examined during a three-year collaboration between the museum and the Cultural Heritage Agency of the Netherlands (RCE).

Fig. 1. *Eucalyptus*, 1912
Oil on canvas, 60.0 x 51.0 cm
Fondation Beyeler, Riehen/Basel, Fi Beyeler Collection
(© 2022 Mondrian/Holtzman Trust)

Fig. 2. *Composition No. XVI ('Arbres')*, 1912-1913, Oil on canvas
85.5 x 75.0 cm
Fondation Beyeler, Riehen/Basel, Beyeler Collection (© 2022 Mondrian/Holtzman Trust)

Fig. 3. *Composition No. VI ('Blue Façade')*, 1914
Oil on canvas, 95.5 x 68.0 cm
Fondation Beyeler, Riehen/Basel, Beyeler Collection (© 2022 Mondrian/Holtzman Trust)

With seven paintings, the Fondation Beyeler owns the largest collection by Piet Mondrian in Switzerland, ranging from important early work to late classics of this 20th century master. This fact, coupled with the comprehensive Piet Mondrian exhibition 'Mondrian Evolution' (June 5th, 2022 to October 9th, 2022) at the museum, gave the impulse to launch the Piet Mondrian Conservation Project from 2019 to 2021. While each painting was researched independently, the objective of the project was to comprehend Mondrian's artistic process and material as a whole. The aim was to put the gained information into context with other Mondrian research and paintings through international collaborations.

Extensive research of provenance was carried out and historical sources were examined and combined with the detailed study of each painting with a stereomicroscope, X-rays and technical imaging. Analyses of the canvas, pigments and binders were performed with non-invasive X-ray fluorescence (XRF) and Raman spectroscopy, and micro-invasive analysis of cross sections and loose material using optical microscopy, Raman and Fourier Transform Infrared (FTIR) spectroscopy, Scanning electron microscopy – energy dispersive X-ray fluorescence spectroscopy (SEM-EDX) and Pyrolysis Gas chromatography mass spectrometry (PY-GC-MS). Important information on the working process and materials used by Mondrian for the three paintings could be gathered and compared with the scarce research data regarding this period.

Experimental part

Technical imaging

Visible light and UV Imaging

A converted Canon EOS 5D Mark II camera was employed with IR-cut filter NG 77D in combination with Broncolor minicom 80 flash lamps for visible light imaging and a Profilux LED 1000 lamp for raking, transmitted and specular light imaging. For ultraviolet fluorescence (UVF) and ultraviolet reflectance (UVR) imaging the same camera and IR-neutralization filter were used with a UVAHAND 250 GS lamp, inserting a LP460 filter for UVF and a SP2 400 NG filter for UVR.

Infrared reflectography, standard and transmitted

For the infrared imaging the Osiris camera was used with lamps containing Osram Halogen Superstar 64702 SST 8750 lm bulbs.

X-radiography

Digital X-radiography was carried out with a 30Sello High Technology Industiral X-Ray apparatus.

Technical analysis

Materials analyses of paints, grounds, underdrawings and canvas fibres were based on observation of the paintings and ensuing research questions. To obtain an indication of pigment and inorganic extenders, the paintings were studied using X-ray fluorescence (XRF) and Raman spectroscopy. Partly directed by the immediate answers obtained with this technique, minute samples were taken. Some of these were prepared as cross sections. The following analytical techniques were applied: optical microscopy (OM), scanning electron microscopy with energy dispersive X-ray analysis (SEM-EDX), Raman and Fourier transform infrared (FTIR) spectroscopy and pyrolysis gas chromatography mass spectrometry (PY-GC/MS). The complete sets of results are reported in the RCE Research Report [9].

XRF spectroscopy

A portable Bruker Tracer 5i X-Ray fluorescence spectrometer equipped with a low power Rhodium x-ray tube and a Silicon-Drift energy dispersive x-ray detector was used. The measurements were performed in the spectrometer mode, using a 3mm collimator, a tube voltage of 15kV or 40kV (to better highlight light and heavy elements, respectively) and a current of 11.8 and 6μA, respectively. The acquisition time was 200 and 60s.

