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Results of a technical study of twelve oil-on-canvas portraits by Louis Dulongpré are presented. Close visual examination was followed by technical photography and X-radiography. The composition and stratigraphy of the paint and ground layers were determined through the analysis of microscopic samples. Sample analysis was undertaken using a multi-instrumental approach. Primary methods were scanning electron microscopy/energy dispersive X-ray spectrometry (SEM/EDS), Fourier transform infrared (FTIR) and Raman spectroscopy, and polarized light microscopy (PLM). In some cases, X-ray diffraction (XRD), gas chromatography/mass spectrometry (GC-MS) and/or pyrolysis-gas chromatography-mass spectrometry (Py-GC-MS) were also undertaken. The earliest work in the study is a signed and dated portrait of Isaac Todd from 1800, while the latest paintings studied are portraits of Joseph Papineau, Jean Dessaulles and Antoine Girouard, dating from circa *1825–1826. Overall trends in painting materials and techniques are discussed as well as some notable changes in materials over the chronological period covered by the study group. Connections among some of the paintings in the study group were made by combining information from visual examination with results from scientific analysis.*

Les résultats d'une étude technique de douze huiles sur toile de Louis Dulongpré sont présentés. Chaque œuvre a reçu un examen visuel détaillé ainsi qu'une prise de photos techniques et de radiographie. La composition et la stratigraphie des couches de préparation et des couches picturales ont été déterminées en analysant des échantillons microscopiques. L'analyse a été entreprise avec une approche multianalytique. Les méthodes principales utilisées sont la microscopie électronique à balayage couplée à la spectrométrie des rayons X (MEB/SRX), la spectroscopie infrarouge à transformée de Fourier (IRTF), la spectroscopie Raman et la microscopie en lumière polarisée (MLP). Dans certains cas, la diffraction des rayons X (DRX), la chromatographie gazeuse couplée à la spectrométrie de masse (CG-SM) et/ou la pyrolyse suivie de la chromatographie gazeuse couplée à la spectrométrie de masse (Py-CG-SM) ont été également utilisées. Le tableau le plus ancien faisant partie du projet est un portrait d'Isaac Todd, datant de 1800, tandis que les plus récentes sont des portraits de Joseph Papineau, Jean Dessaulles et Antoine Girouard, datant d'environ 1825–1826. Des tendances générales des matériaux et techniques sont discutées, ainsi que quelques changements notables dans les matériaux utilisés au cours de la période étudiée. Des relations entre certains tableaux étudiés ont été établies en combinant l'information des examens visuels avec les résultats des analyses scientifiques.

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INTRODUCTION

Louis Dulongpré: His Career in Brief

Nineteenth-century Quebec artist Louis Dulongpré (1759–1843) was born in Saint-Denis, near Paris, and first arrived in North America as a French soldier during the American War of Independence. He subsequently moved to Montreal in 1784 and quickly became active in the cultural community. He initially taught music lessons, and, as one of the founders of the Théâtre de Société, worked as a stage manager and also designed and painted stage sets.[1] With natural artistic talent, and perhaps encouraged by the success of François Beaucourt,[2] Dulongpré decided to travel to the United States in 1793 to train in drawing and painting. In 1794, he returned to Montreal with the intent to work as an artist.[1,3] He initially produced primarily pastel portraits and, from about 1800 onwards, oil paintings.[1,3]

During the period from 1800 to 1826, he undertook many commissioned paintings. A well-known portraitist and man of tradition and culture, he became friends with prominent families of the day, such as the Vigers, the Papineaus and the Dessaulles.[3] In addition to portraits, he also produced numerous works for church decoration, both in the Montreal area and farther afield, in Saint-Jean-Port-Joli and Rivière-Ouelle, for example.[1]

Dulongpré was acquainted with other professional artists around Montreal and Quebec. In a 1799 journal entry, François Baillairgé describes selling a "demiard" (half pint) of oil to his "rival in painting Sir Dulongpré."[4] During the period from 1802 to 1807, Dulongpré engaged Joseph Morland as an apprentice.[1,5] Correspondence indicates that Dulongpré was also on friendly terms with William Berczy and met him several times around 1808.[1,6]

Although he had a successful career as an artist, financial hardship marked the end of Dulongpré's life, and by 1837 he was bankrupt. He was taken in by Rosalie Papineau-Dessaulles and died in the Dessaulles manor house in Saint-Hyacinthe in 1843.[1,7] Dulongpré was a prolific painter; according to his obituaries, he is thought to have created over 3,000 portraits in oil and pastel.[1,3] However, today, only a very small fraction of these works have been definitively attributed to him. Attributions to Dulongpré are often problematic; he rarely signed or dated his paintings and, adding to the complexity, he made multiple versions of some of his works.[1,3] Attributions are also hindered by the fact that Dulongpré's paintings are stylistically uneven.[1,3]

Context and Scope of the Study

A research project to document Louis Dulongpré's materials and techniques for a selected group of oil paintings was undertaken at the Canadian Conservation Institute (CCI). Due to the difficulty in confirming attributions to Dulongpré, one

of the goals of the project was to gather technical and material evidence that could assist in such investigations. Another goal was to collect information that could shed light on conservation issues observed in Dulongpré's works and inform future treatments of his paintings. In fact, the project was initiated in the context of the conservation treatment at CCI of an oil on canvas portrait of Jean Dessaulles that showed severe cracking, related to a problematic starch-based ground layer.[8] At that time, little was known about the artist's materials and techniques.

The research project included the examination of eighteen oil paintings: twelve portraits and six paintings depicting religious subjects. The choice of paintings in the study was informed by previous research on the artist[1,3,9,10] and was undertaken after consultation with curators and conservators. Works were chosen that were accessible for sampling and examination, had a relatively firm attribution to Dulongpré and represented different periods in his oil painting career. Paintings that were signed, inscribed or had associated supporting documentation were prioritized. As well, paintings where multiple versions exist were included with the aim of comparing their materials and techniques. While the number of paintings examined is obviously small compared to Dulongpré's overall oeuvre, we hope that this study will be a starting point for future investigations.

The present paper describes the results for the twelve oil on canvas portraits that were studied. Overall trends are discussed, and some notable differences in materials and techniques among the study group are highlighted. Connections and comparisons among some of the portraits are also presented. The results from the analysis of six paintings of religious subjects will be the subject of a future publication.

PORTRAITS INCLUDED IN THE STUDY

The twelve portraits examined are listed in **Table I** and illustrated in **Figure 1**. The paintings were divided into three groups: (1) early oil portraits, 1800 to *circa* 1818; (2) portraits of Joseph Papineau, 1825; and (3) portraits of Jean Dessaulles and Antoine Girouard (c. 1825–1826).

Early Oil Portraits (1800 to *circa* 1818)

The earliest painting in the study, a likeness of Isaac Todd (**Figure 1a**) in the collection of the Musée national des beaux-arts du Québec (MNBAQ), is one of the few paintings by Dulongpré that is signed and dated. **Figure 2** is an infra-red photographic detail of the signature, which reads "L. Dulongpré Pinxit 1800". The date is difficult to read in normal lighting and has been listed incorrectly as 1806 in a number of early sources. It was originally thought that the subject of this portrait was James McGill, but the sitter is now recognized as Isaac Todd, a friend and associate of McGill at the North West Company.[10]

A portrait known to portray James McGill (**Figure 1b**) is in the collection of the McCord Museum. As described by Derome,[10] the image of McGill in this oil on canvas painting is virtually identical to that of an engraving on copper dating from the second half of the nineteenth century. An inscription on the engraving states that it is a copy of an original portrait of James McGill by Louis Dulongpré housed at McGill University. The connection with the engraving, along with associated correspondence, provides strong evidence that the painting in the McCord collection is by Dulongpré. Although the portrait is not signed or dated, it is thought to have been painted prior to McGill's death in 1813.[10]

Table I. Portraits included in the study.

