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An Investigation of Extreme Delamination in *Nu Féminin* (1967)

by Montréal Artist Jori Smith

ABSTRACT

The painting, *Nu Féminin* (1967), by Montréal artist Jori Smith (1907-2005), was donated to the Master of Art Conservation (MAC) program in 2012. It is in very poor condition, undergoing severe cupping, tenting, and delamination affecting the entire painted surface. The failure of adhesion is occurring at the ground layer and the cupped and delaminating areas are, in some cases, as much as 5 cm in diameter. The primary objective of this analytical and technical study was to analyze and identify the materials used, with the goal of determining the factors promoting this delamination. Additionally, technical and archival research was carried out, to gain a broader understanding of the artists' materials and techniques and the conservation issues present in her other work.

The painting was analyzed with x-ray fluorescence spectroscopy (XRF), polarized light microscopy (PLM), Fourier-transform infrared spectroscopy, using attenuated total reflectance (ATR-FTIR) and Scanning Electron Microscopy with energy dispersive x-ray spectroscopy (SEM-EDX). Analysis found that the ground layers were composed primarily of titanium white and kaolin, and did not contain zinc soaps, as hypothesised. However, XRF analyses taken at the delamination interface found zinc on the bottom surface of delaminating flakes. This may be indicative a thin layer of zinc soaps, which has migrated through from the paint layer. Although not a major component of the ground layers, zinc is present in most of the paint layers, and zinc soaps were found at the interface of delaminating paint layers. Archival research showed that in the later years of her career, the artist often reworked or reused her canvases, which may explain the complex layer structure observed, and some of the problems that have arisen as a result.

1. INTRODUCTION

Typically the deterioration of paintings will involve a combination of chemical, physical and biological processes. Temperature, relative humidity and light all play an important role; however, in some cases, works of art can deteriorate rapidly as a result of the intrinsic behavior of the materials used (Mecklenburg et al. 2013). Severe delamination of paint can occur as the result of a fundamental incompatibility within, or between layers in the structure of the painting. This includes a lack of adhesion occurring between the ground and paint layers, between paint

layers, between the paint and varnish or at the interface between the paint layers and the primary support, or a lack of cohesion within any one of these layers.

There are many reasons that this lack of cohesion or adhesion may exist in a painting. Cohesive failure within a paint or ground layer may be due to insufficient amounts of binding material, however, other factors must also be considered. For example, paintings by early 20th century artists Sir Alfred Munnings, Piet Mondrian, and Arthur Briscoe have all displayed issues of chalking and crumbling in a lemon yellow colour in their works, often leading to the delamination of overlying paint layers. In these cases, the deterioration appeared to be associated with the use of impure cadmium sulphide pigments (Whitehouse and Eastaugh 2001).

Severe delamination has affected the works of many early 20th century artists from Paul-Émile Borduas and Riopelle, to Pierre Soulages and Joan Mitchell, and has often been linked to metal soaps. These artists are all known to have used pre-prepared canvases from Lefebvre-Foinet from 1959. Canvases made by the Parisian colourmaker during this time period are known to be problematic, having an oil rich lead ground with a high concentration of lead palmitate (Barbarant and Helou-de La Grandière 2012). In the black and white paintings from the later years of Borduas' career, several problems have been observed, including large drying cracks and severe delamination, with lifting and curling of the black patches from the white background (O'Malley and Moffatt 2001). These issues are found across his body of work from this period, and therefore one can conclude that the problem stems not from a local museum environment, but from the materials and methods he used to create them. Moffatt and Miller (1994) analysed eight Borduas paintings from this period, and found high levels of lead soaps in the lead white and linseed oil underlayer below these delaminating patches. These areas also have a waxy texture, contributing to reduced bond strength. In the work *Peinture, 130 x 165 cm, 18 avril 1959* (1959, Musée d'art modern de Saint-Étienne Métropole) by French artist Pierre Soulages, cleavage was observed at the level of the white preparation layer, similar to what is seen in *Nu Féminin*. Like Borduas, Soulages painted in oil, using lead white, and large thick areas of black paint. These flakes displayed a tendency to curl up on themselves, due to high internal stresses. (Barbarant and Helou-de La Grandière 2012).

The formation of metal carboxylate soaps does not occur only with lead based pigments. Other metals, including copper and zinc, are known to form similar soap compounds. Zinc oxide is

used as a white pigment, either alone, or in mixtures with other white pigments. It is also present as an extender in other colours. Zinc stearate, is a common paint additive, and zinc soaps may also form in-situ from the reaction of zinc oxide with free fatty acids. At the Canadian Conservation Institute, Helwig et al. (2014) observed that in modern oil paintings suffering from issues of lifting paint and delamination, high concentrations of zinc fatty acid salts are often found at the problematic interface. For example, in *Rouge sur Blanc* (1956, MACM) by Jean McEwan, lifting, cracking and poor adhesion was associated with the use of zinc white and presence of high concentrations of zinc soaps (Helwig et al. 2014).

Another factor to consider with 20th century paintings is the use of oil paint over a commercial or artist-applied acrylic ground. The issue here is that there is no significant chemical bonding, between oil and acrylics, only physical adhesion. While this alone may not be enough to cause delamination, the addition of other factors, such as dirt or grease between layers, may lead to adhesive failure. In 2008, Maor showed that delamination at the interface between an acrylic ground and oil paint layer was contributed to by the presence of metal soaps, especially zinc soaps, with a high concentration of soaps present at the oil-acrylic interface.

In this paper, the severe delamination present in an oil painting by Jori Smith from 1967, will be examined and discussed, in relation to the artist's wider artistic practice.

1.1 THE ARTIST, JORI SMITH

Marjorie (Jori) Smith, was born in 1907 in Montréal, Québec, to an Irish mother and English father and grew up in the Anglophone neighbourhood of Westmount. She studied at the Art Academy of Montreal and then the École des Beaux-Arts from 1923 to 1928, before marrying fellow Montréal artist Jean Palardy in 1930. The couple spent much of the 1930s living in Charlevoix County, in central Québec, returning to Montréal periodically to sell their work. The couple was able to live cheaply away from the city, in small towns such as St-Urbain and St-Hilarion, often renting rooms in the homes of local families for as little as two dollars a week, while Jori painted portraits of local women and children (Tierney 2004). She later published a book, *Charlevoix County, 1930*, (1998) which serves as a memoir for these years and depicts the social relations, values and traditions of rural Québec during this time. In 1940, Jori and Jean

bought a house in Petite-Rivière, a small town in Charlevoix County along the St-Lawrence River, to which Jori often returned over the next 30 years (Tierney 2004).

Jori was an integrationist, a progressive, a feminist, a socialist and an artist. Her works spanned a range of subjects, including portraits, landscapes, still-life, and nudes; however, she was best known for her portraits of women and children, especially young girls, which are often described as sombre, sad, and tranquil (Pageot 2000). She experimented with a variety of media, including ink and watercolour, but favoured oil, and almost always worked from living subjects, rarely spending more than two hours on a portrait (Tierney 2004). Jori had a large group of friends from within the Montréal Arts scene, including close friends painter Marian Scott and writer P.K. Page (Meadowcroft 1993). She was fluent in both English and French, and was in the unique position of crossing two languages and cultures, forging links with both the Francophone and Anglophone arts communities in Montréal, in a time when it was still very uncommon to do so (Pageot 2000). Jori's work responds to many of the art movements of the day, but cannot be placed clearly within one school (Tierney 2004). She was associated with the modernists, although her works varied in style. She has also been associated with the "naives" due to the simplicity and emotional directness of her portraits (Meadowcroft 1993). She was the only female member of John Lyman's Eastern Group, formed in 1938, and a member of the Contemporary Arts Society, which was formed in 1939. These groups sought to unite Montréal artists and offer an alternative to Group of Seven nationalism (Tierney 2004).

For a 20 year period, from the early 1950s to the early 1970s Jori withdrew from public view. She separated from Jean Palardy in 1957, and according to Meadowcroft (1993) produced very little over the next twenty years. Although she continued to paint, she destroyed nearly all her work, and did not exhibit. Jori also felt that there was a lack of interest in her work, because it wasn't avant-garde, and didn't fit within the emerging abstract art scene (Tierney 2004).

Personal illness and hip surgery in the early 1960s also affected her ability to paint. Her letters and journals from the early 1960s often detail the pain and frustration she experienced at this time (Jori Smith Fonds, Volume 4, Folder 13). According to the artist:

"... My whole world fell to pieces when I was 50. I not only lost all my friends (or nearly) but my studio & my health. I never *never* believed that I would recover. I wanted to die. How terrible are such moments of despair. I painted

every day and every day I wiped it off and started again. For many years I never kept anything I painted & I've often wondered why did I not [give up] all together? Was it only habit or was it perhaps hope, hope that some miracle would occur." (Smith 1987)

After the death of her mother in 1970, Jori returned to more regular painting and exhibition of her works. An exhibit at Kastel Gallery in 1976, her first Montréal exhibit in 20 years, marked her return to the local art scene. For the remainder of her life, Jori continued to paint. In 2001 she was awarded the Médaille de l'Assemblée Nationale du Québec and in 2002 she was awarded the Order of Canada (Carroll 2002). She died in 2005, at the age of 98 (Stone 2006).

1.2 HISTORICAL AND TECHNICAL ANALYSIS OF *NU FÉMININ*

Jori Smith's *Nu Féminin* (1967) is an oil painting on stretched canvas, donated to the Art Conservation program at Queen's University in 2012. The painting depicts a standing female nude against a simple dark green background, with a tan cat at her feet. The primary support is a stretched canvas with a simple weave, and 22 warp and 16 weft fibres per square centimetre, identified by ATR-FTIR and PLM as linen. The canvas appears commercially primed and stretched, and a Grumbacher stamp is present in black ink on the bottom edge of the stretcher. Paint was applied smoothly, with minimal texture over one or more applications of white ground, and the artist's signature (Jori Smith 67) is present, in red paint, in the lower left corner.

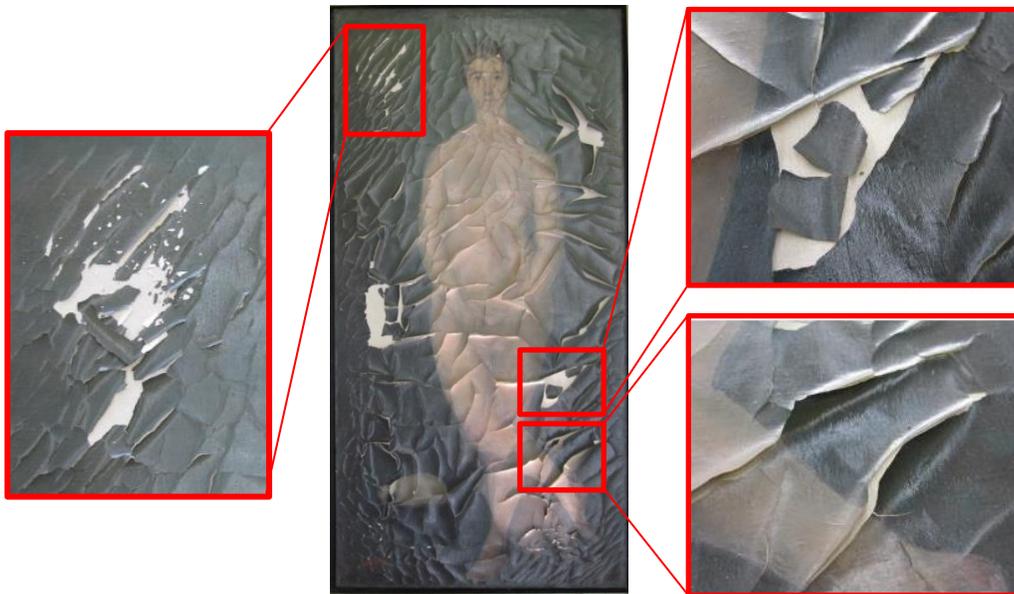


Fig. 1. *Nu Féminin*, in its current state, with details showing the extent of deterioration

The painting is undergoing severe deterioration, with the failure of adhesion or cohesion occurring at or within the ground layer. The paint layer has cracked through to the canvas and at the edges of the cracks, significant lifting and cupping is occurring. In many areas, the edges curl back onto themselves; these areas are dry and brittle, and are prone to breaking upon contact. In large areas, adhesion between the paint layer and the support has failed completely, leaving large islands of paint, often several centimetres in diameter, floating on the surface of the canvas. Cupping and delamination are less pronounced toward the edges of the canvas, where cracks are closer together and movement in the canvas has been restricted by the stretcher. A continuous white ground layer is visible across the bottom surface of the delaminated flakes; however, a thin white coating still appears to be present on the canvas. The cleavage interface appears clean and smooth, with no evidence of powdering paint. This may indicate a failure of adhesion at the interface between two ground layers, rather than a lack of cohesion within the ground layer. Thus, the canvas was likely pre-primed by the manufacturer, with a secondary ground, applied by the artist. Based on the time period, either an acrylic or oil based commercial ground, based on either titanium or zinc is possible.