Optical microscopy and SEM-EDX

The cross sections (Poly-Pol PS 230® embedding resin) were examined using a Zeiss AxioImager A2m optical microscope with incident polarized light from a VIS-LED lamp for bright field and dark field illumination, and incident UV light from the Solid-State Light Source Colibri 7, type RGB-UV, LED 'UV' (385nm) for UV-induced fluorescence. The filter set used for UV fluorescence consists of the following filters: excitation G 365, beam splitter FT 395, and emission LP 420 (filter set 02).

The warp and weft yarns of the canvas were analysed separately. The fibres were embedded in glycerol/water (50/50) and examined using a Zeiss AxioImager A2m optical microscope in transmitted polarised light and with crossed polarizers. To distinguish between linen and hemp the 'modified Herzog test (red plate test)' was applied using a lambda-plate.

SEM-EDX analysis of the cross sections and loose samples was performed using a Jeol JSM 5910 LV SEM with Thermo Scientific SDD EDX detector. The primary electron beam energy used was 20kV. The cross sections were examined in the low vacuum mode (29Pa).

Raman and micro-Raman spectroscopy

The handheld Raman measurements were conducted with a Bravo Spectrometer (Bruker). The device records spectra in two separate spectral ranges of 300–2200 and of 1200–3200cm^{-1} with a DUO Laser system (785nm and 853nm). The energy reaching the surface during the measurement was about 45mW, with measurements conducted at a distance of about half a millimetre, with a spot size of 1mm.

The micro-Raman spectra were obtained with a Perkin-Elmer Raman Micro 300 (Raman microscope) and a Raman Station 400F (Raman spectrometer) with a diode laser (785 nm), in combination with an Olympus BX51M microscope. Exposure time, laser power and accumulations were selected for each measurement to obtain optimal spectra. The laser spot has a diameter of ca. 20µm (50× objective) or 10µm (100× objective) and the laser power (10%-100%) varies in the range of 7-70mW (50× objective) and 4-40mW (100× objective) with a 600 lines/mm grating. Raman scattering is filtered with a double holographic notch filter system and is detected with an air-cooled charge coupled device (CCD) detector.

PY-GC-MS

Glues and paint binders were analysed with thermally assisted hydrolysis and methylation gas chromatography-mass spectrometry (THM-GCMS), used in combination with pyrolysis as a sample introduction technique. A suspension of sample material in a few drops of tetra-methyl ammonium hydroxide (TMAH) in methanol (5%) was transferred to a metal pyrolysis cup and analysed. A Frontier Lab 3030D pyrolyser was used in combination with a Thermo Scientific Trace 1310 gas chromatograph and a Thermo Scientific ISQ mass spectrometer. The pyrolysis temperature was 480°C; the temperature of the pyrolysis interface was 290°C. By means of a split connector the pyrolysis unit is directly linked to a SLB5 ms (Supelco) column (length 20 m, internal diameter 0.18 mm, film thickness 0.18 µm). Helium with a programmed flow (0.5 to 1.2 ml/min) was used as carrier gas in combination with a temperature program of 35°C (1) – 60°C/min – 110°C – 14°C/min – 240°C – 5°C/min – 315°C (2). The column was directly coupled to the ion source of the mass spectrometer. The temperature of the interface and ion source were 250˚C and 220˚C, respectively. Mass spectra were recorded from 29 to 600 AMU at a speed of 7 scans per second. Xcalibur software 4.1 was used for recording and processing the data.

FTIR spectroscopy

ATR-FTIR transmission measurements were carried out with a Perkin Elmer Spectrum 100 FTIR spectrometer in combination with a Spectrum Spotlight 400 FTIR microscope and a Golden Gate Single Reflection Diamond ATR. For ATR imaging a germanium crystal was used. The detector is a 16x1 pixel linear Mercury Cadmium Telluride (MCT) array detector.