Portrait	Date	Institution	Accession number
Isaac Todd	1800	Musée national des beaux-arts du Québec (MNBAQ)	56.299
James McGill	c. 1800–1813	McCord Museum (McCord)	M970X.106
James Sinclair	1808	Royal Ontario Museum (ROM)	962.260
Abbé Boissonnault	1810	Musée national des beaux-arts du Québec (MNBAQ)	A-68 150P
Thomas McCord	c. 1816	McCord Museum (McCord)	M8354
Sarah Solomon	c. 1818	McCord Museum (McCord)	M8355
Joseph Papineau	1825	Library and Archives Canada (LAC)	1978-39-8
Joseph Papineau	1825	Montreal Museum of Fine Arts (MMFA, gift of the Gustave J. Papineau family)	2008.87
Joseph Papineau	1825	National Gallery of Canada (NGC)	18022
Jean Dessaulles	c. 1825	National Gallery of Canada (NGC)	18039
Jean Dessaulles	c. 1825	Centre d'archives du séminaire de Saint-Hyacinthe (SSH)	e.2000.1571
Antoine Girouard	1826	Centre d'archives du séminaire de Saint-Hyacinthe (SSH)	e.2000.2046

Figure 1. Images of the twelve portraits in the study, shown approximately to scale. Top row: (a) Isaac Todd, (b) James McGill, (c) James Sinclair, (d) Abbé Boissonnault. Second row: (e) Thomas McCord, (f) Sarah Solomon, (g) Joseph Papineau (LAC), (h) Joseph Papineau (MMFA). Bottom row: (i) Joseph Papineau (NGC), (j) Jean Dessaulles (NGC), (k) Jean Dessaulles (SSH), (l) Antoine Girouard. All photographs are © Government of Canada, Canadian Conservation Institute, except for Joseph Papineau (MMFA), courtesy of The Montreal Museum of Fine Arts; Joseph Papineau (NGC) and Jean Dessaulles (NGC), both © National Gallery of Canada, Ottawa. Accession numbers for the paintings are listed in Table I and dimensions are listed in Table II.

A portrait of James Sinclair (**Figure 1c**), a British military officer who lived in Trois-Rivières, is in the collection of the Royal Ontario Museum (ROM). There are four original documents pasted to its verso, including a handwritten autobiography, dated 1808 and signed by Sinclair. This autobiography provides direct evidence that the painting is by Dulongpré, stating: "On the other Side, is the Portrait of James Sinclair Esqr, now in his 76 year of age, _ done by Louis Dulongpré Esqr. Master Limner in all Canada."

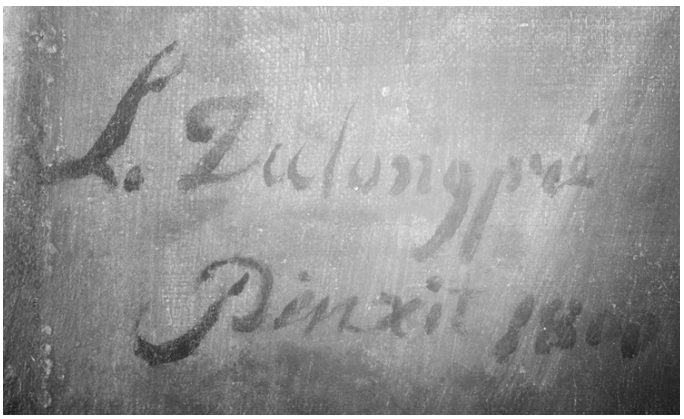

Figure 2. Detail of bottom left corner, infrared photograph of portrait of Isaac Todd showing the signature and date. Photo: © Government of Canada, Canadian Conservation Institute.

A portrait of Abbé Boissonnault (**Figure 1d**) is dated to 1810 by an inscription, possibly by Boissonnault himself, on the back of the canvas[11] which reads: "J. F^{rs}. Boissonnault, P^{tre}. Curé de S^{t}. Pierre de Sorel peint le 25 Janvier 1810 à l'âge de 64 ans 23 jours par M. Ls. Dulongpré Montréal." Boissonnault was the curate of Saint-Pierre-de-Sorel and Île Dupas between 1806 and 1814 and curate of Saint-Jean-Port-Joli from 1814 to 1843.[3] The portrait was discovered in Saint-Jean-Port-Joli and purchased by the MNBAQ.[3]

Portraits of Thomas McCord (**Figure 1e**) and his wife Sarah Solomon (**Figure 1f**) were brought into the collection of the McCord Museum through its founder David Ross McCord (grandson of Thomas McCord). Although there has been some question about their provenance, curatorial and historical research provides evidence to support an attribution to Dulongpré.[1] The McCord collection holds two receipts made out to Thomas McCord for paintings by Louis Dulongpré; one receipt specifies a portrait of Thomas McCord, paid in 1816, while the second receipt, for a half-figure portrait paid in 1818, is perhaps for the portrait of Sarah Solomon.[1] Both portraits are believed to be copies made by Dulongpré from Irish or English originals.[1]

Portraits of Joseph Papineau (1825)

In 1825, Dulongpré painted four versions of a portrait of Joseph Papineau, an important seigneur and political figure in Lower Canada.[1,3,9] Because Papineau was an unwilling sitter, his son, Louis-Joseph, arranged for Dulongpré to visit his father several times, ostensibly to play board games but, in fact, to study his father's features. Dulongpré would quickly return to his studio afterwards to paint from memory. According to correspondence, Louis-Joseph deemed this approach successful and ordered four portraits, of which one was advanced enough to present to his father in April 1825.[1] An extant receipt suggests that all four were completed by June of the same year.[1,3,9]

Three versions of the Papineau portrait are currently known (**Figures 1g**, **1h** and **1i**); they are in the collections of the National Gallery of Canada (NGC), Library and Archives Canada (LAC) and the Montreal Museum of Fine Arts (MMFA) and were all acquired through descendants of the Papineau or Dessaulles family.[1,3,9,12,13]

Portraits of Jean Dessaulles and Antoine Girouard (*circa* 1825–1826)

Jean Dessaulles was the seigneur of Saint-Hyacinthe and benefactor of the local seminary. He was connected to the Papineau family through his marriage to Joseph Papineau's daughter Rosalie.[14] Louis Dulongpré was a family friend of the Dessaulles and the Papineaus, and he is known to have painted Jean Dessaulles' portrait in Saint-Hyacinthe.[15] There are two known oil portraits of Dessaulles by Dulongpré (**Figures 1j** and **1k**), one in the collection of the NGC and the other in the collection of the Centre d'archives du Séminaire de Saint-Hyacinthe (SSH). The NGC portrait depicts Dessaulles with his hand resting on a letter addressed to F. Burton, Quebec. Sir Francis Nathaniel Burton, lieutenant governor of Lower Canada from 1808 to 1832, resided in Quebec from 1824 to 1825; the portrait of Dessaulles is thought to have been painted by Dulongpré around this time.[16,17] In the SSH portrait of Dessaulles, the sitter faces in the opposite direction, and, instead of a letter, Dessaulles' hand rests on a map of the seigneury of Saint-Hyacinthe, with the seminary (built between 1810 and 1816) visible. This version of the portrait is also thought to have been painted around 1825.[16]

Another portrait by Dulongpré in the collection of the Centre d'archives du Séminaire de Saint-Hyacinthe depicts Antoine Girouard (**Figure 1l**), curate, founder of the Saint-Hyacinthe seminary and friend of Jean Dessaulles.[14,18] The portrait of Girouard shows his hand resting on an architectural plan of the seminary at Saint-Hyacinthe. Based on historic documents from the college, Girouard, although initially hesitant to pose, eventually agreed to have his portrait painted by Dulongpré, and it was presented to him in 1826.[14,18]

METHODS

The research project involved a non-invasive technical examination of each portrait, followed by sampling and scientific analysis of the painting materials. While certain paintings were sent to CCI for examination, most were examined on site in the various participating institutions.