While flaking is occurring primarily at the ground layer, in some small areas, minor flaking between paint layers can also be seen. In the background, along the left edge, flaking reveals a yellowish underlayer, while in the top left quadrant, a red layer is visible beneath the background. In all cases, clean cleavage is occurring between layers, indicating a problem of adhesion at these interfaces, rather than one of cohesion within a paint layer.

No previous treatment records were available, although the painting appears to have been retouched. Old paint losses, visible along the top edge, have been covered up, either by the artist, or as part of a past conservation treatment. While it is possible that the paint layer was consolidated in the past, this is not immediately evident.

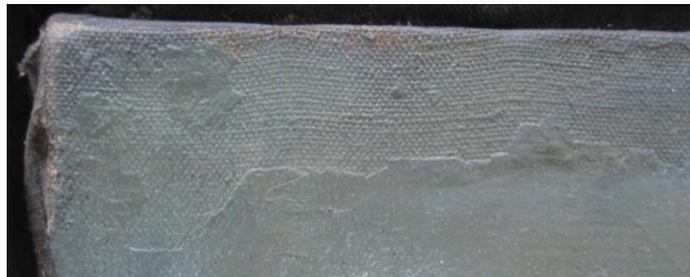


Fig. 2. Detail of the top right corner, showing overpainted losses

The painting was documented using photography in normal and raking light, in UV fluorescence, and with Infrared Reflectance (IRR), using a modified Nikon camera. IRR reveals a grid-like network of broad brushstrokes along the lower left side of the painting, an apparent attempt to mask earlier cracking in the paint layer. An underdrawing is also faintly visible beneath the hands, showing a shift in composition from the initial sketch to the finished painting. No underlying composition or other evidence that canvas has been repurposed could be detected.

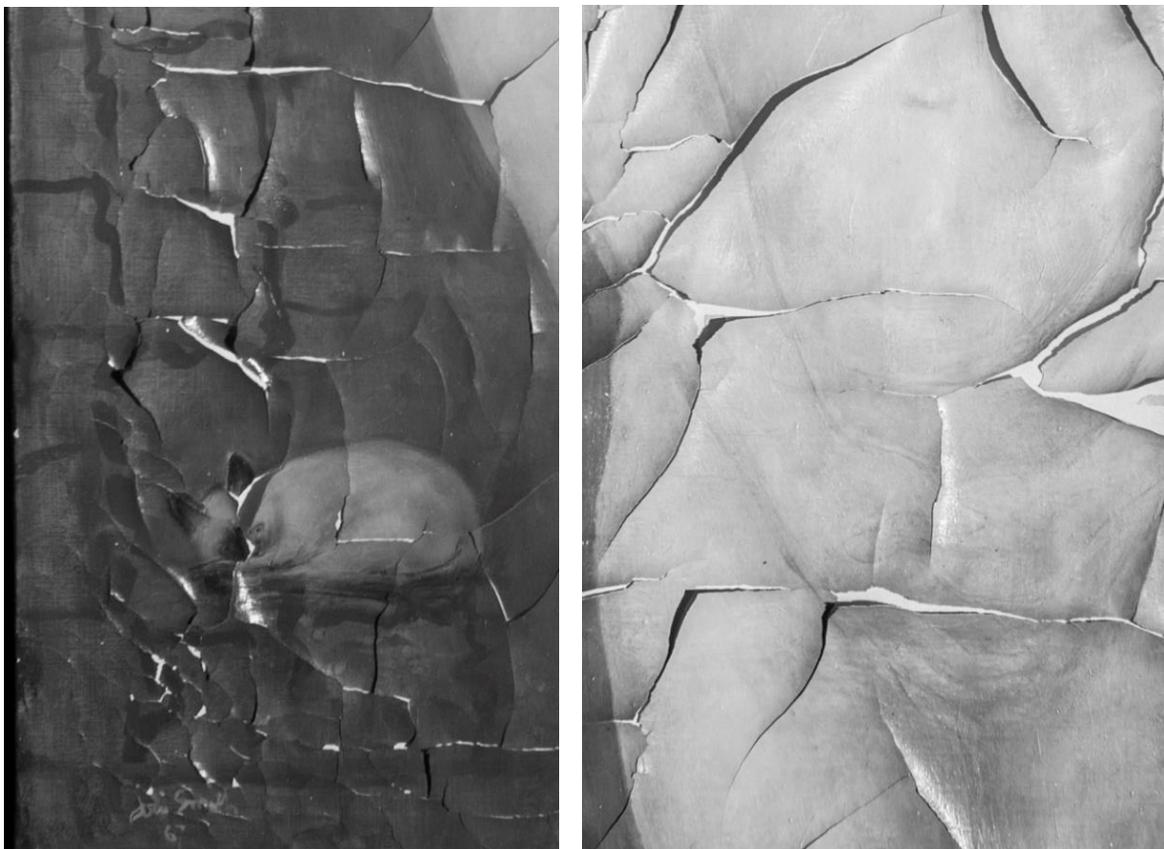


Fig. 3. IR reflectance photographs, showing (a) a loose grid of brushmarks visible in the bottom left corner, and (b) faint underdrawing in the hands.

2. METHODS OF ANALYSIS

The elemental composition of several pigment and ground samples were analyzed in situ with x-ray fluorescence (XRF), using a Bruker III-SD handheld XRF analyzer. Collection times of approximately 20-30 seconds were used. These analyses were used to help guide further sampling and analysis. Further information on analysis and sampling locations can be found in Appendix 1

Five cross sections were taken from the painting. The cross-sections were mounted in Ward's Bio-Plastic, a polymer resin. Samples were then carefully ground to expose the sample with wet 240, 320, 400 and 600 grit abrasive papers and polished with a microcloth and 0.5 micron alumina slurry on a Buehler Ltd. polishing wheel. The cross sections were first examined and photographed using incident light and fluorescence microscopy, using an Olympus BX51 microscope with an Olympus DP72 microscope digital camera and an X-cite series120Q fluorescence excitation source, with a wide band UV excitation filter cube (WU: excitation filter: 330-385nm, mirror: 400, barrier filter: 420 longpass.) Cross sections were then carbon coated and analyzed by SEM-EDX using an FEI-MLA Quanta 650 Field Emission Gun–Environmental SEM (FEG-ESEM) with a X Flash 5010 x-ray detector and Bruker Esprit 1.9 software. The SEM was operated in high vacuum mode with an accelerating voltage of 25 keV using a backscattered electron detector (BSE) and a secondary electron (SE) detector. SEM was used to capture high resolution images of the cross sections, while the x-ray detector was used for spot analyses and to map the distribution of key elements, such as zinc and titanium within cross sections.

Ground and pigment samples were analysed by Fourier transform infrared spectroscopy (FTIR). using a Nicolet Avatar 320 FTIR spectrometer with a Golden Gate single reflection ATR. Basic parameters of 32 scans with a resolution of 4 cm^{-1} were used. As many of the samples were small in size, many samples were run with 128 scans to improve signal to noise. Fibres and fragments of layers of interest were subsequently examined using polarized light microscopy (PLM) using an Olympus BX41 or Olympus BX51 microscope. Permanent slides were created by mounting pigment dispersions and fibre samples in Cargille Meltmount ($n=1.662$).

3. RESULTS OF ANALYSIS

3.1 GROUND LAYERS

As the delamination was occurring at the ground layer, analysis of the ground was of primary importance. When studying the cross sections, three ground layers were observed: a thick white base layer (1), a thin, translucent layer (2) and a second thin white layer (3) with a composition that differs slightly from the base layer. The translucent middle layer fluoresces brightly in autofluorescence and appears black in SEM images, indicating that it is highly carbonaceous in composition. The colour of the fluorescence could indicate animal glue, or

another proteinaceous material, as these often display a white autofluorescence. There is also the ground layer which remains on the canvas, which will be referred to as layer 0. This sequence of ground layers was consistent across all five cross sections examined. For layers 1 and 0, ATR-FTIR identified the binder as a drying oil. In addition, a significant amount of animal glue, likely used to size the canvas, was detected in layer 0. FTIR spectra of the upper ground layers (2 and 3) were not obtained, as the layers were thin and too difficult to separate and analyze using the ATR method.

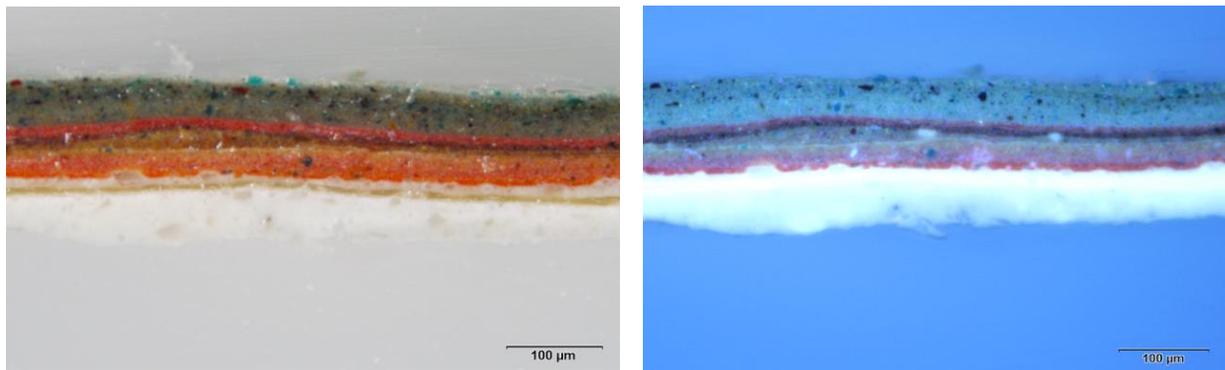


Fig. 4. A cross section from the background (Sample 7), as seen in reflected light and autofluorescence. Three ground layers are clearly visible.

Using elemental analysis by SEM-EDX, the primary ground layer (1) was found to contain titanium, aluminium, silicon, and oxygen, with some magnesium and calcium. ATR-FTIR of layer 1, taken at the delamination interface, confirms that one of the primary components of this layer is kaolin, an aluminosilicate clay. Although not easily identified by FTIR, a peak at 747 cm^{-1} and shoulder at 650 cm^{-1} may be due to titanium white. (McCrone 2012). The presence of TiO_2 is also supported by the presence of a large amount of very small, highly birefringent particles in PLM. (McCrone 1982) The composition of the upper ground layer (3) is similar, but has a greater concentration of calcium and a significantly lower concentration of silicon and aluminium. This trend is clearly visible in spectral mapping of the cross sections, seen in figure 5. There is greater variation in the composition of the upper ground (3) across samples, with an especially high calcium concentration seen in sample 6. This variability may be attributable to the fact that the layer is thin, and included large calcium containing particles. This made it more difficult to obtain an SEM-EDX spectrum that was representative of the overall composition.