Results and discussion

Eucalyptus (1912)

This relatively small painting stayed in Mondrian's possession until his death. The painting appears to be in it's original condition; only the stretcher is not original. Raking light shows a peculiar warping pattern of the canvas in the top right half (Fig. 4). Close examination of the paint layer in these areas suggests that *Eucalyptus* was painted on the canvas already in this condition. Furthermore, the right edge also shows the original selvedge of the pre-primed roll from which the canvas originates. This indicates that this "end piece" of the canvas shows distortions caused by the stretching of a pre-primed canvas roll during preparation and drying at the canvas maker's shop. Perhaps such fragments were sold cheaper, which would have been appealing to Mondrian during this time. In several stages in his life, Mondrian mentions money troubles in the many letters he wrote. Around the time he painted *Eucalyptus*, he writes to Lodewijk Shelfhout on May 25th, 1913, that he has to take on commissioned work due to financial reasons [10].

The painting process of *Eucalyptus* took place in several stages. First, Mondrian made a preparatory sketch with very diluted black oil paint; this layer is so underbound, that it is soluble in water today. The paint application appears quick and hasty, as if the artist wanted to transfer his idea to the canvas as fast as possible. The sketch was rubbed off in places while still wet and also scraped away after the color dried (Fig. 5). During this scraping the ground layer was also affected, exposing the canvas nap. Indeed, Mondrian scraped paint from the canvas as part of the creative process throughout his career [6]. These corrections indicate that Mondrian revised the oil sketch, thereby developing and strengthening the composition during the process.

Then follows a second layer of the same diluted paint, a bit more pigment and medium rich this time (Fig. 6) and applied with hatching and shading. In a third step, Mondrian used a range of mixed gray oil paints, filling out nearly all of the planes between the black lines. This paint is applied more thickly and with heavier impasto than in the underlying oil sketch (Fig. 7). In the process, some black lines are completely overpainted, but a number of them remain visible. Thus, Mondrian actually integrates the oil sketch into the final composition, instead of using it as a mere reference.

Fig. 4. Raking light image shows peculiar warping on the right side of the canvas support

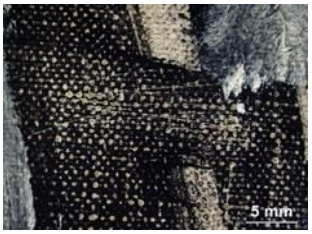

Fig. 5. Detail of the artist partly scratching away his first oil sketch

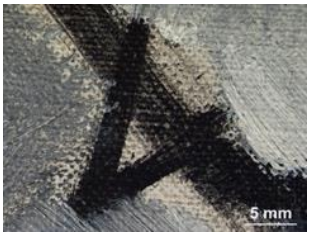

Fig. 6. Detail of a second sketch phase, over the first sketch

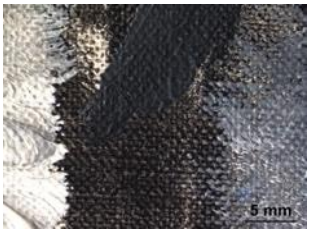

Fig. 7. Detail of denser paint layer over the oil sketch

Lastly, Mondrian added a few more black lines to accentuate the finished composition. In visible light, these later black brushstrokes are barely distinguishable from those of the underlying first oil sketch. However, closer examination by microscope reveals that the black of the sketch is distinctly matter and has a warmer tone. In transmitted light, these different blacks can be differentiated: the black of the sketch appears brownish, while the upper black lines are denser (Fig. 8). The X-ray image provides a better distinction (Fig. 9). While the sketched black lines only contain black pigments and do not absorb the X-rays, the top black oil paint also contains lead white and becomes visible.

Unfortunately, even with the help of X-rays, the composition of the first sketch is not fully discernible. Clearly, it would be of great interest to reconstruct in detail how Mondrian developed the composition in this key phase of his oeuvre, the transition from figuration to an abstract, Cubist style. An approximate impression of how the first sketch would have appeared is provided by another work, also executed on canvas, bearing the same title and date as *Eucalyptus* (Fig.10). This painting, which is considered to be unfinished, only bears the first oil sketch and was not covered by further layers of oil paint by Mondrian. It gives a good insight

into the sketch-like use of diluted black paint as a first phase with fast and energetic strokes, just as the underlying sketch in *Eucalyptus*.