The technical study included close visual examination,[19] as well as infrared photography, ultraviolet photography and X-radiography when possible. Since most paintings had been treated at the time of the examination, the conservation and curatorial files were also examined; they provided useful information about the pre-treatment condition of the works.

Microscopic samples of paint, ground and canvas fibres were removed from each work. Approximately 10–15 samples from each painting were analyzed, for a total of 154 samples. This included samples of the main colours on each painting as well as cross-sections to determine the stratigraphy. The primary methods used to identify the pigments, fillers and binding medium were: scanning electron microscopy/energy

dispersive X-ray spectrometry (SEM/EDS), Fourier transform infrared (FTIR) spectroscopy, Raman spectroscopy and polarized light microscopy (PLM). In some cases, X-ray diffraction (XRD), gas chromatography/mass spectrometry (GC-MS) or pyrolysis-gas chromatography-mass spectrometry (Py-GC-MS) were also undertaken. Details are provided in the **Appendix**.

RESULTS AND DISCUSSION

Dimensions, Auxiliary Supports and Canvases

The key information about the dimensions, the auxiliary supports and the characteristics of the canvas for the twelve portraits is summarized in **Table II** and discussed below.

Dimensions

Although the dimensions of the portraits vary, some are of similar size. Among the early works, the portraits of Isaac Todd and James McGill are of very similar dimensions. The three versions of Joseph Papineau and the NGC version of the portrait of Jean Dessaulles are all approximately 24 x 30 inches, a common British stretcher size for portraits.[20] The two works from the Séminaire de Saint-Hyacinthe (Jean Dessaulles and Antoine Girouard) are larger, measuring approximately 28 x 36 inches, another common British stretcher size.[20]

Auxiliary Supports

An early, likely original, auxiliary support was present, or was described in the conservation dossiers, for five of the twelve portraits. The strainer used for the portrait of James Sinclair has square cut, half-lap and pin joints with small, rectangular-shaped, curved nails through the corner joints (**Figures 3a** and **3b**). The original stretchers for the NGC and MMFA Papineau portraits are both 1-key stretchers, with lap or mortise and tenon joints, joined with an unusual oblique cut (**Figures 3c** and **3d**). The stretchers for the two portraits of Jean Dessaulles are similar to each other, both with square cut mortise and tenon corner joints (**Figures 3e** and **3f**).[21] The stretcher bars are thinner on the NGC version of Dessaulles, not unexpected given the painting's slightly smaller size. The tacks used to attach the canvas to the auxiliary support for the early strainers/stretchers appear to be hand-wrought. For some works, the tack heads are round to oblong while others are square to rectangular in shape.

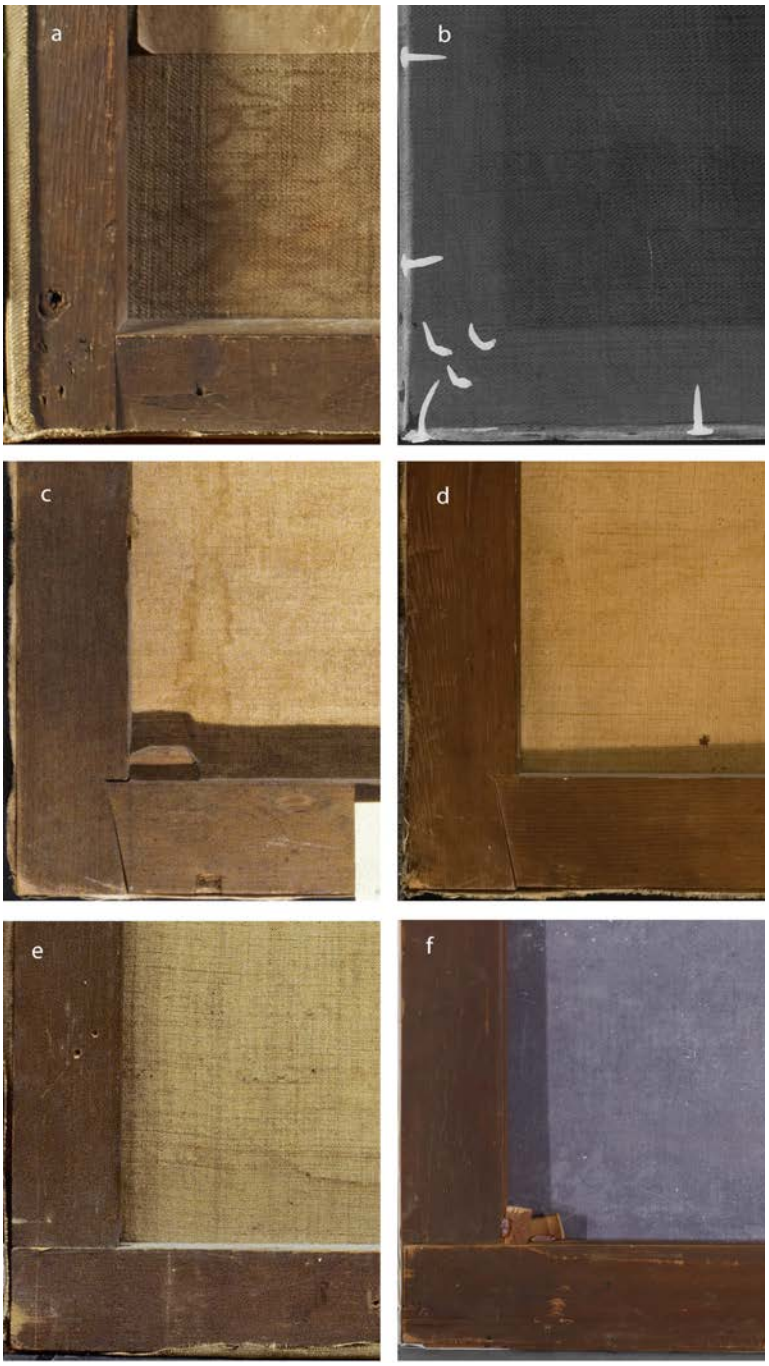

Figure 3. Details of early auxiliary supports: (a) strainer for James Sinclair, (b) strainer for James Sinclair, X-radiograph, (c) stretcher for NGC version of Joseph Papineau, (d) stretcher for MMFA version of Joseph Papineau, (e) stretcher for NGC version of Jean Dessaulles, (f) stretcher for SSH version of Jean Dessaulles. Photos: © Government of Canada, Canadian Conservation Institute, except Figure 3e, © Conservation and Technical Research, National Gallery of Canada, Ottawa.

Canvases

Most canvases are plain weave and of a light to medium weight. All canvases where fibre identification was carried out were found to be bast, with microscopic characteristics consistent with linen. The threads vary in thickness and have irregular slubs, giving a typical texture marked by horizontal and vertical striations. Two of the early paintings, the portraits of James Sinclair and Thomas McCord, are on a twill weave canvas. The canvas for the portrait of Thomas McCord is of particular note as it was determined to

Table II. Key observations: dimensions, support and ground.