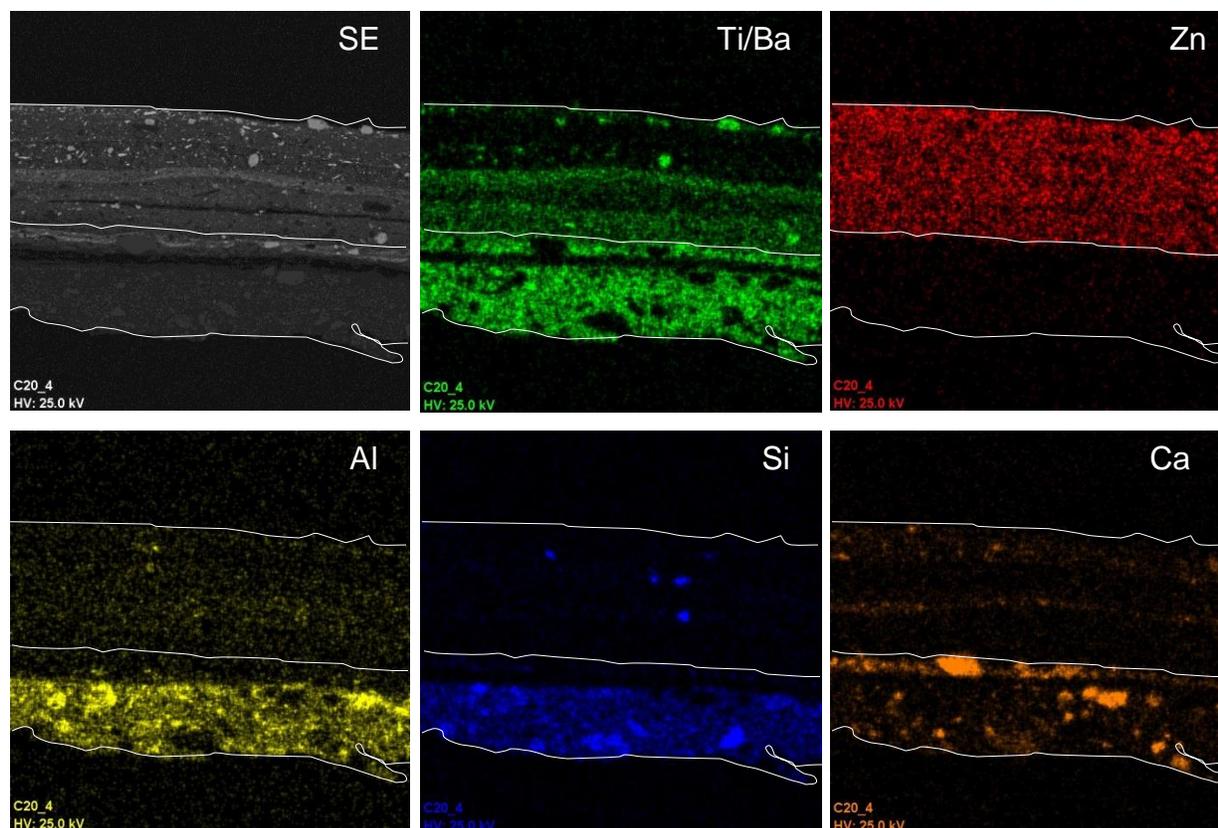


Fig. 5. SEM-EDX elemental mapping of titanium, zinc, aluminium, silicon and calcium for a cross section taken from the background (sample 7). White lines demarcate the top and bottom of the cross section and the ground-paint interface.

From the element maps, we can see that aluminium and silicon are most concentrated in the lower ground layer (1), where the aluminosilicates have been detected by FTIR. Large inclusions are present in the ground layer. Many of these inclusions contain both aluminium and silicon; however, some inclusions contain only silicon. We also see large calcium containing inclusions in the ground layers, with a higher concentration in the upper ground layer. These inclusions could be calcium carbonate (chalk) or calcium sulphate (gypsum), both of which are commonly used in ground layers. Based on spot mapping, the calcium sometimes appears to be associated with magnesium. This may indicate the presence of a calcium magnesium carbonate, such as Dolomite ($\text{CaMg}(\text{CO}_3)_2$), which is sometimes found in whiting or other calcium carbonate pigments.

The elemental composition at the delamination interface was also analyzed in-situ using XRF. The ground layer remaining on the canvas (0) shows primarily titanium, with minor contributions from calcium and zinc, and possible traces of iron. Conversely, analyses from the

bottom surface of the delaminating flakes (1) contained much higher levels of zinc. The concentration of both metals was higher in layer 1 than in the thin, glue-based canvas layer (0). The presence of zinc at the delamination interface suggests that the migration of soaps to this interface may be playing a role in the delamination observed. Unfortunately, despite finding zinc at the delamination interface by XRF, and in the paint layers, by XRF and SEM-EDX, we were unable to confirm the presence of zinc or soaps in the ground layers using any other analytical technique. Zinc oxide cannot be detected by FTIR as it has no peaks in the mid-IR region, and traces of zinc soaps, if present, may fall below the detection limit of the ATR-FTIR instrument. Titanium and zinc oxides are not easily distinguished by PLM, as both have a refractive index greater than $n=1.66$ and small particle sizes less than $1\mu\text{m}$, and no significant concentration of zinc was present in the SEM-EDX analyses using either the spectral or mapping functions.

3.2 PAINT LAYERS

Samples were taken from three important colour areas, the dark green background, the peach flesh, and the light brown cat. FTIR determined that the pigments from all areas were bound in drying oil. Cross sections were complex, containing up to 13 distinguishable layers (see Appendix 2), and colours found beneath the surface often seem unrelated to the final composition. For example, red, orange and brown layers were found beneath the nude figure and in the background, and brown, blue-grey and yellow layers were found beneath the cat. This suggests either a substantial reworking of the canvas, with a change in colour scheme or re-use of the canvas by the artist – both of which were part of her artistic practice during the later decades of her career. A complete review of the pigments and fillers used in each layer of the painting is beyond the scope of this paper; however, some of the key pigments and colour areas will be briefly discussed. Images of all cross sections, in normal light and autofluorescence, can be found in appendix 2.

3.2.1 The Background

The first area that will be discussed is the dark green background. Three cross sections were taken from different areas of the background: the upper left quadrant (sample 3), the upper right quadrant (sample 7) and the left edge in the bottom left quadrant (sample 8). This allowed for an examination of the uniformity of the layered structure across the background. The top

edge was also analyzed by FT-IR and XRF (sample 4) as the paint here concealed a large area of loss.

Sample 3 contains ten layers that can be distinguished in reflected light or autofluorescence. No SEM analysis was conducted on this sample. First, there are the ground layers (1-3) previously discussed, then there is an orange yellow (4), which blends into a yellow layer (5), indicating wet-in-wet application. Layer 5 contains barium sulphate (BaSO_4). This common filler is often co-precipitated with cadmium sulphide (CdS), to make the pigment cadmium yellow lithopone. High levels of zinc soaps are also present. Next, there is another pair of orange-yellow layers (6-7). These layers appear compositionally distinct from the previous layers, as they display much different colours in autofluorescence. An issue of adherence is visible between layers 5 and 6, which may be due to the soaps found in layer 5. When studying the works of abstract expressionists from the late 50s and early 60s, Rogala et al. (2010) found that blind cleavage and interlayer failure often occurred when a zinc oxide layer was present below cadmium pigments. Finally, there are at least three distinct applications of a dark green paint (8-10). These layers are not distinct in reflected light, but can be distinguished in autofluorescence. The XRF at the surface of these layers show zinc as the major component, with iron, lead, chromium, titanium and/or barium, and traces of calcium. No conclusive information was gained from FTIR spectra, although the layers visually appear to contain a mixture of blue, black, white, yellow and orange pigment particles. Sample 4, taken from an area of apparent overpaint, contains the same elements by XRF as sample 3, differing only in the ratios of these components. The two samples could not be distinguished by FTIR, and no retouching is visible by UV or IRR photography. This suggests that the damage either occurred prior to the completion of the final composition, or that the retouching was done by the artist herself, using a similar paint mixture, soon after the painting was completed.

Sample 7 contains 12 distinct layers, as observed by PLM and SEM. This area was selected for sampling, because small areas of flaking, revealing a red layer, were observed. First, there are the three ground layers (1-3), followed by red, orange, and peach layers (4-6). These layers blend together, suggesting the paint was mixed wet-in-wet. Next there is a light brown layer (7), covered by a thin dark brown layer (8), and a bright red layer (9). Analysis of the red layer (9) by FTIR, reveals the presence of barium sulphate and zinc soaps, while elemental mapping reveals

the presence of cadmium in the red layer. As previously discussed, Cadmium red and yellow pigments often consist of CdS/CdSe co-precipitated with barium sulphate. The zinc soaps detected may be playing a role in the delamination observed. Finally, there are again at least three green layers (10-12), clearly visible in SEM and autofluorescence. The layer structure is similar to, but not the same as, Sample 3. SEM analysis of the top green layer (12) shows zinc as the major component with significant amounts of titanium/barium and oxygen and traces of iron. Similarly, the major components of this layer, as seen by XRF are zinc, lead/sulphur and titanium, with smaller amounts of calcium, chromium and aluminium and traces of iron, silicon and phosphorus. The mapping function of the SEM-EDX instrument is unable to distinguish between titanium and barium, as the K lines of titanium overlap with the principal L lines of barium. However, spot analysis of the round particles in the green paint layers confirms the presence of barium, and peak ratios in the EDX spectra indicate that both titanium and barium are likely present. The occurrence of calcium and phosphorous together in this dark green layer may indicate the presence of bone black, and the presence of chromium in the green layers could indicate either chromium oxide green (viridian – $\text{Cr}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$), chrome yellow (PbCrO_4), or chromium green, a mixture of chrome yellow with Prussian blue. In PLM, separate blue particles, and small yellow particles can be seen, indicating the likely presence of a mixed green pigment, however, the very distinct peak at 2080 cm^{-1} in the FTIR, associated with the C=N stretch of Prussian blue, was not observed.

The third cross section, taken from the ground along the left edge, had a much different stratigraphy, consisting of only nine layers, distinguishable in reflected light and autofluorescence, There are the ground layers (1-3), a thick peach layer (4), a purple layer (5), a dark blue layer (6), an intermittent dark blue-green layer (7), a black layer (8) and a dark green layer (9). Some mild flaking was occurring in this area, and zinc soaps, present in the peach layer, could be contributing to this weaker adhesion.

3.2.2 The Nude

The second key colour area analyzed was the peach flesh. The cross section was taken from the centre of the chest and contains ten layers that can be distinguished by SEM and PLM. First, there are the ground layers (1-3) previously discussed. This is followed by a series of orange, peach, brown, and red layers (4-7). These layers are thin and intermixed, indicating that

the paint may have been applied using a wet-in-wet techniques. Finally there is a thin red layer (8) and a thick peach layer (9). SEM-BSE and fluorescence images reveal that this is covered by a thin, intermittent layer (10), not distinguishable in reflected light. Based on SEM-EDX analysis, the peach layer (9) contains primarily zinc, sulphur and oxygen, with lead and traces of aluminium and iron. An XRF spectrum taken slightly lower on the chest shows primarily zinc with titanium, lead, iron and traces of chromium and calcium. (Aluminium, oxygen and sulphur will not be observed by XRF). The FTIR spectrum of the reddish interlayers (4-6) contains zinc soaps, and possibly barium sulphate. As previously mentioned, the latter is commonly associated with cadmium pigments. The FTIR for these layers show that the binder is a drying oil. No further information on the pigments was determined by FTIR.

3.2.3 The Cat

The final colour area analyzed was the light brown cat in the lower left corner (Sample 6). This cross section contains eight layers that can be distinguished by SEM and PLM, including the three ground layers (1-3), a thick yellow layer (4), a blue-black layer (5) a brown layer (6), a tan layer (7), and finally, the light brown surface layer (8). The XRF at the surface of the painting (layer 8) shows primarily Zn with Pb, Fe, Ti, and traces of Cr and Ca. By SEM-EDX, the layer contains Zn, Pb/S, Ca, Ba/Ti, and O, some Al and P, and smaller traces of Cr and Fe. Visually, this layer appears to contain a mixture of white, yellow, orange, black and blue pigment particles. SEM-EDX spot analyses show that the surface layer (8) contains small, dark particles containing Ca, P, and O. This likely indicates calcium phosphate (CaPO_4), which suggests the presence of bone black. Layers 7 and 8 include many white, round, Ba, S, and O containing particles, likely barium sulphate (BaSO_4), a common filler and extender. The surface layer (8) also contains some Pb and S rich particles. Zinc oxide appears to have been used as the primary mixing white in the composition. Mapping shows that zinc is most concentrated in the top two layers, which are light in colour. Smaller amounts of zinc are also found in the brown and yellow layers. Iron is most concentrated in the brown and tan layers, suggesting that the colours are iron oxide based. Cadmium is concentrated in the yellow layer (4), indicating that cadmium yellow (CdS) pigment was likely used; possibly co-precipitated with barium sulphate (BaSO_4). There is also a smaller amount of cadmium found in the brown layer, which could contain cadmium yellow or red.