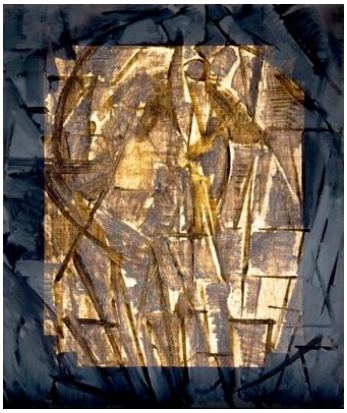

Fig. 8. Transmitted light image shows the variations in density of the working phases

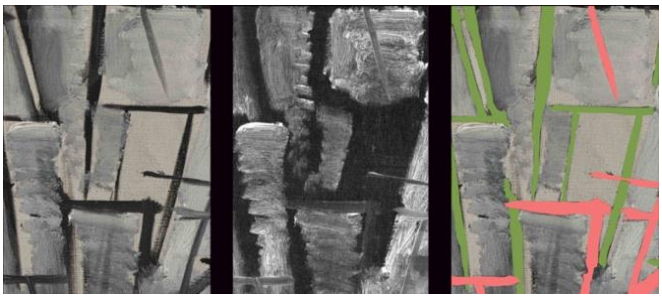

Fig. 9. Detail comparison of visible (left) and x-ray (middle): the black lines of the sketch (green on the right) do not appear in the x-ray photograph, whereas the painted lines on top do (pink on the right).

Fig. 10. *Eucalyptus*, 1912, oil sketch on canvas (unfinished), 51 x 39.5cm
(© Sidney Janis Family)

Both warp and weft threads of the canvas of *Eucalyptus* were analysed (thread count: 22 warp to 20 weft fibers/ cm) and were found to show characteristics corresponding to linen.

As already mentioned, Mondrian used a diluted paint to first sketch the composition (underdrawing). In cross section 59.7-X1 (Fig. 11) the complete buildup is shown: ground layer (1), underdrawing (oil sketch) (2), and grey paint (3). The industrial ground layer is mainly based on zinc white, with some lead white and chalk in a linseed oil binder with a low amount of rapeseed oil. With FTIR spectroscopy zinc carboxylates were identified in this layer. In the underdrawing linseed oil was identified as well; it is impossible to tell how diluted the oil has

been, nor if this medium differs from the paint layer medium (linseed oil). The underdrawing seems to consist of a monolayer of mainly angular black pigment particles (<5μm). Their EDX spectra show carbon with some calcium and phosphorous, pointing to bone black (Fig. 11 – spot a). The grey paint layer (3) contains fine lead white with some zinc white. Here, two types of black pigment were observed: i) only showing carbon; ii) containing carbon, calcium and phosphorous (Fig. 11 – spot b and c). Apparently, carbon black and bone black are both present in the grey paint layer.