	Early Portraits (1800 to *circa* 1818)					
Painting	Isaac Todd	James McGill	James Sinclair	Abbé Boissonnault	Thomas McCord	Sarah Soloman
Date	1800	c. 1800–1813	1808	1810	c. 1816	c. 1818
Dimensions (W x H)	68.7 x 85.2 cm 27.0 x 33.5 in.	67.8 x 83.8 cm 26.7 x 33.0 in.	56.5 x 69.4 cm 22.2 x 27.3 in.	55.1 x 67.3 cm 21.7 x 26.5 in.	65.8 x 77.6 cm 25.9 x 30.6 in.	61.3 x 73.5 cm 24.1 x 28.9 in.
Original stretcher	--	--	Square cut, lap joint strainer, 3 metal nails	--	--	--
Canvas weave	plain	plain	twill	plain	twill (striped)	plain
Canvas type	linen	linen	linen	linen	linen	linen
Thread count (per cm)[23]	16V x 14H	16V x 16H	18V x 18H	17 x 13	32V x 22H	14V x 12H
Selvages	possibly top and bottom	--	none noted	--	--	--
Sizing*	starch, protein	--	--	--	protein	--
Ground: application	tacking margins not covered	tacking margins cut; garland, all edges	tacking margins covered, 3 sides; garland, top edge	tacking margins covered; slight garland, top and bottom edges	tacking margins not covered[24]	tacking margins cut; garland, bottom edge and slight garland, left edge
Ground: x-radiography	--	broad, overlapping strokes	even density	even density[23]	broad, overlapping strokes	even density
Ground: colour and stratigraphy	red, single application	red, single application	white, single application	white, two applications	white, single application	variable: single pink or white, pink followed by white
Ground: composition*	lead white, chalk, red iron oxide, minor barium sulfate, (yellow iron oxide, brown and black)	lead white, chalk, red iron oxide, silicates, quartz, minor barium sulfate	lead white, chalk	lead white, chalk	lead white, chalk, (red iron oxide)	lead white, chalk, red iron oxide, probably barium sulfate
First colouring	grey and beige	black	black, light brown and pale pink	possibly beige	none observed	black

*Compounds present in trace amounts are in parentheses.

be a patterned twill fabric, with alternating thick and thin blue stripes, reminiscent of mattress ticking.[22] Because the painting is lined, the striped pattern, created by dark vertical threads, was visible only where the original canvas was exposed at the top and bottom edges of the portrait.

As shown in **Table II**, the thread counts are variable among the twelve canvases.[23] However, certain canvases showed marked similarities. The NGC and MMFA versions of the Papineau portrait are very similar in weave, weight and thread count and may be the same fabric. Taking into account slight differences in thread count, which could be due to the limitations of measuring on tacking margins and on lined paintings, the canvases for the portraits of Isaac Todd and James McGill are likewise very similar to one another. The canvases for the two paintings from Saint-Hyacinthe, Jean Dessaulles and Antoine Girouard, are also alike in appearance and thread count.

On the paintings where the tacking margins of the canvas were preserved, selvages were often hard to discern, particularly when the works had been lined. As shown in **Table II**, among the five portraits where selvages were noted, they were found to be inconsistent in placement. Only the NGC version of Dessaulles had clear selvages on two edges (left and right), indicating that the warp runs vertically and

…continued from facing page

Joseph Papineau Portraits			Jean Dessaulles and Antoine Girouard Portraits		
Papineau (LAC)	Papineau (MMFA)	Papineau (NGC)	Dessaulles (NGC)	Dessaulles (SSH)	Antoine Girouard
c. 1825	c. 1825	c. 1825	c. 1825	c. 1825	c. 1826
61.8 x 76.8 cm 24.3 x 30.2 in.	60.4 x 76.4 cm 23.8 x 30.1 in.	61.4 x 76.4 cm 24.2 x 30.1 in.	61.5 x 74.5 cm 24.2 x 29.3 in.	70.4 x 90.0 cm 27.7 x 35.4 in.	71.0 x 91.0 cm 28.0 x 35.8 in.
--	oblique cut, lap or mortise and tenon, 1 key	oblique cut, lap or mortise and tenon, 1 key	butt joint, mortise and tenon, open slots	butt joint, mortise and tenon, 2 keys	--
plain	plain	plain	plain	plain	plain
--	linen	linen	linen	--	--
20V x 17H	14V x 14H	15V x 15H	14V x 14H	15V x 16H	15V x 17H
possibly left edge	top edge	top edge	left and right edges	--	--
starch, protein	starch, protein, (oil, bone black)	starch protein	starch, protein	starch, protein, oil, gypsum, red iron oxide[§]	starch
tacking margins not covered	tacking margins not covered	tacking margins not covered	tacking margins not covered	tacking margins covered; slight garland, all edges	tacking margins cut; garland, all edges
broad, overlapping strokes	even density	a few broad strokes	some diagonal strokes, finer than seen on other paintings	some broad overlapping strokes	no x-ray, but broad sweeping brushstrokes in specular light
pink, single application	off-white, single application	off-white, single application	pale grey to beige, single application	pink followed by light pink	pale grey to beige, single application
lead white, calcium carbonate, red iron oxide, quartz, minor barium sulfate, (brown to black pigment)	lead white, calcium carbonate, small amounts red iron oxide, carbon-based black pigment	lead white, calcium carbonate, small amounts red and yellow iron oxide, (black)	lead white, calcium carbonate, small amounts carbon-based black, yellow iron oxide	lead white, calcium carbonate, small amounts red iron oxide, barium sulfate	lead white, calcium carbonate, small amounts iron oxide pigments, vermilion, charcoal black, Prussian blue
beige, brown and white	beige and brown	beige, grey and possibly pink	none observed	possibly grey-green	none observed

[§]Because this layer is directly on the canvas and is based on a starch-protein mixture, it has been included in the entry on "sizing." However, its thickness and colour are unusual for a size layer and it is perhaps better described as an initial, starch-based ground layer.

that the width of the bolt of canvas would have been approximately 25 to 26 inches. A single selvage was observed on the top edge of both the MMFA and NGC versions of Joseph Papineau, indicating that, for these two canvases, the warp runs horizontally.

Sizing

For most paintings, it was not possible to discern the presence of a size through visual examination. However, in the case of the MMFA version of Joseph Papineau, which had not been treated, there were indications that the canvas had been sized; it was noted that the fibres of the threads were held firmly in place and that the reverse of the canvas was stiffer to the touch than the fabric along the tacking margins.

For seven of the twelve paintings, it was possible to identify a size layer in the cross-sections. The size layers were transparent, thin (on the order of 20 micrometres thick) and unpigmented. They functioned to seal the canvas prior to applying the ground. As shown in **Table II**, the size layers were identified as starch, protein or, most often, a mixture of starch and protein.

The SSH version of the portrait of Jean Dessaulles is an exception. On this painting, a thick, dark pink, highly pigmented layer has been applied directly on the canvas. The medium is composed of starch, protein and a small amount of drying oil. It is pigmented with gypsum and red iron oxide. As described in a previous publication, a large quantity of undissolved starch grains was observed in this layer, indicating that the starch was not sufficiently heated to form a paste and explaining its granular, friable texture.[8] This pigmented starch-based layer is about 200 micrometres thick – much thicker than a typical size layer. Because this layer is directly on the canvas and is based on a starch-protein mixture, it has been included in **Table II** in the entry on "sizing." However, its thickness and colour are unusual for a size layer and it is perhaps better described as an initial, starch-based ground layer. This layer, with its unusual composition and lack of cohesion, has led to the cracking and flaking paint in this portrait.[8]

Ground Layers

There was considerable variability in the application method, colour, composition and stratigraphy of the ground layers among the twelve portraits. Some of the key observations that allowed comparison of the ground layers among the portraits are listed in **Table II** and described below.

Application Method

On eight of the twelve portraits, there is evidence that the canvas was cut to size, attached to a stretcher or strainer, and that the ground layer was then applied to the stretched canvas. In six works, this is based on the fact that the ground layers did not extend onto the tacking margins.[24] For two other paintings, although the tacking margins had been cut during a previous conservation treatment, tension garlanding on all four edges is consistent with the ground being applied with the canvas stretched on its auxiliary support or one of similar dimension to the finished work.