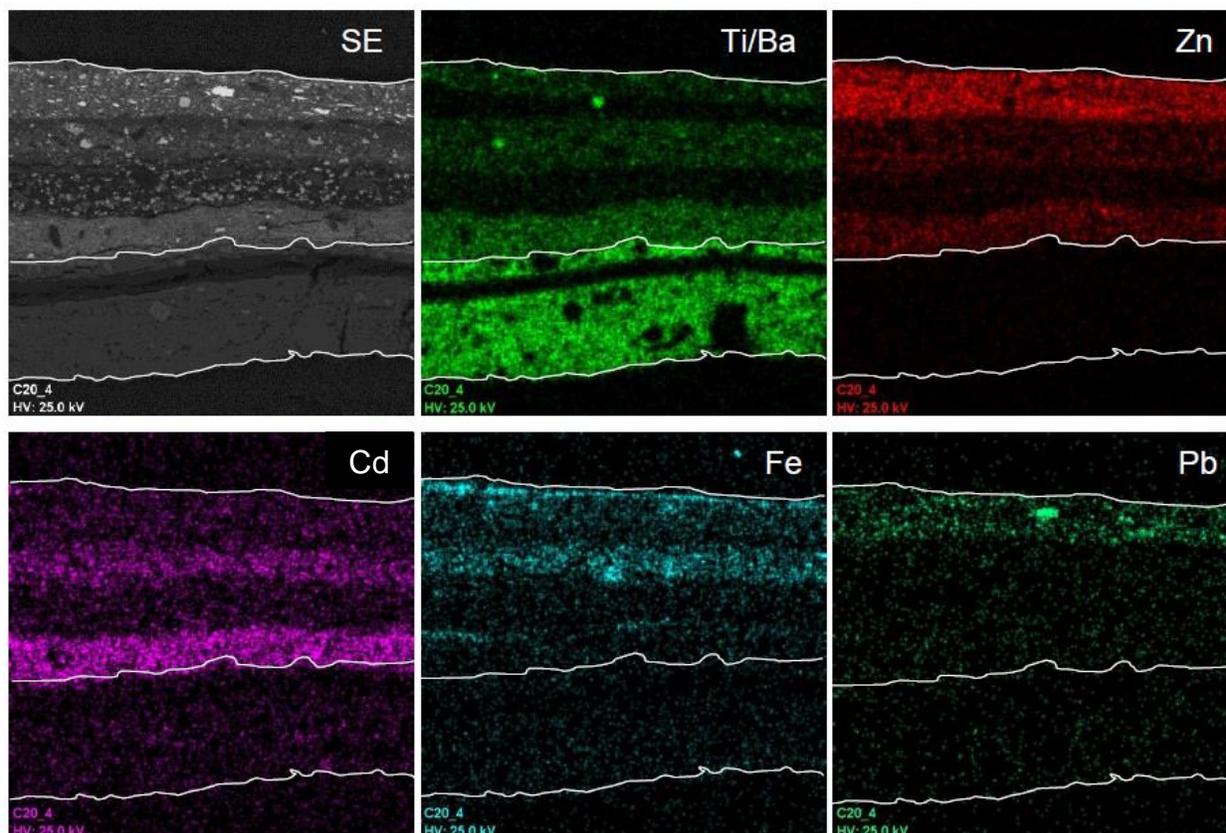


Fig. 6. SEM-EDX elemental mapping of T/Ba, Zn, Cd, Fe, and Pb from a cross section of the light brown cat, sample 6. White lines mark the top and bottom surfaces of the cross section and the ground-paint interface.

4. DISCUSSION AND COMPARISON WITH OTHER WORKS

Nu Féminin was created in the late 1960s, a period where Jori was not exhibiting her work, and destroyed much of what she created. It is of interest to know whether her materials or working methods at this time differed at all from those used in her earlier works, and whether these differences are reflected in the current condition of the works. As part of a greater exploration of the artist and her working practice, twenty works by Jori Smith, along with their associated curatorial and treatment dossiers, were studied. These works belong to the collections of four Galleries: The Agnes Etherington Art Centre (AEAC) in Kingston, ON, the National Gallery of Canada (NGC), in Ottawa, the Leonard and Bina Ellen Art Gallery (LBE) at Concordia University in Montreal, and the Musée nationale des beaux-arts du Québec (MNBAQ), in Quebec City. The works ranged in date between 1933 and 1982, although the majority of the works were from the 1930s and 1940s, when the artist was most actively selling and exhibiting her works. Works consulted included a genre scene, a still life, two nudes, and many portraits of

men, women and children. Research also included consultation of records, letters and diaries from the Jori Smith Fonds (MG 30, D 249) from the Library and Archives Canada, donated by the artist in several installments, beginning in the late 70s, and correspondence with the McMichael Canadian Art Collection, Musée de Joliette about works by Jori Smith in their collections.

The two nudes examined, which date from 1937 and 1940 respectively, differ greatly from *Nu Féminin* in their style and composition. *Nu* (1940, MNBAQ) uses thick brushstrokes and bold forms and is more abstract than her typical work. The paint layer is of varying thickness, and an imprimatura or thin coloured ground layer is visible between the brushstrokes. *Nude* (1937, NGC), purported to be a self-portrait of the artist, is painted in muted tones, with dark outlines and painterly brushwork, and a more lifelike feel than the other two nudes. Although the 1940 painting has been strip-lined, neither of these earlier paintings has any significant flaking or other conservation issues. In fact, all of the paintings examined were in generally good condition. Some of the paintings displayed minor cracking or flaking, but most had undergone little to no previous conservation treatment.

Due to the difference in painting style seen when comparing *Nu Féminin* to the artist's earlier works, consultation of works from later in her career was desired. Unfortunately, works by the artist from after 1960 are difficult to find in public collections. Only one work from this period was directly examined, a portrait of the artist's mother from 1982 (Ma Mère, Naomi Neal, LBE). The style clearly differs from her earlier works. The paint application is more opaque and feels more heavily worked, lacking the spontaneity present in her earlier portraits, qualities it shares with *Nu Féminin*. No ground layer or underdrawing is visible through the paint layer. Technical examination suggests that the canvas may have been re-used, and some minor cracking and lifting present in the forehead, reveals further paint layers below. This notion is supported by entries from the artist's journals, which reveal that the portrait was started on March 3, 1981 and finished four days later, only to be completely reworked more than a year later, in April 1982 (Jori Smith Fonds Volume 17 Folder 17). Another one of her later works, a still life from 1975 (*Possessions*, McMichael), was also confirmed to be in good condition (Douglas 2014). This work was a part of Jori's 1976 exhibit at the Kastel Gallery in Montreal, and more closely resembles *Nu Féminin* in color and style than any of the other works examined.

Jori often destroyed or repainted her works when she was not satisfied with them. Her opinion of her art seems to have been in constant evolution. In a journal entry from April 1979 she wrote:

"I am confused as always about my work. I passionately enjoy every minute of work but when it is finished I look at it in dismay. Although sometimes, as early as this A.M., when I awoke suddenly surprised by the still-life laboured upon these last ten days, I had a thrill of delight thinking, then, 'why I believe there is something good in it'."(Jori Smith Fonds, Volume 17 Folder 15)

Such examples are plentiful in her later journals. In a series of journal entries from 1992, Jori describes the working and reworking of a portrait of Pierre over the course of several months. One entry states "I wiped off Pierre. & boldly re-painted it in my wild new simple style concentrating upon colour relations..." Months later she states "I believe I have Pierre now. Was brave & took risks, thrilling adventures in colour..." However, an entry from the following day begins "Started again from scratch on Pierre. If tomorrow it does not come off, it's finished...I've worked so hard on this portrait, it grieves me to abandon it now..." A later annotation inside the front cover of the journal indicates that the painting was eventually destroyed. (Jori Smith Fonds Volume 18 Folder 8)

There is also clear evidence that she re-used old canvases for new compositions, especially in her later works. For example, in a journal entry from 1990, Jori states: " [I took] 3 old canvases, lilacs, pears and an *affreux* portrait d'une jeune fille. Painted a new base on each, upon which I am convinced that I can create something beautiful, quieter & more sensitive in manner than what they were..."(Jori Smith Fonds Volume 18 Folder 2). Another example of re-use was seen in the 1946 portrait of *Clovis Kernizan* (MNBAQ). The composition was painted while the artist was travelling and has a portrait of a woman on the verso, which shows damage and horizontal cracking from being rolled. Such re-use is not surprising, considering the periods of financial struggle the artist experienced throughout her career. Sometimes Jori even destroyed or reworked paintings after they had been shown, and often showed dissatisfaction with works that had already been sold. In a 1977 letter to the National Gallery of Canada, regarding their acquisition of her portrait of *Madeleine Laliberté* (1955), she called the portrait a "daub and of no importance". (Jori Smith Fonds Volume 6 Folder 7), and in a journal entry from 1981 Jori said that her agent had arrived with "payment for *Daffodils* which I would have destroyed had it been

returned to me" (Jori Smith Fonds Volume 17 Folder 17). These examples all lend support to the re-working, or even re-painting of her canvas, *Nu Féminin*.

5. CONCLUSION

The painting *Nu Féminin* (1967), by Montréal artist Jori Smith, is in very poor condition, with severe delamination affecting the entire surface. The problem is occurring at the interface between a thick white ground layer and the canvas, where a thinner white ground remains. While the ground layers are primarily composed of Titanium White, with Kaolin Clay, XRF analyses taken at the interface reveal a zinc containing layer present on the bottom surface of delaminating flakes. This may be indicative of a very thin layer of zinc soaps, which has migrated through the paint layer, although soaps were not apparent by FTIR in this layer.

While the ground layers did not contain significant amounts of zinc, zinc was one of the primary components of many of the paint layers, and zinc soaps were often observed. There are several reasons why may be the case. Zinc oxide is used as a white pigment, either alone, as zinc white, or in mixtures with other white pigments. It is also present as an extender in other paint colours. Zinc stearate, a zinc soap is a common paint additive, and zinc soaps may also form in-situ from the reaction of zinc oxide with free fatty acids.

The painting has a complex layered structure. Each of the cross sections examined has approximately 8-13 distinct layers, and many of the underlying paint colours contrast strongly with the current composition. Some of the paint layers were mixed wet-in-wet, while others have distinct margins. Old losses in the background have been overpainted, but the composition of the paint covering these losses is similar to the paint from the remainder of the background. This suggests that the losses existed prior to the completion of the current composition, or were overpainted by the artist. There is also evidence of retouching in other areas in IR reflectance photography. These factors, combined with what is known of the artist's practice, suggest that the composition may have been changed, perhaps more than once, before arriving at the final composition, and that the issues of cracking and delamination in this piece may have begun before the painting even left the artists' studio.