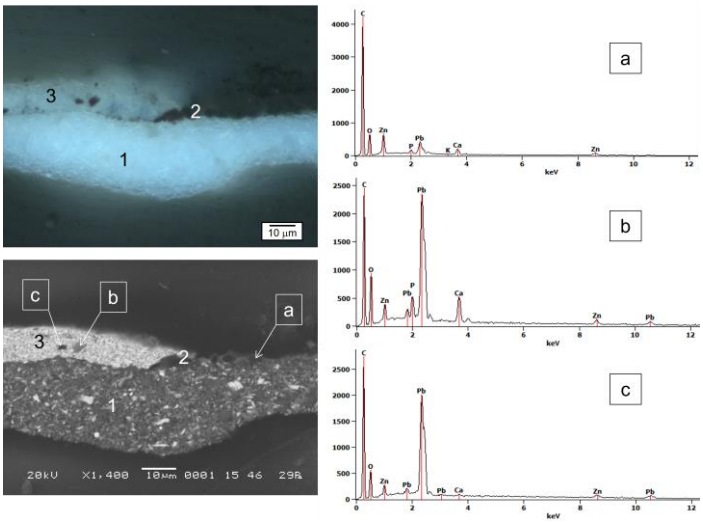

Fig. 11. Detail of the cross section of sample 59.7-X1 in visible light (upper image) and back scattered electrons (SEM-BSE) (lower image), showing the ground layer (1) with zinc white, lead white (bright particles) and chalk (dark grey); the underdrawing (2) with angular black pigment particles containing C, Ca and P (spot a); paint layer (3) with lead white (very small bright particles), bone black (spot b) and carbon black (spot c)

This difference in the choice of materials indicates that Mondrian clearly worked in two separate phases: a classical sketch phase in a pure black medium and a paint phase with mixtures of paint. In *Eucalyptus* both phases are then united to form the final composition.

Composition no. XVI ('Arbres') (1912/1913)

In Mondrian's Cubist phase, from 1911 on, the motif of the tree has a prominent position [11]. *Composition No. XVI* also belongs to the group of paintings addressing this theme and was probably created on the basis of tree drawings made by the artist at the end of 1911 or during the summer of 1912, which he brought with him when he moved from the Netherlands to Paris.

Composition No. XVI is a very 'authentic' work of art and remains untouched by conservation treatments. Both the stretcher and the stretching of the canvas are original. The folding of the canvas at the corners of the strainer is very characteristic, as is the manner of cutting the canvas, exactly parallel to the stretcher at the back of the picture (Fig. 12).

The verso of the painting reads like an open book (Fig. 13). Mondrian noted down various titles for this work with numberings, both on the back of the canvas and the stretcher bars. The verso of the strainer bars offers further clues. Remains of torn and glued paper indicate that Mondrian previously used the frame for stretching a piece of paper when working on a drawing. Pinholes at the corners of the painting and old nails in the stretching frame indicate that in an initial stage Mondrian first pinned the canvas that he only mounted on the reused stretching frame during the further painting process. Such a procedure was also found in similar works [12].

Mondrian started the composition with linear brushstrokes. The line structure was then continuously built up by making the black lines wider and also opaquer, mixing white paint with the black paint. Subsequently, the remaining areas within the black lines were filled in

with monochrome color fields, mixed with white, in a selective color palette of white, gray, ochre, green, and pink violet. Many unpainted areas of the off-white primer are a deliberate part of the composition. For this work Mondrian chose light pastel tones that are unusual in his Cubist pictures. The choice of colors and the quick brushwork could suggest that he was engaging here with the art of Cézanne, whose paintings he had seen on various occasions in 1911 [1].