While this seems typical of Dulongpré's practice, there are exceptions; on three of the portraits, the ground layers extend to the limits of the support fabric. In these cases, examination of tension garlands and tack holes, combined with the fact that the ground covers the tacking margins, suggests that the ground was likely applied to a larger piece of canvas, which was subsequently cut down and restretched onto the painting's auxiliary support. The ground layers cover all four tacking margins on the portrait of Abbé Boissonnault and on the SSH version of Jean Dessaulles. On the portrait of James Sinclair, although three tacking margins were covered by the ground, the top tacking margin is not. The X-radiograph of this painting shows slight garlanding at the top, unprimed margin, suggesting that the support for this painting was cut down on the left, right and bottom edges from a larger primed canvas. Although the tacking margins of the portrait of Sarah Solomon have been cut, the presence of only very slight to no tension garlanding suggests that the ground layer for this work may also have been applied on a larger piece of canvas that was cut down.

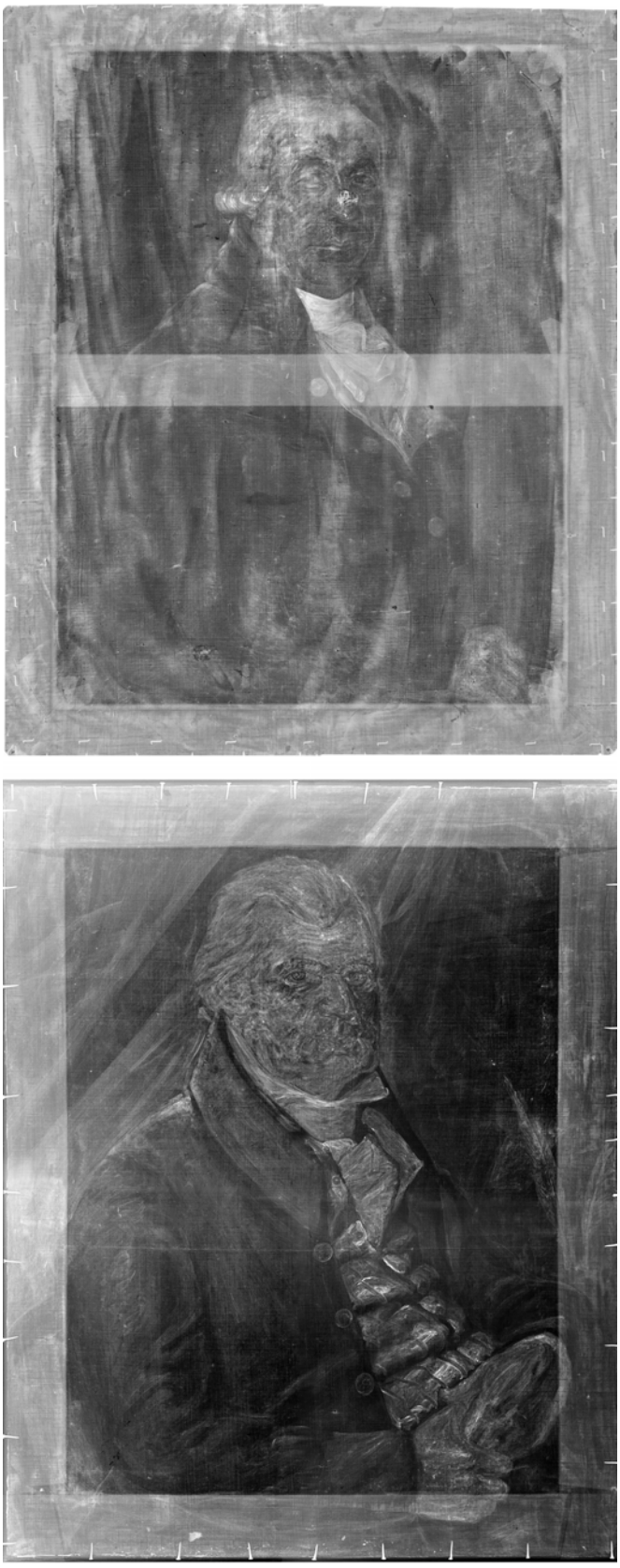

Figure 4. Top: X-radiograph of portrait of James McGill, showing ground applied with a spatula or similar tool. Photo: © Government of Canada, Canadian Conservation Institute. Bottom: X-radiograph of MMFA version of Joseph Papineau showing evenly applied ground. Photo: The Montreal Museum of Fine Arts.

Evidence from X-radiography suggests that the grounds for about half of the works were applied in broad strokes using a spatula or similar tool (**Figure 4 top**). The presence of these broad, multidirectional, overlapping strokes visible with X-radiography has been previously noted as typical of Dulongpré's method.[1] However, this is not a universal characteristic; evidence from X-radiographs of four of the portraits studied indicated an even, consistent layer of ground (**Figure 4 bottom**). As well as broad strokes suggesting spatula application of the ground, the LAC and NGC versions of the Papineau portrait showed underlying wide brushstrokes, possibly related to the presence of a first colouring or underlayer.

Colour

During visual examination, the presence of underlayers applied in specific areas of the design, as well as the presence of discoloured varnish and surface dirt, sometimes made determination of the colour of the ground difficult. For these reasons, cross-sections were essential to determine the colour and number of ground layers. The colours of the ground layers observed in the cross-sections are listed in **Table II** and illustrated in **Figure 5**. Of the twelve paintings studied, five have white or off-white grounds, two have pale grey grounds, and five have red or pink grounds. There was no chronological pattern to the use of coloured grounds versus white grounds nor were the ground colours in different versions of the same portrait always the same.

Composition

As shown in **Table II**, all of the grounds, whether coloured or white, are based on lead white and calcium carbonate[25] in drying oil, a typical composition for the early nineteenth century. Some of the cross-sections from paintings with white or off-white grounds showed a few scattered particles of iron oxide pigments or carbon-based black within the lead white-calcium carbonate matrix. The off-white grounds for the NGC and MMFA versions of Joseph Papineau include enough pigment particles to suggest that they were intentionally pigmented (**Figure 5a**). The pale grey ground of the NGC version of Jean Dessaulles is tinted with finely divided carbon-based black pigment and a small amount of yellow iron oxide. The pale grey ground for the portrait of Antoine Girouard has a warmer tone and contains a more complex mixture of pigments; particles of red iron oxide, vermilion, charcoal black and Prussian blue were identified (**Figure 5b**).

For all five portraits executed on red or pink grounds, the ground layers are coloured with red iron oxide pigments. The colour varies from red to pale pink, depending on the amount of pigment that was added (**Figures 5c–5f**). As well as lead white, calcium carbonate and red iron oxide, small amounts of brown to black pigments, silicates and barium sulfate were identified in the red and pink grounds. It is notable that barium sulfate, identified in all the red and pink grounds, was not found in any of the white, off-white or grey grounds.

Stratigraphy

In most cases, the ground layers are relatively thin, allowing the fine, but textured weave of the canvas to be visible on the painted surface. Examination of cross-sections revealed that although the ground was generally applied in a single layer, there were a few exceptions. The white ground for the portrait of Abbé Boissonnault was determined to have been applied in two layers (**Figure 5g**), and its thick, smooth appearance is unusual among the paintings examined. The preparation layers on the SSH version of Jean Dessaulles consist of two oil-based ground applications (pink followed by thin, light pink) on top of the dark-pink, starch-based layer described in the previous section (**Figure 5f**). The portrait of Sarah Solomon has a pink ground covered by a white ground in parts of the background (**Figure 5d**), while other areas showed a single application of either pink or white ground.

Underdrawing and Pentimenti

Although there was little evidence of extensive preparatory underdrawing, infrared photography and examination using the microscope did reveal a few sketch lines along the edge of forms in almost all paintings. The infrared photograph of the portrait of James McGill was remarkable in that it also showed a clear set of grid lines under the face of the sitter (**Figure 6**), possible evidence of a copying or enlarging technique.