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REFERENCES

- Barbarant, G. Helou-de La Grandière, P. 2012. Pierre Soulages : L'art et le métier, la restauration de «Peinture, 130x165 cm, 18 avril 1959 ». In *La restauration des peintures et des sculptures: Connaissance et reconnaissance de l'oeuvre*. P.-Y. Kairis, B. Sarrazin, and F. Trémolières (eds) Paris: Armand Colin. 311–331.
- Carroll, A. 2002. On a roll: painter, 95, saluted: Montrealer Jori Smith named to Order of Canada for 'groundbreaking role' in art: *The Gazette*. July 6, A4.
- Douglas, A. 2014. Personal Communication [email: March 13, 2014]. Conservator. McMichael Canadian Art Collection, Kleinburg, ON.
- Helwig, K., M.-C. Corbeil, E. Moffatt, J. Poulin. 2013. Using analysis to shed light on conservation issues in modern oil paintings by Canadian artists. In *Issues in Contemporary Oil Paint, 28 and 29 March, Amersfoort, The Netherlands*. 79–80.
- Helwig, K., J. Poulin, M.-C. Corbeil, E. Moffatt and D. Duguay. 2014. Conservation Issues in Several 20th-Century Canadian Oil Paintings: the Role of Zinc Carboxylate Reaction Products. In K.J. van den Berg, A. Burnstock, A. de Tagle, M. de Keijzer, G. Heydenreich, J. Krueger and T. Learner (eds). *Issues in Contemporary Oil Paints (ICOP), Proceedings of the Symposium, 28 and 29 March 2013, Amersfoort, The Netherlands*; Springer.
- Jori Smith Fonds. MG 30, D 249. Library and Archives Canada, Ottawa, Ontario, Canada.
- LBE. Jori Smith. Curatorial and Treatment Files. Leonard & Bina Ellen Art Gallery. Concordia University, Montreal, QC.
- Maor, Y. 2008. Delamination of Oil Paint from Acrylic Ground. M.A.C thesis. Queen's University, Kingston, Ontario, Canada
- Meadowcroft, B. 1993. *Rediscovering Jori Smith: selected works, 1932-1993*. Exhibition Brochure. Montreal, QC: Galerie Dominion.
- McCrone, W. C. 1982. The microscopical identification of artists' pigments. *Journal of the International Institute for Conservation - Canadian Group*. 7:11–34.
- McCrone. 2012. *McCrone Atlas of Microscopic Particles*. Online Database. Westmont, IL: McCrone Associates Inc. www.mccroneatlas.com/ (accessed 04/05/14)

- Mecklenburg, M., L Fuster-Lopez, D. J. Yusa Marco, M. R. Sorensen, K. P. Simonsen and M. Scharff. 2013. The role of grounds in contemporary oil paintings: an approach to their stability and preservation. In *Issues in Contemporary Oil Paint, 28 and 29 March, Amersfoort, The Netherlands*. 70–71.
- Moffatt, E. and D. Miller. 1994. Spectroscopic and Chromatographic Analysis of Selected Paintings from the Parisian period of Paul-Emile Borduas. *Journal of the International Institute for Conservation - Canadian Group*. 19:3–13
- MNBAQ. Jori Smith. Curatorial and treatment files. Musée National des Beaux-Arts du Québec, Quebec, QC.
- NGC. Jori Smith. Curatorial and treatment files. National Gallery of Canada. Ottawa, ON
- O'Malley, M., and E. A. Moffatt. 2001. Paul-Emile Borduas: the blacks and whites of the later paintings (1955-1960). In *Deterioration of Artists' Paints: Effects and Analysis. (A Joint Meeting of ICOM-CC Working Groups Paintings 1 & 2 and the Paintings Section UKIC, British Museum, London 10th and 11th September 2001: Extended Abstracts of Presentations)*. London: British Museum. 84–87.
- Pageot, E.-A. 2000. Jori Smith, une figure de la modernité picturale québécoise. Étude d'un cas : le portrait d'enfant. *Globe : revue internationale d'études québécoises*, 3(2):171–186.
- Rogala, D., S. Lake, C. Maines, and M. Mecklenburg. 2010. Condition Problems Related to Zinc Oxide Underlayers: Examination of Selected Abstract Expressionist Paintings from the Collection of the Hirshhorn Museum and Sculpture Garden, Smithsonian Institution *Journal of the American Institute of Conservation*. 49:96–113.
- Smith, Jori. 1987. Autobiographical Sketch. Unpublished Typescript. Library and Archives Canada. MG30, D249, volume 19, file 20, 31.
- Stone, M. J. 2006. Jori Smith, Artist 1906-2005. *Globe and Mail*, January 2, S6
- Tierney, C. 2004. Jori Smith: A Contextual Analysis. M.A. Thesis in Canadian Art History. Carleton University, Ottawa, Ontario, Canada.
- Whitehouse, R., and N. Eastaugh. 2001. From Munnings to Mondriaan: Studies in the deterioration of early twentieth century artists' materials. In *Deterioration of Artists' Paints: Effects and Analysis. (A Joint Meeting of ICOM-CC Working Groups Paintings 1 & 2 and the Paintings Section UKIC, British Museum, London 10th and 11th September 2001: Extended Abstracts of Presentations)* London: British Museum, 61–65.

FURTHER READING

- Hill, C. 1974. Interview with Jori Smith [sound recording] National Gallery of Canada, Ottawa. January 16, 1974. <http://bibcat.gallery.ca/record=b1227617~S4> (accessed 03/08/14)
- Smith, Jori. 1998. *Charlevoix County, 1930*. Manotick, ON: Penumbra Press.

Appendix 1. SAMPLING AND ANALYSIS

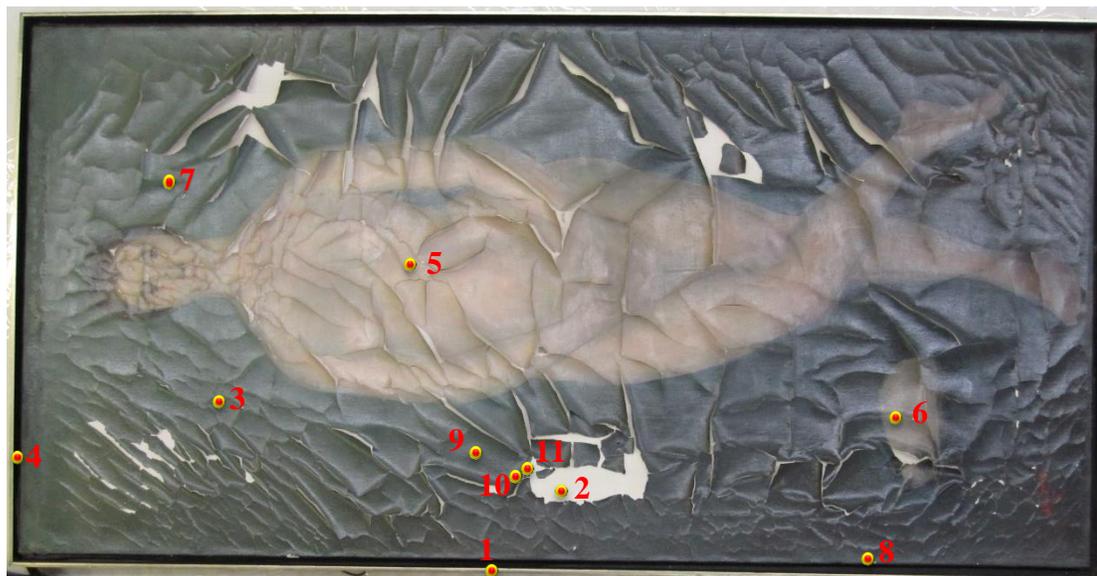


Fig. 7. Approximate locations of in situ XRF analyses

Table 1. Sample Descriptions and Locations

Sample Number	Sample Description	Sample Location (x, y) Measured from bottom left corner
1	Tan/yellow coloured canvas fibre from edge	Loose fibre removed from verso along tacking margin
2	Scraping of white ground remaining on bare canvas in a major area of delamination and paint loss in the background	6.8 cm, 48.7 cm
3	Cross section of the green background, taken from a lifted area	13.8 cm, 79.9 cm
4	Apparent dark green overpaint from the top edge	9.0 cm, 100.8 cm
5	Cross section from the torso, taken from lifted area	27.5 cm, 63.1 cm
6	Cross section from the tan cat in the lower left corner, taken from a lifted area	13.9 cm, 16.9 cm
7	Cross section from the green background, area with apparent yellow underlayer	34.1 cm, 85.8 cm
8	Cross section from the green background, area with apparent red underlayer. Cracked between layers 3 and 4 during sampling.	0.1 cm, 20.4 cm
9	Uneven varnish or resinous accretion with yellowed appearance (for FTIR and GCMS)	12.0 cm, 59.1 cm

10	Scraping of white ground remaining on bare canvas in a major area of delamination and in the background (for FTIR and GCMS)	8.2 cm, 50.5 cm
11	Scraping of the white ground layer from the underside of the corresponding delaminated flake from sample 10 (for FTIR and GCMS)	8.5 cm, 50.5 cm

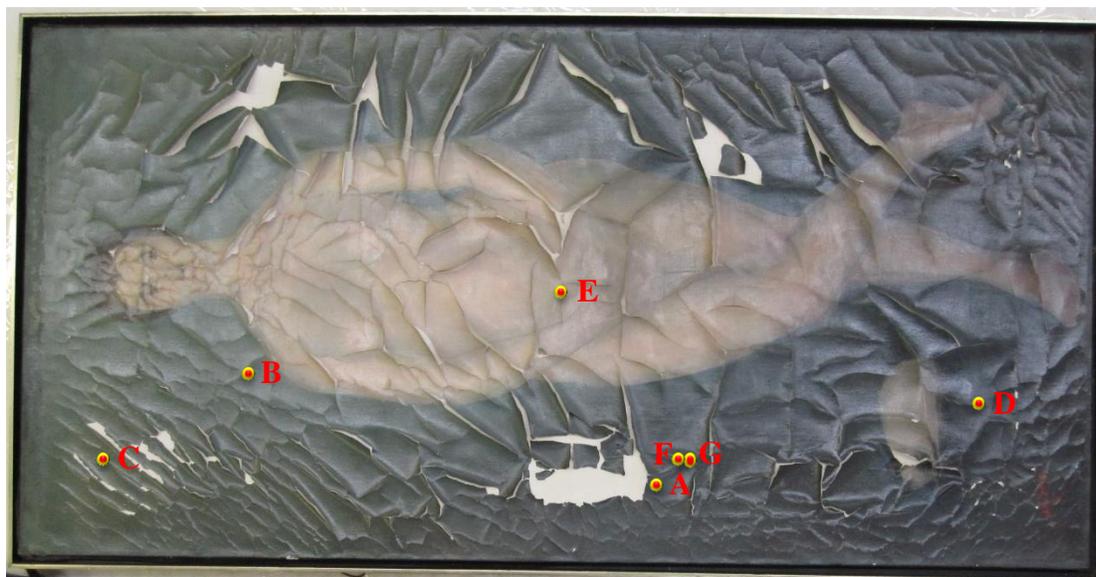


Fig. 8. Approximate locations of in situ XRF analyses

Table 2. XRF Analysis Descriptions and Locations

Location	Description	Sample Location (x, y) measured from bottom left corner
A	Area of white ground remaining on the canvas by proper right hip, exposed due to major loss.	8 cm, 48 cm
B	Green background, upper left quadrant	19 cm, 122 cm
C	Apparent dark green overpaint from the top edge	5 cm, 130 cm
D	Tan coloured cat in the lower left corner	15.5 cm, 17.5 cm
E	Flesh coloured area of the stomach	25 cm, 85 cm
F	Area of white ground remaining on the canvas below delaminated flake	10 cm, 44.5 cm
G	Ground layer on the underside of the delaminated flake	10 cm, 44.5 cm