Fig. 12. The folding of the canvas at the corner

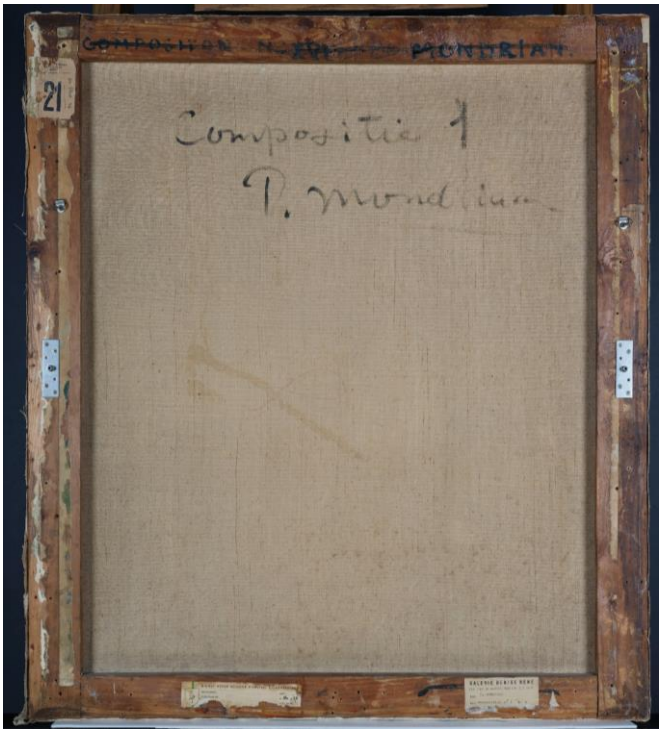

Fig. 13. Verso of *Composition No. XVI*

The painting's linen canvas (thread count: 20 warps to 15 weft fibers/cm) was pre-primed. A sample was taken to include the priming, underdrawing and a grey paint layer (Fig. 14). Two commercially applied ground layers (1-2) mainly based on lead white could be distinguished; the dimensions of this pigment vary from fine to rather coarse (ca. 50μm), especially in the upper ground layer. Yellow ochre was added to obtain an off-white priming. Layer 3 is most likely related to Mondrian's underdrawing. Here, small particles of lead white and black pigment only containing carbon were found. The grey paint layer (4), instead, contains fine lead white with two types of black pigment, carbon black and bone black, just like the grey paint in *Eucalyptus.*

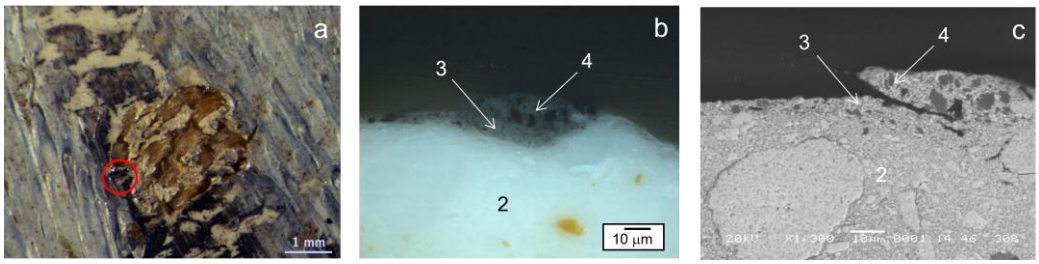

Fig. 14. Sampling point (a) and detail of the cross section of sample 75.3-X1 in visible light (b) and back scattered electrons (SEM-BSE) (c), showing the upper ground layer (2) with lead white and yellow ochre; the underdrawing (3) with black pigment particles containing carbon; a grey paint layer (4) with lead white (very small bright particles), bone black and carbon black.

XRF analyses revealed that the ochre-coloured paint indeed contains yellow ochre, consisting of natural iron oxide, mixed with zinc white paint including barium sulphate and possibly traces of chalk (or gypsum) as extenders. The combination of zinc and barium may also indicate the presence of lithopone; however, this would still be mixed with zinc white as the barium content is relatively low. Micro-Raman spectroscopy and SEM-EDX show that the light purple paint contains haematite and lead white, whereas the light green paint is made of lead white and chromium oxide, either in the opaque or the transparent hydrated form (viridian). The paint binder is linseed oil, as ascertained with PY-GC-MS.

Comparison with the XRF point analyses of the contemporary *Composition no. IX* (B36, 1913) of the MOMA (New York) collection revealed some similarities [7]. A pre-primed canvas with a lead white ground was used. According to the stamp this was bought from Blanchet (Paris). In the Beyeler's *Composition no. XVI,* no stamp of a canvas supplier could be found on the reverse. The thread counts (20 horizontal x 18 vertical/cm for *Composition no. IX*; warp 20 x weft 15/cm for *Composition no. XVI*) do not completely match. The earth pigments of *Composition no. IX* also contain some barium, pointing to the use of the same type of ochre paint. Conversely, in the MOMA painting the black paint was reported to contain both bone black and mars black. The latter pigment could not be detected in our painting.