Examination under normal light, combined with infrared photography, revealed slight changes in design (*pentimenti*) in about half of the portraits; these were generally small modifications to the contours of head, shoulders and to the size or placement of the fingers (**Figure 7**). In addition, a change in the position of the buttons was noted in the SSH version of Jean Dessaulles, and, in the portrait of Antoine Girouard, slight changes to the profile of the face and eyebrows and a small modification to the scroll were observed. Underlying brushstrokes not related to the finished design, as well as infrared photography, revealed a more significant change by the artist to the back of Sarah Solomon's dress. Overall, the relatively minor reworking or alteration of the design elements seems characteristic of Dulongpré's technique.

Painting Technique

While some of the portraits in the study have been extensively treated, others have undergone little restoration. These different levels of intervention, combined with the fact that it was not possible to examine the paintings side by side, made comparison of the painting technique among the portraits difficult. Despite this, certain typical aspects were noted.

Visual observation, combined with infrared photography and X-radiography, showed that Dulongpré typically applied his paint deliberately and efficiently with little reworking. It was usually applied in thin, smooth layers with only slight raised texture in some of the details. Paint in the torsos is thinly applied, wet-in-wet, and the forms and creases of the black coats of the male portraits are delineated with minimal, broad brushstrokes. More elaborate clothing details such as vests and sashes, or background details such as inkwells and quills, were applied in thin, fluid, spontaneous strokes, sometimes with glazes and simple application of highlights to give form to details such as ruffles.

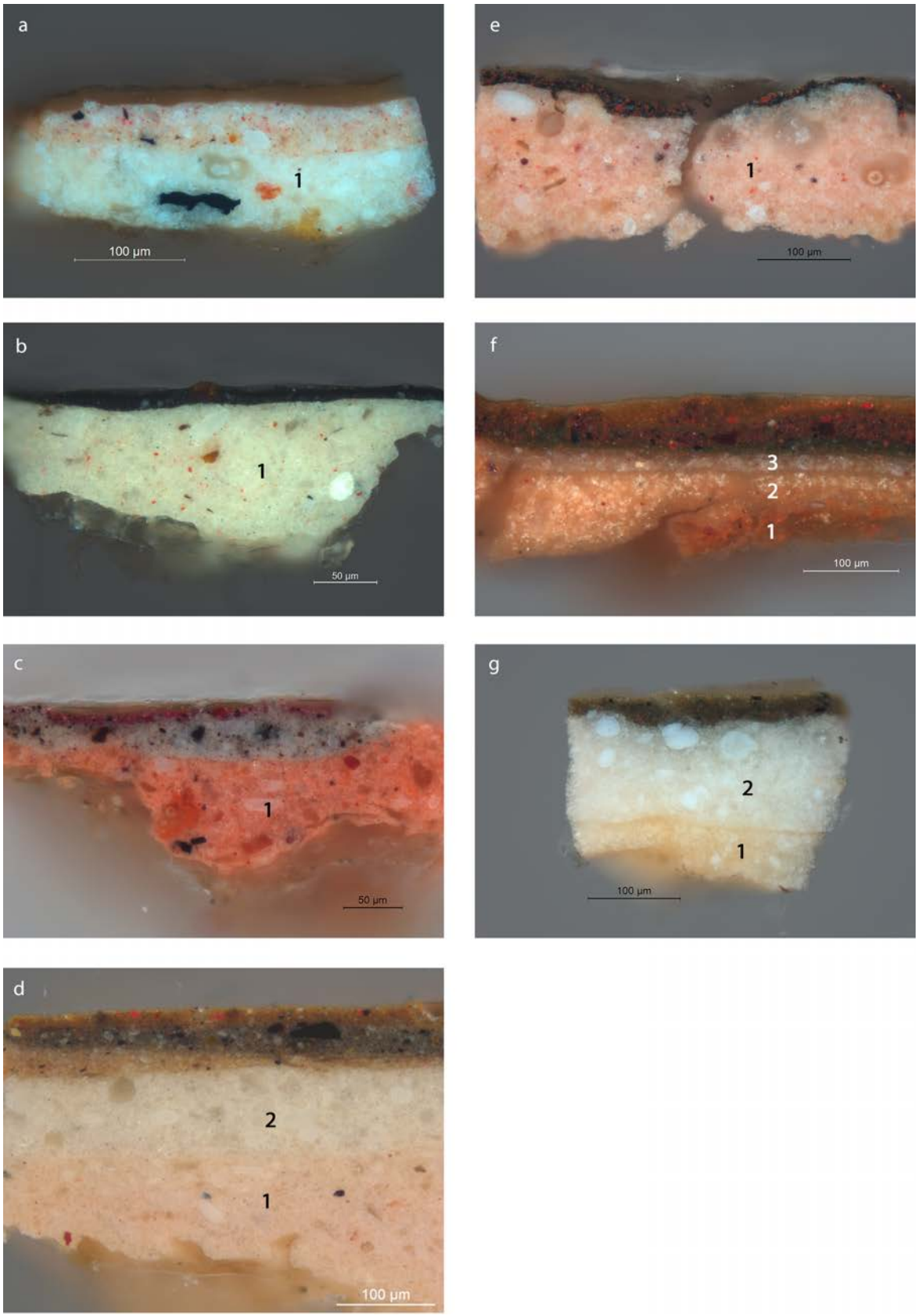

Figure 5. Selected cross-sections, showing the variety of colours of the ground layers. The ground layers are labelled with numbers, the paint and varnish layers are not labelled. a. MMFA version of Papineau, off-white ground (1); b. Antoine Girouard, warm grey ground (1); c. Isaac Todd, red ground (1); d. Sarah Solomon, pink ground (1) followed by white ground (2); e. LAC version of Papineau, pink ground (1); f. SSH version of Jean Dessaulles, dark-pink, starch-based preparation (1), followed by pink ground (2) and thin, light pink ground (3); g. Abbé Boissonnault, two layers of white ground (1 and 2). Photos: © Government of Canada, Canadian Conservation Institute.

Figure 6. Detail of the face, infrared photograph of portrait of James McGill showing grid lines. Photo: © Government of Canada, Canadian Conservation Institute.

Figure 7. Detail of a hand, infrared photograph of SSH version of Jean Dessaulles, showing change in the position of the fingers. Photo: © Government of Canada, Canadian Conservation Institute.

Many of the paintings showed first-colouring layers, sometimes referred to as dead colouring or first painting, an initial stage in painting. These thin, coloured layers are applied over the ground to block in specific design areas; the colours observed are listed in **Table II**. Light-coloured elements, such as architectural drawings and letters, were often left *en-reserve* within the background and blocked in with a pale underlayer to receive the image paint on top. Hands were also often blocked in with a pale first-colouring layer. The paint of the clothing was sometimes applied over a dark underlayer; for example, black first colouring was observed under the jacket of James McGill and under parts of Sarah Solomon's dress. Of the twelve portraits, the LAC version of Joseph Papineau showed the most extensive use of first colouring; beige, brown and white underlayers, in addition to the pink ground, were visible at the junction of forms and were also documented in cross-sections. Both ground layers and first-colouring layers provided undertones to the composition. For example, the red grounds in the portraits of Isaac Todd and James McGill provide a reddish undertone to the image in a number of areas.

The heads of the sitters are always painted in a space left *en-reserve* within the background. Where noted, this was also true for the torsos and hands. The slight change in the size and position of the head in the LAC Papineau portrait and the reworking in the thicker paint around the head of Sinclair show the artist making slight alterations as he worked to obtain the sitter's likeness. Design areas, such as the head, torso and background, often butt up against one another. In most cases, there is minimal overlapping or blending along the edges of forms. The portrait of Sarah Solomon, however, is an exception, as much of the application along the edge of forms is wet-in-wet.