Appendix 2. CROSS SECTIONS

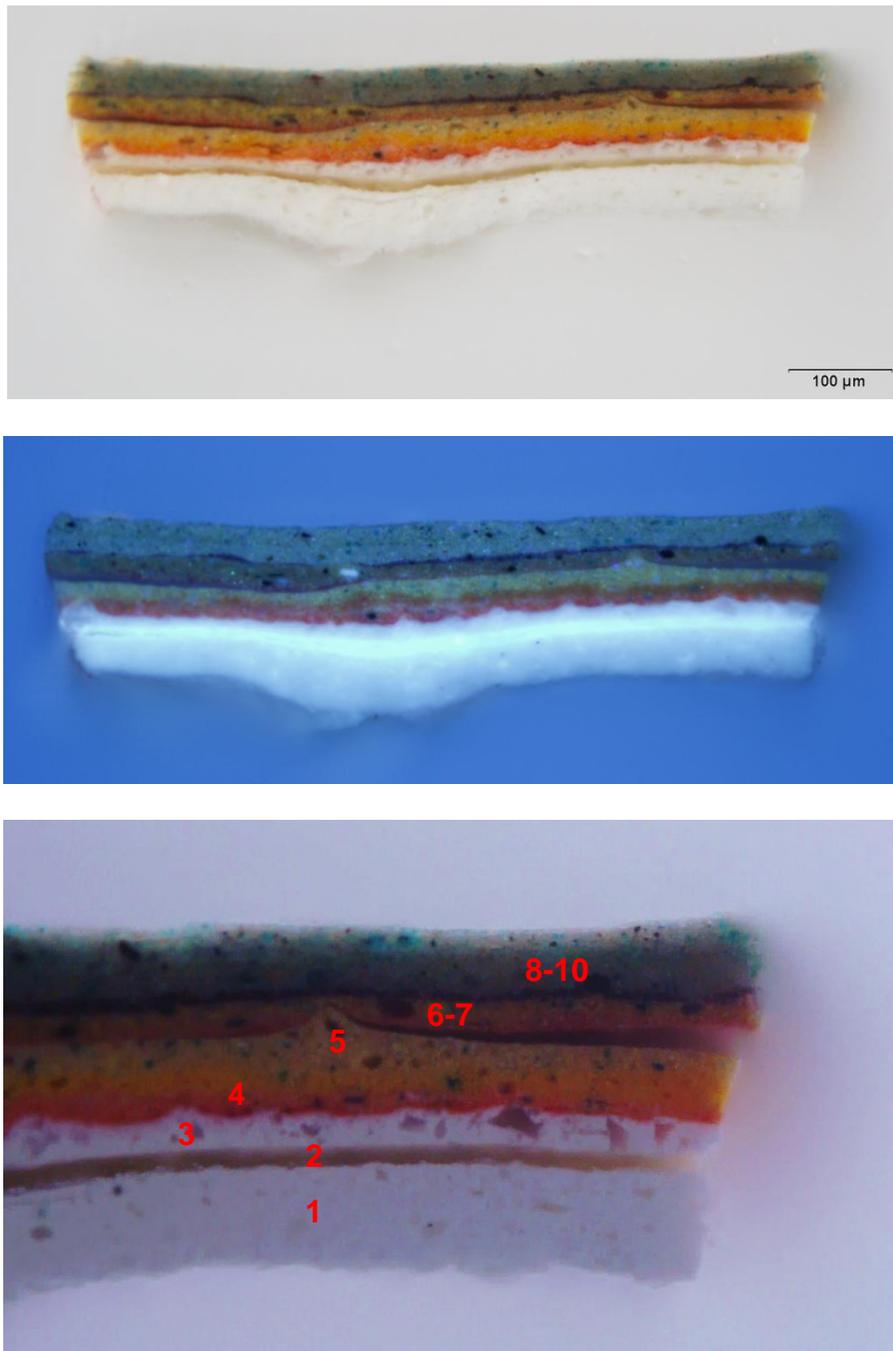


Fig. 9. Cross section from the green background (Sample 3) in **a**) Reflected light, 200x **b**) autofluorescence (WU), 200x and **c**) Reflected light, 400x. The cross section contains 10 visually distinguishable layers, A thick white ground layer (1), a thin transparent layer with bright white fluorescence (2), A thinner secondary ground layer (3), a red/orange layer appearing red in autofluorescence (4) that blends into a yellow layer (5), a thin orange layer (6) that blends into a thin yellow layer (7), and finally 2-3 layers of dark green(8-10). Interlayer cleavage is present between layers (5) and (6), and either a thin dark paint layer or slight cleavage appears to be present between layers (7) and (8).

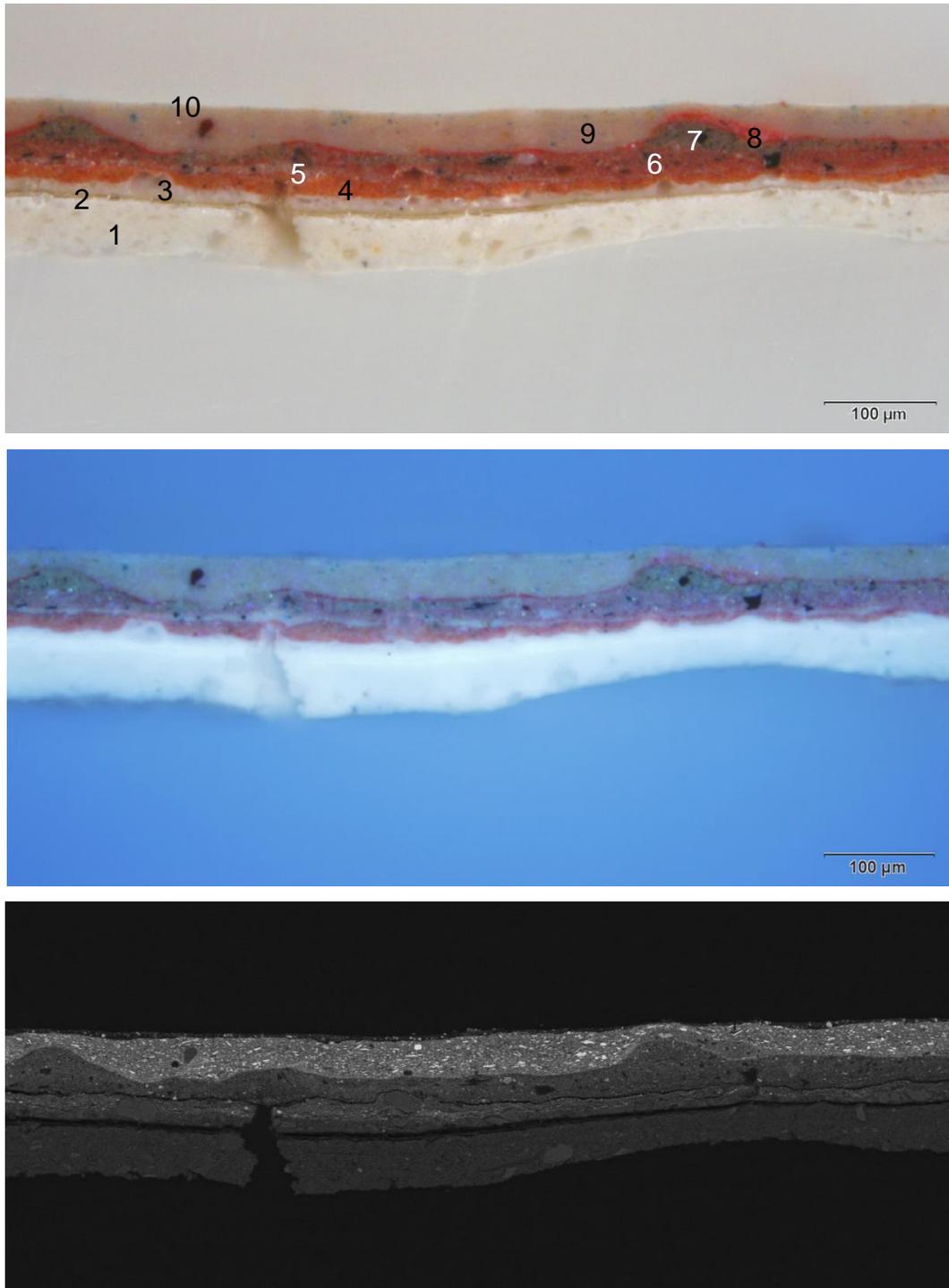


Fig. 10. Images of the cross section from the peach skin (Sample 5) in **a**) reflected light, 200x, **b**) autofluorescence (WU), 200x, and **c**) an SEM-BSED image made using a QFIR ESEM at 25.00 keV in HV mode, WD 8.6mm (236x). Although it appears simple at first, the cross section contains 10 visually distinct layers: a thick white ground layer (1), a thin transparent layer with bright white fluorescence (2), a thinner secondary ground layer (3), a thin red/orange (4), a very thin, intermittent tan layer (5), a red/orange layer (6) an uneven brown layer (7), a very thin bright red layer (8), a thick peach layer (9), and a very thin, discontinuous peach layer (10).

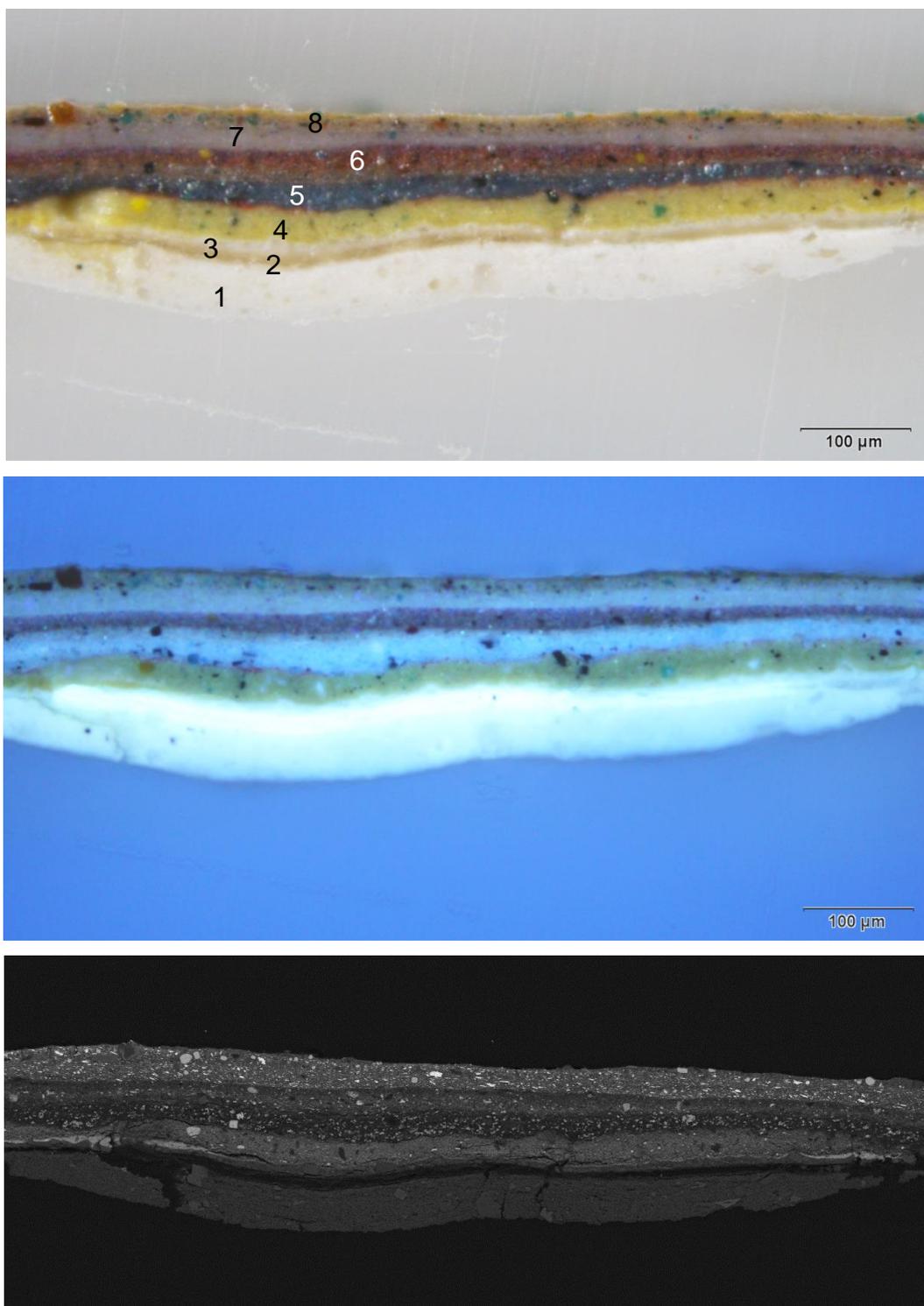


Fig. 11. Images of the cross section from the tan cat (Sample 6) in **a**) reflected light, 200x, **b**) autofluorescence (WU), 200x, and **c**) an SEM-BSED image made using a QFIR ESEM at 25.00 keV in HV mode, WD 12.8 mm (200x). 8 visually distinct layers are present: a thick white ground layer (1), a thin transparent layer with bright white fluorescence (2), a thinner secondary ground layer (3), a relatively thick yellow paint layer (4), a dark blue/grey layer (5), a brown layer (6), a light tan layer (7), the tan surface layer (8).