Composition no. VI ('Blue Façade') (1914)

After abstracting his landscape paintings, which were still inspired by sketches from the Netherlands [13], Mondrian started to be more and more inspired by the demolished buildings of his new surrounding in Paris. *Composition No. VI ('Blue Façade')* was painted after a sketch, which is today preserved in the collection of the Kunstmuseum the Hague (Fig. 15). Comparing the sketch with *Composition No.VI*, various elements and color ideas of the sketch were transmitted into the painting. The importance of the sketch for Mondrian's working process is described by Robert Welsh. [14] Mondrian not only made sketches on paper of an oil painting in advance, but he also started his paintings by sketching the lines directly on the canvas, as we have already seen for *Eucalyptus* and *Composition No. XVI*. Mondrian's paintings also show evidence of his familiarity with the use of drawing instruments. Initially, he fills the planes with hatching, as in his sketches, and uses charcoal to experiment with changes of composition on the canvas.

For *Composition No. VI*, Mondrian used a coarsely woven preprimed canvas with 13 horizontal and 11 vertical threads/ cm, probably from the same batch as *Composition ovale en plans de couleurs 2* (1914) of the collection of Kunstmuseum the Hague that has the same number of threads per cm [15]. Onto the canvas of *Composition No. VI*, Mondrian drew charcoal lines. These grainy lines of charcoal are still partly visible along the painted lines. Archival research showed that the painting was heavily restored in the 1970's, while the changes caused then were tried to be undone in the 1990's. A black and white picture from 1972, showing the front and reverse of the original stretching before cleaning, lining and

varnishing, gave a lot of information about titles, primer and stretching (Fig. 16). By comparing this photograph with the painting now, it is also evident that, due to this past treatment, charcoal was wiped away in some areas.

In a letter to Schelfhout (1881-1943), Dutch painter and friend of Mondrian, in 1914 the artist mentioned a sketch among 15 paintings he sent to the Walrecht exhibition: „Among the works (I have sent) there is only one recent sketch. But I have sent 15 paintings, which I think is a good number for this period. ". This is believed to be *Composition No. VI* [16].

The research at Fondation Beyeler showed that the painting was reworked, probably after the Walrecht exhibition as Mondrian added lines in the upper right corner on dried paint.

In general, the paint was applied in a quick and sketchy manner, with short brush strokes. The paint was also partially mixed on the canvas, as the inhomogenous mixture of lead white with the colours demonstrated in the x-ray picture (Fig. 17). Analysis confirmed that the colours were mixed with lead white and that this shows so well because the ground layer contains only little lead white. Therefore, the colour mixing has more contrast and shows clearly.

Fig. 15. *Partialy demolished Building/ Blue Façade*, Piet Mondrian, 1914, Sketchbook II (©Kunstmuseum the Hague)

Fig. 16. *Composition No. VI* (‘*Blue Façade’*), Piet Mondrian, 1914, black and white picture taken before 1972, Archive Gallery Beyeler

Fig. 17. *Composition No. VI* (‘*Blue Façade’*), Piet Mondrian, 1914, Beyeler Museum, X-Ray

The ground layer (1) is clearly visible in the cross section of one of the black lines (Fig. 18) and contains chalk, with zinc white and some lead white particles. On top, a white paint layer (2), based on lead white, coarse barium sulphate and some chalk, and a black paint layer (3) of bone black and some lead whites are present. In another cross section, taken from an ochre-coloured area, a layer similar to layer 2 was observed. This layer can most likely be related to the light-coloured background paint of the composition. In the ochre paint – applied wet-in-wet – some umber and, like in *Composition no. XVI* and *Composition no. IX* (MOMA) [7], a small amount of barium sulphate was detected, suggesting that the same type of ochre paint has been used in these three paintings. With Raman spectroscopy, the bluish areas were found to contain Prussian blue, mixed with lead white to obtain the different hues.

The PY-GC-MS results clearly show that the ground layer contains oil, probably linseed oil, with the addition of a very small amount of rapeseed oil. A drop on the black line, strongly fluorescing in UV light, is based on slightly heat-bodied oil. Some markers for *Brassica napus (*rapeseed oil), dodecandioic and tridecandioic acid, were also identified, as well as relatively high amounts of 14- and 15-hydroxy-hexadecanoic acid. This points to the occurrence of beeswax, although the wax hydrocarbons are lacking. Traces of residual poly(iso-buytlmethacrylate) (iBMA), likely related to a varnish (e.g., Paraloid B-67) that was applied

and then taken off in the past, were found in several samples. In the lining material a mixture of oil and beeswax was detected, together with iBMA.