The amount of modelling and blending of paint in the faces was variable among the twelve portraits. The portraits of Sarah Solomon (**Figure 8 left**) and Thomas McCord show the most blended, delicate rendering of the facial features. It is possible that the stylistic differences in these portraits compared to the others are a result of them being copies of English or Irish originals. Other paintings, for example the

Figure 8. Details of the face, normal light, from left to right: Sarah Solomon, Antoine Girouard, Joseph Papineau (LAC version). Photos: © Government of Canada, Canadian Conservation Institute.

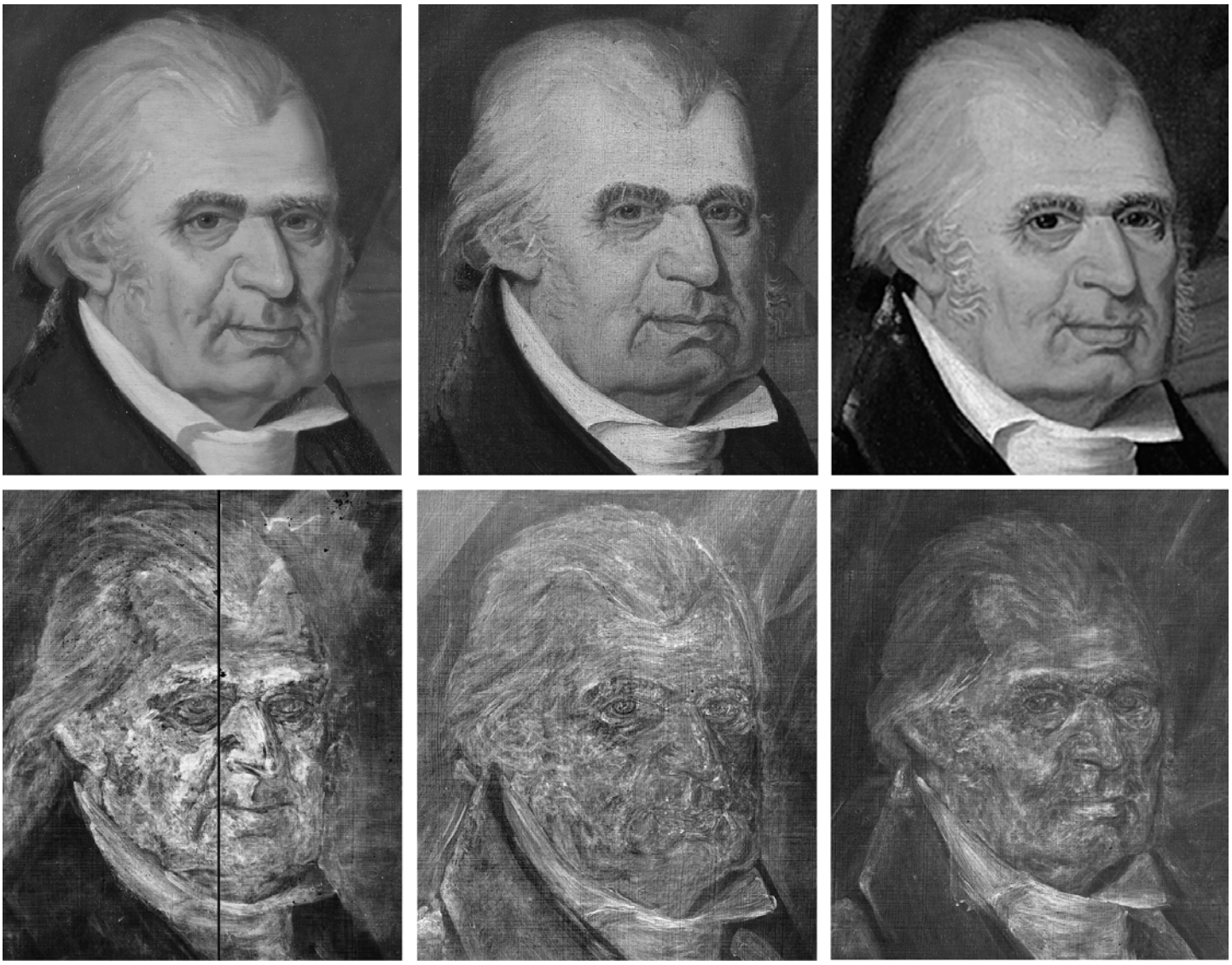

Figure 9. Details of the face, normal light (top) and X-radiograph (bottom), for three versions of Joseph Papineau: LAC version (left), MMFA version (centre), NGC version (right). The normal light photographs are reproduced in black and white to facilitate comparison, since the colour is variable due to varnish, level of conservation intervention and photographic conditions. Photos: left, © Library and Archives Canada; centre, courtesy of The Montreal Museum of Fine Arts; right, © Conservation and Technical Research, National Gallery of Canada, Ottawa.

portrait of Antoine Girouard (**Figure 8 centre**), also show a largely blended paint application, but with deliberate, distinct lines delineating contours and shadows of the facial features. In certain works, such as the portraits of Joseph Papineau (**Figure 8 right**), the facial features are defined primarily by juxtaposition of shadow and highlights, with strong brushstrokes used to sharpen outlines.

The LAC version of Papineau shows somewhat more blending and reworking of the paint than the NGC and MMFA versions. The X-radiographs of the MMFA and NGC portraits indicate a thin paint application, applied in short, distinct brushstrokes, precisely placed to follow the shape of the features. The brushstrokes in the X-radiograph of the LAC version, on the other hand, are thicker, heavier and are not as precisely placed (**Figure 9**).

Like the faces, the hands in some works are painted with a coarse, unblended paint application and juxtaposition of tones, while others show more blending and modelling. Fingernails are rendered with outlines, and, in most paintings, a rosiness to the knuckles and blue to suggest veins is noticeable. It has been observed that Dulongpré had great difficulty portraying hands; they tend to have a rubbery, fleshy appearance and problematic anatomy.[3] This difficulty was noted, to a greater or lesser degree, on all the portraits studied (**Figure 10**).

Paint Characteristics and Defects

Most of the paintings showed a typical fine crack network along the threads of the weave with minute losses of paint and ground being very typical, particularly in the later paintings (**Figure 11 left**). A medium, mechanical crack network was

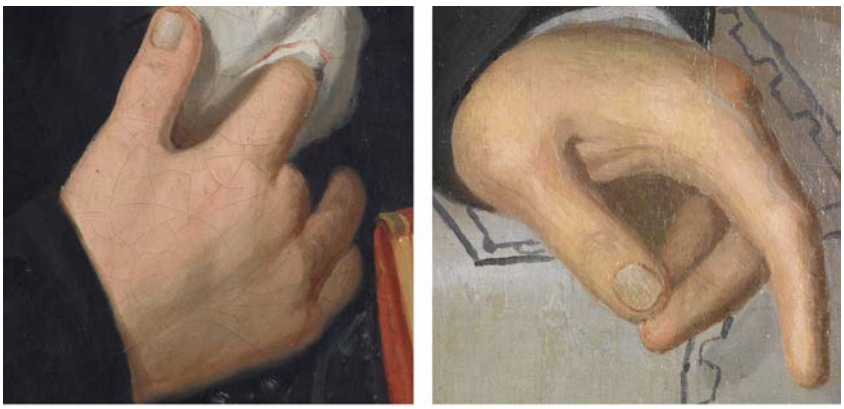

Figure 10. Details of hands, normal light: Abbé Boissonnault (left), Antoine Girouard (right). Photos: © Government of Canada, Canadian Conservation Institute.

also visible in many paintings, particularly in light coloured areas. The paint surface of the portrait of Boissonnault was atypically smooth. The large crack network (**Figure 11 right**) with sharp cupping over this smooth paint surface was unusual among the paintings examined and may be attributed to the thicker, smoother ground layer in this painting (**Figure 5g**).