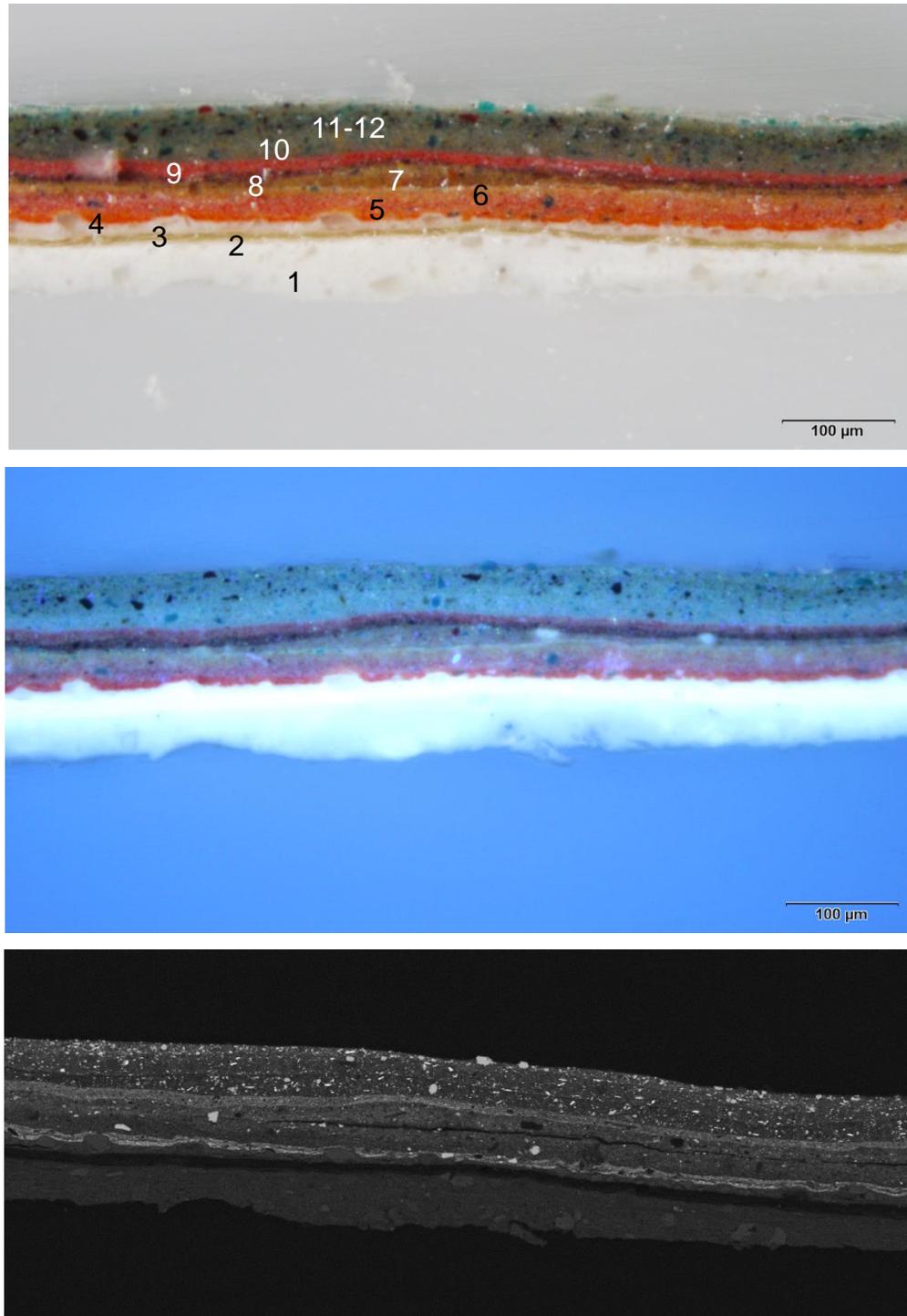


Fig. 12. Images of the cross section from the background (Sample 7) in **a**) reflected light, 200x, **b**) autofluorescence (WU), 200x, and **c**) an SEM-BSED image made using a QFIR ESEM at 25.00 keV in HV mode, WD 14.5 mm (234x). 12 visually distinct layers are present: a thick white ground layer (1), a thin transparent layer with bright white fluorescence (2), a thinner secondary ground layer (3), a red/orange layer appearing red in autofluorescence (4) and that blends into an orange layer (5), a very thin tan layer (6), a brown layer (7), a thin dark brown layer (8), a thin red layer (9), and finally 2-3 layers of green paint (10-12).-

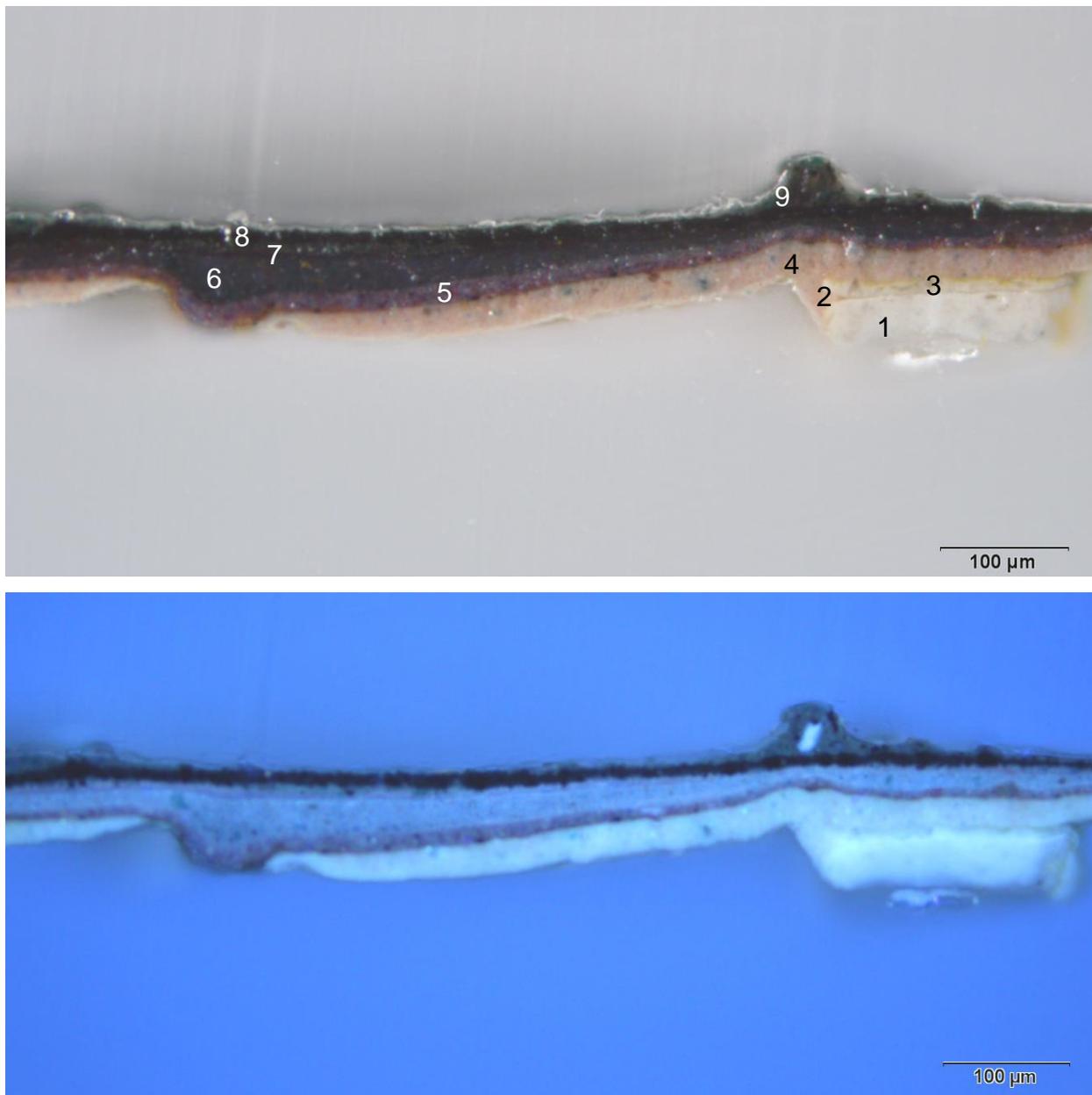


Fig. 13. Images of a partial cross section from the dark green background (Sample 8) in **a**) reflected light, 200x, and **b**) autofluorescence (WU), 200x. The cross section contains 8 visually distinct layers: a thick white ground layer (1), a thin transparent layer with bright white fluorescence (2), a thinner off-white secondary ground layer (3), a peach layer (4), a purple layer (5), a dark blue layer (6), and a partial thin dark blue layer (7), which are distinguishable in autofluorescence, a black layer (8) and finally, a dark green layer (9).

Appendix 3. KEY FTIR SPECTRA

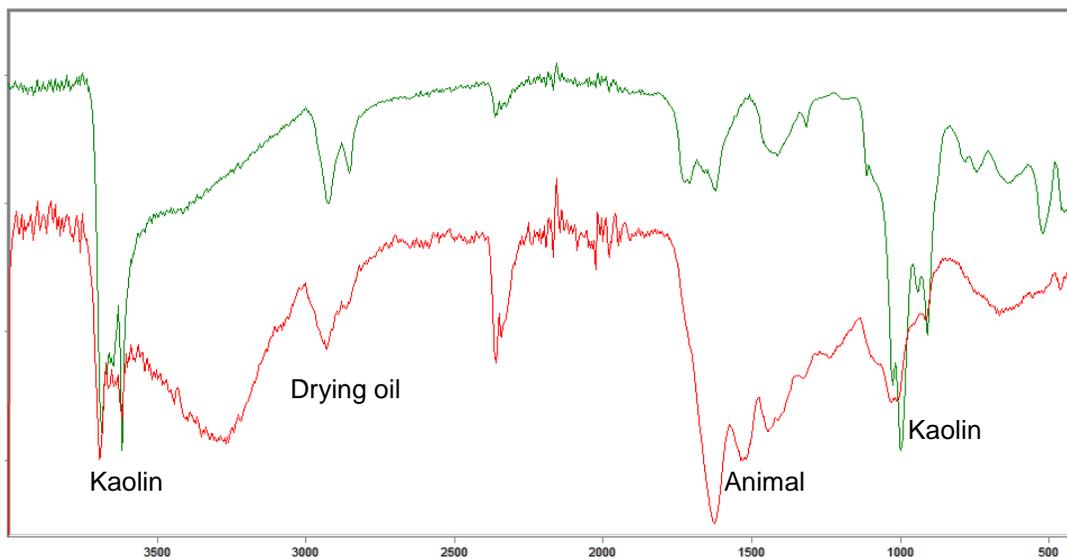


Fig. 14. FTIR comparison of samples taken from the delamination interface: the bottom surface of layer 1, the delaminating flake (top), and the top surface of layer 0, the layer remaining on the canvas (bottom).

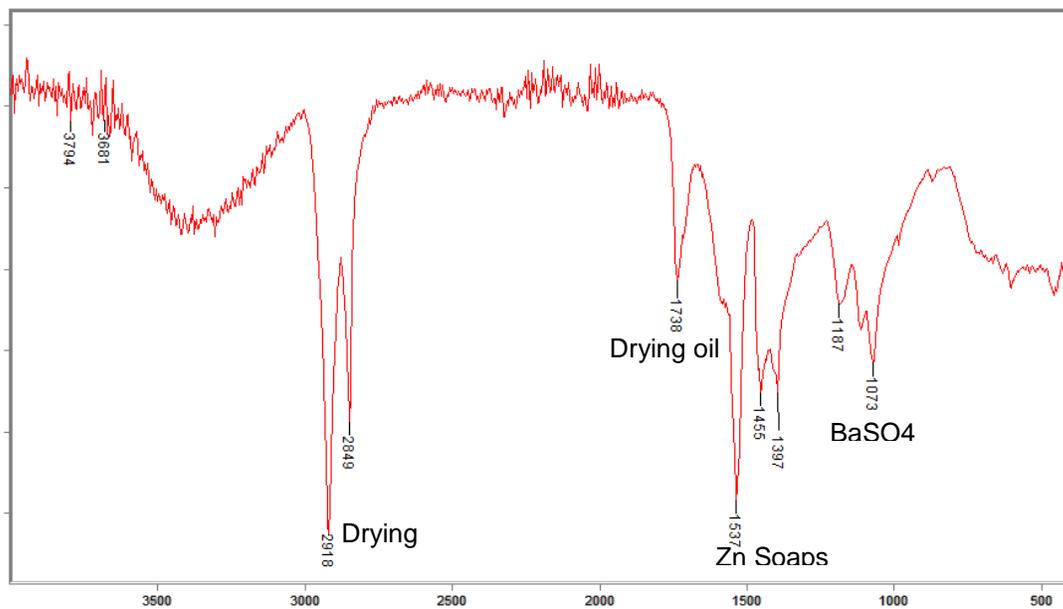


Fig. 15. FTIR of the red interlayers (4-6) of Sample 5, with drying oil, barium sulphate and zinc soaps, as indicated. Similar spectra were observed for other cadmium red and yellow containing layers