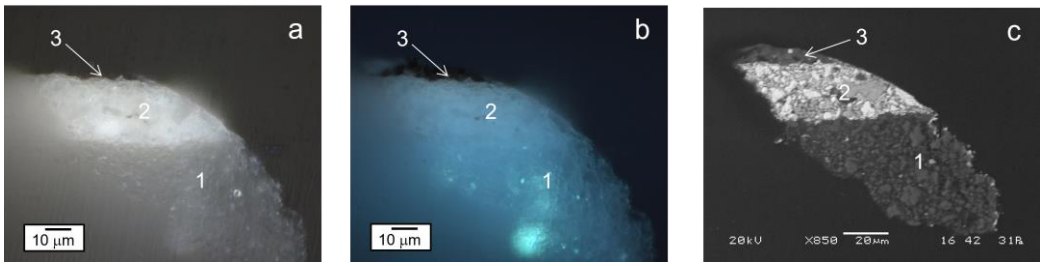

Fig. 18. Cross section of sample 89.8-P1 in a) incident polarised light; b) UV fluorescence; c) back scattered electrons (SEM-BSE)

Composition no. V (B45, MOMA) was made in the same year (1914). This painting was also technically examined in detail [7-8] and, although more colourful than *Composition No. VI*, serves as a good comparison to the present research results. According to the reported thread count (20 horizontal x 18 vertical / cm) this canvas seems to be more finely woven than that of *Composition no. VI*. Macro-XRF mapping and XRF point measurements [8] provided an insight into the inorganic pigments and fillers. The ground layer was found to contain lead white with some barium sulphate, just like the background paint of *Composition No. VI*. The black paints were reported to contain both bone and carbon black and some cobalt blue was identified in the lower layers; the other blue pigment was defined as 'organic blue'. A large variety of yellow pigments was detected in the MOMA painting: yellow ochre, cadmium yellow, and chrome yellow.

Conclusions

The examination of the three paintings by Mondrian, which were executed during his first stay in Paris in three consecutive years (1912-1914), showed distinctive features both in his painting technique and use of materials. All three works were painted on different plain weave linen canvases with commercial non-absorbent grounds in oil. *Eucalyptus* (1912) shows one layer containing zinc white with some lead white pigment and chalk extender, *Composition No. XVI* (1912/1913) is built up with two, seemingly identical, layers of lead white with traces of yellow ochre to create an off-white ground, while *Composition No. VI* (1914) presents one layer consisting of chalk and zinc white.

Oil sketches were first applied in *Eucalyptus* and *Composition No. XVI*, whereas in *Composition No. VI* Mondrian traced his composition with charcoal. In *Eucalyptus* the underdrawing consists of bone black, whereas in *Composition No. XVI* carbon black is present. Interestingly, in both paintings the dark grey paints used for the final black lines contained bone black combined with a carbon black, possibly lamp black.

The paint cross sections indicate that the paints have been applied on a dry surface of paint; only on one occasion (*Composition No. VI*) two layers of dark and beige paints are wet-in-wet. Linseed oil could be identified as binding medium.

The pigments of the pastel colours in *Composition No. XVI* and *Composition No. VI* could all be addressed and show a mostly consistent use of colours. Not surprisingly, the yellow ochre colour was indeed from yellow ochre, while the darker brown ochre colour was combined with umber in *Composition No. VI*. The green, in *Composition No. XVI*, is a chromium oxide and the light purple colour contained some haematite. Light and dark blues in *Composition No.VI* were made with Prussian blue. Lead white pigment was extensively used for the white 'imprimatura' (apparently covering the whole surface of the painting) and grey paints, but also for the pastel-like colours. While lead white is the common white pigment, zinc white is only occasionally present in the ochres of *Composition No. XVI*.

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