Appendix 4. SEM-EDX ELEMENTAL MAPPING

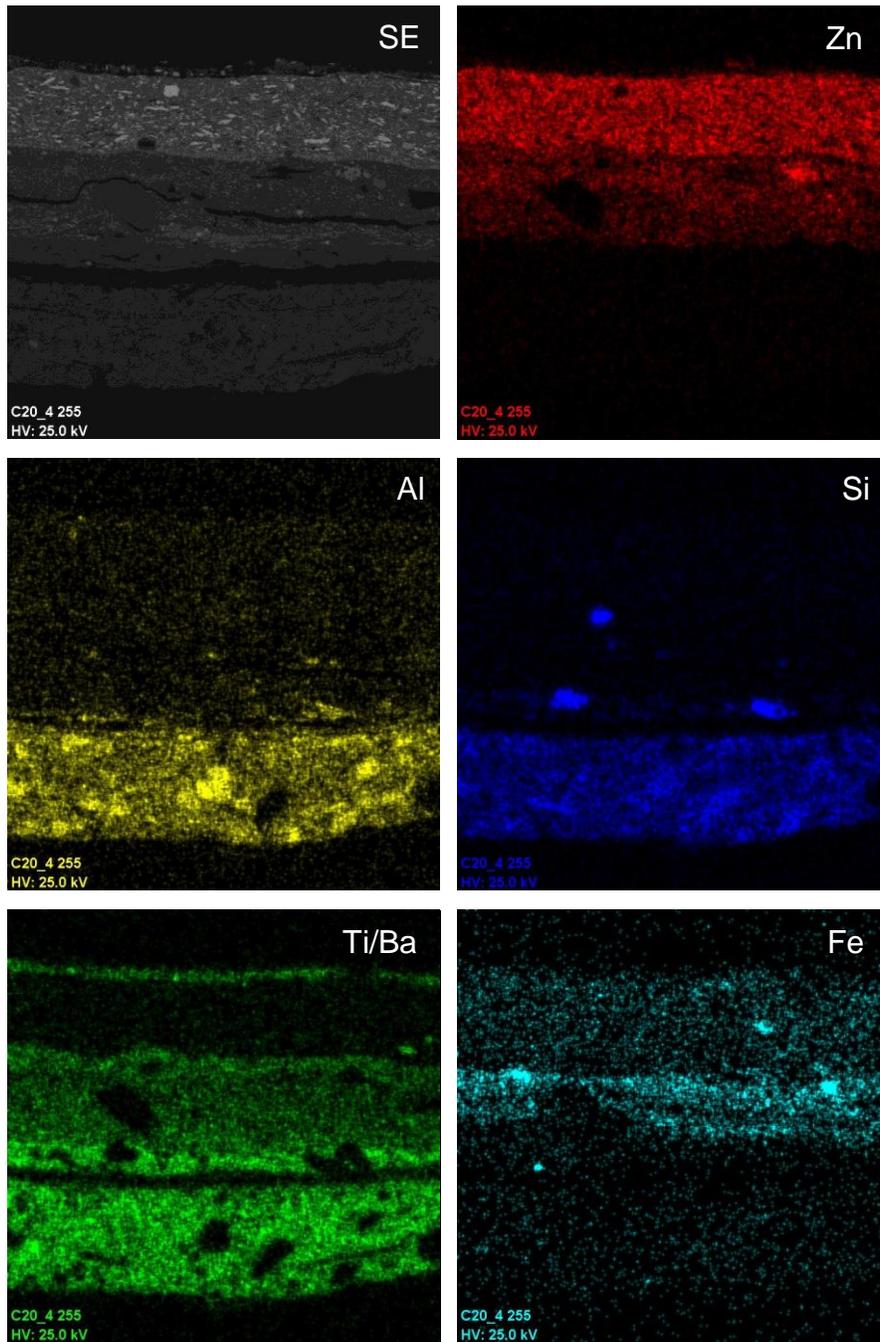


Fig. 16. SEM-EDX elemental mapping of zinc, aluminium, silicon, titanium/barium, and iron for sample 5, a cross section taken from the chest of the figure.

* Titanium and Barium could not be clearly distinguished when mapping because of their overlapping peaks. The ground layer is principally composed of Titanium white, and aluminosilicates; however, further scans and spot mapping clearly show the presence of round barium and sulphur containing particles (Likely BaSO₄) in the upper layers

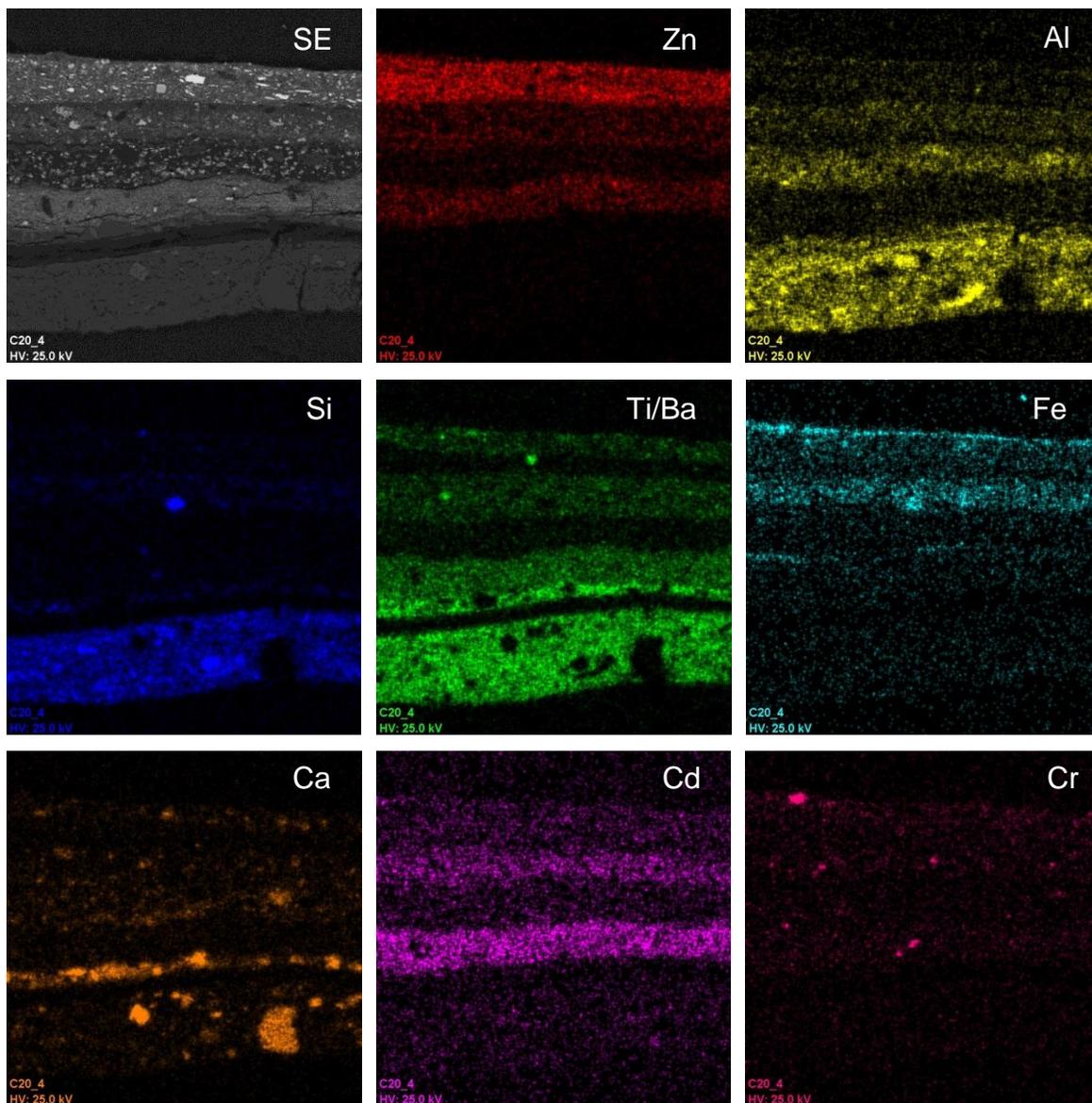


Fig. 17. SEM-EDX elemental mapping of zinc, aluminium, silicon, titanium/barium* iron, calcium, cadmium, and chromium for sample 6, a cross section from the tan coloured cat in the bottom left quadrant.

* Titanium and Barium could not be clearly distinguished when mapping because of their overlapping peaks. The ground layer is principally composed of Titanium white, and aluminosilicates; however, further scans and spot mapping clearly show the presence of round barium and sulphur containing particles (Likely BaSO_4) in the upper layers

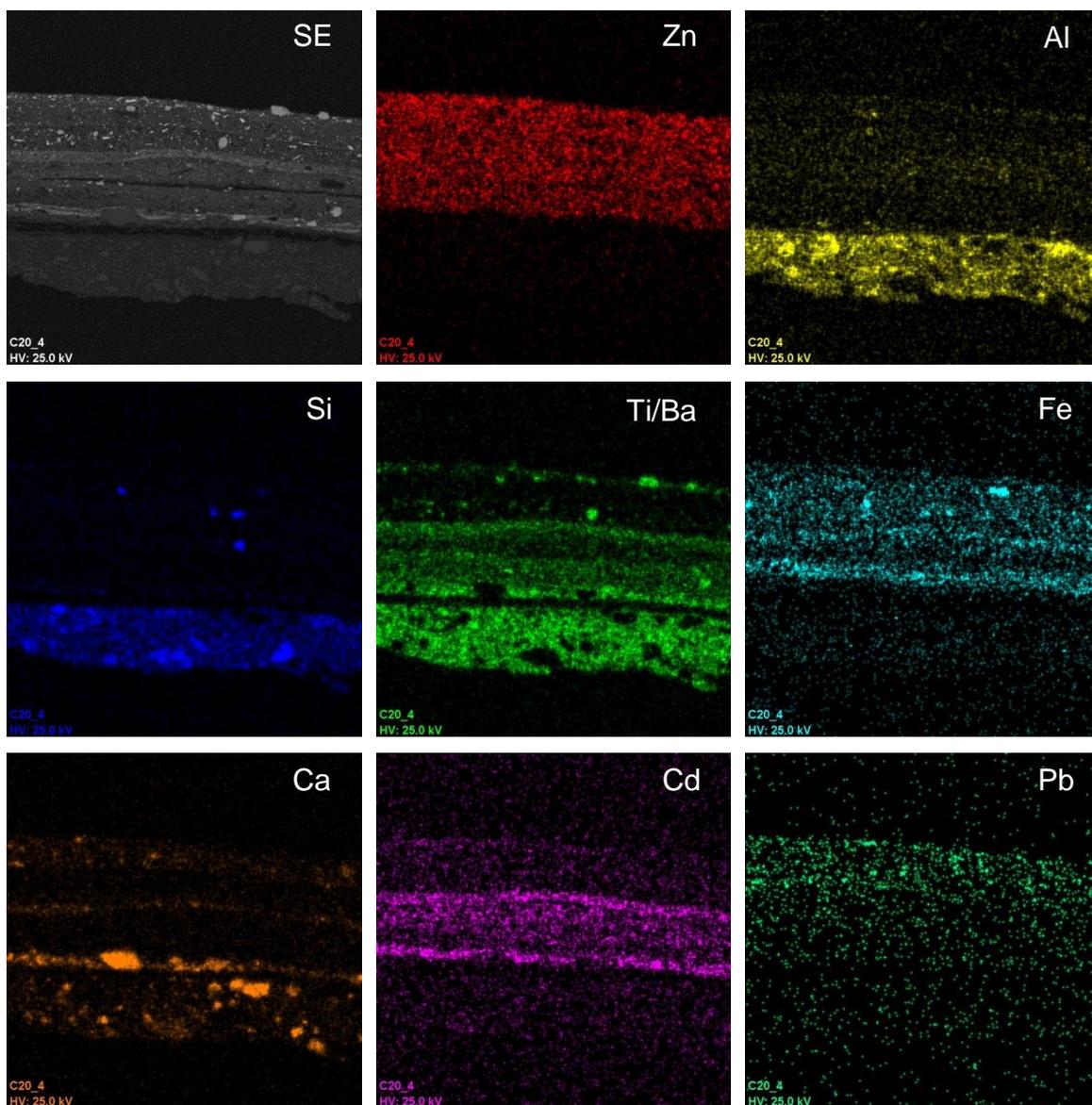


Fig. 18. SEM-EDX Elemental Mapping of Zinc, Aluminium, Silicon, Titanium/Barium*, Iron, Calcium, Cadmium and Lead for sample 7, a cross section taken from the green background.

* Titanium and Barium could not be clearly distinguished when mapping because of their overlapping peaks. The ground layer is principally composed of Titanium white, and aluminosilicates; however, further scans and spot mapping clearly show the presence of round barium and sulphur containing particles (Likely BaSO_4) in the upper layers