For the portraits in the study group, cleavage most often occurred between the ground and canvas. An exception to this is the SSH version of Jean Dessaulles, which exhibited cleavage either within the inherently unstable preparation layer or between the paint and oil ground. In this painting, damage was quite extensive, due to the friable nature of the first layer applied to the canvas (see section on sizing). The fact that the paint layers penetrate cracks in the ground indicates that the ground layer cracked before the portrait was painted.[8] The horizontal pattern to the cracking suggests that the prepared canvas may have been rolled for storage before it was used.[8]

Defects associated with drying incompatibilities of the layers were apparent in most paintings. Drying cracks, with the paint crawling along lower layers, and underlayers protruding up through cracks were common. These appeared in specific areas of the painting, often, but not always, in brown or glossy black passages. They also appeared along the edges of some forms in which the layers overlapped and in thin, fluidly painted detailed elements of the background. Not only could these defects be related to the choice and use of materials, they could also be indicative of the speed with which Dulongpré executed his paintings, applying upper layers before the underlying layers were dry. In the background area of Sarah Solomon, for example, examination with a microscope revealed that a white layer, possibly a first colouring, protrudes through cracks in the

Figure 11. Left: UV fluorescence photographic detail of SSH version of Dessaulles. The fine crack network and minute losses to paint and ground are visible as are the horizontal and vertical strokes of the original varnish. Right: UV fluorescence photographic detail of Abbé Boissonnault showing the atypical large crack network as well as vertical strokes of an early varnish. The upper left corner, not covered by the streaky varnish, shows the reduced fluorescence of an even earlier surface coating. Photos: © Government of Canada, Canadian Conservation Institute.

upper paint, suggesting that it was slower drying than the overlying paint.

It was also typical to see translucent crystals and empty craters typical of metal soap formation in the surface of the painting. Discrete pigment particles of various colours were also visible within the paint layers, and sometimes larger coloured inclusions are present. It was not unusual to find hairs embedded in the surface. Chunks of dried paint, embedded in the paint layer, were common in the later paintings.

Varnish and Glaze Layers

Most paintings have undergone conservation treatment, including varnish removal and revarnishing. However, examination under ultraviolet light and the observation of discoloured residues of varnish on the paint surface under magnification provide indications that original or early varnishes may still be present. When examined under ultraviolet light, a heavier fluorescence in areas on some treated paintings suggests that certain areas were cleaned more than others. Accordingly, some treatment records confirm early varnishes could not be removed entirely due to the presence of underlying glazes and solvent sensitive layers.

Two paintings that were untreated at the time of examination, the MMFA version of Joseph Papineau and the SSH version of Jean Dessaulles, show a broad brushstroke application of the original varnish in the UV fluorescence photographs. In the Dessaulles portrait, both horizontal and vertical strokes can be seen, producing a thin, streaky varnish layer, with some areas receiving minimal coverage (**Figure 11 left**). While the strokes on the Papineau portrait are predominantly vertical, there are both vertical and horizontal strokes at the right side of the head and intermittent wavy strokes along the edges. Although the Boissonnault portrait has been treated, the early varnish layers were not removed in the most recent treatment. The UV fluorescence photograph of this painting shows an early varnish, applied in vertical streaks, possibly with a varnish pad or fully loaded brush, beneath the current synthetic coating and on top of an even earlier surface coating (**Figure 11 right**). Residues of early varnish were also visible on the portrait of Isaac Todd and on the NGC version of Papineau, where it appears as a discoloured residue with a wrinkled texture.

Py-GC-MS of varnish layers was undertaken on four paintings where early, possibly original, varnish remained. The results are listed in **Table III**. The early varnish layers on the portrait of Abbé Boissonnault, analyzed together, were found to contain shellac and camphor. Camphor was used as a plasticizer in both oil and spirit varnishes during the nineteenth century.[26] Early varnish on the portrait of James Sinclair was identified as mastic. The varnish on the untreated version of Papineau from the MMFA, which is thought to be original, contained mastic and drying oil. On the Dessaulles portrait from the NGC, which had only been partially cleaned due to the presence of solvent-sensitive paint and glazes, a thick application over the trousers, composed of multiple layers of varnish and glaze, contains drying oil, mastic and *Pinaceae* resin.

The portrait of James McGill showed evidence of what appears to be an original, intermediate varnish layer in the coat. The top button of McGill's jacket was painted with a grey underlayer, followed by a yellow ochre paint (**Figure 12 top**); a cross-section from this area showed a thin varnish layer between the underlayer and the paint (**Figure 12 bottom**). Analysis using FTIR spectroscopy showed that this varnish is protein-based. It is possible that this corresponds to a temporary varnish applied by Dulongpré before adding the final yellow paint to the button. Temporary egg-white varnishes are commonly referred to in nineteenth-century artists' manuals.[27]

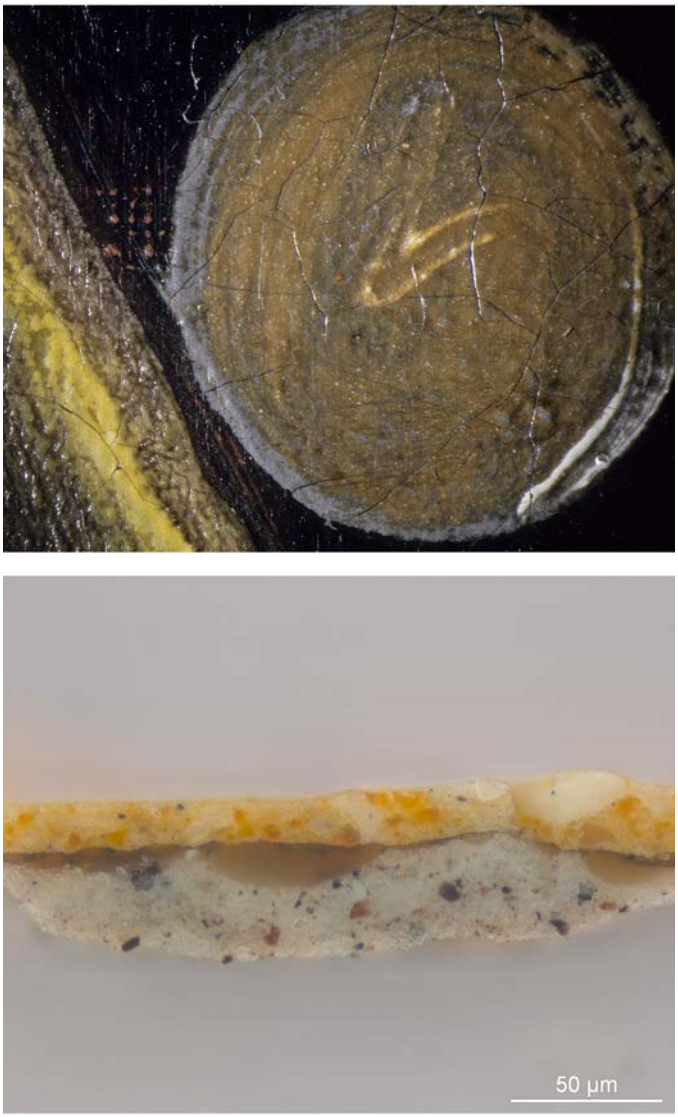

Figure 12. Top button on jacket, portrait of James McGill. Top: photographic detail of button showing grey paint with overlying yellow paint. Bottom: cross-section showing varnish between grey and yellow layer. Photos: © Government of Canada, Canadian Conservation Institute.

Table III. Analysis of sample paint medium and varnish using Py-GC-MS or GC-MS.

Painting, Date	Colour	P/S, oil type*	Other components**
Isaac Todd	Red	5.8, poppy	beeswax, (linseed oil heat markers,[29] tallow, *Pinaceae* resin, mastic)
1800	Brown	4.1, poppy	beeswax, (linseed oil heat markers, tallow, *Pinaceae* resin)
	Brown	2.3, intermediate	beeswax, (linseed oil heat markers, tallow, *Pinaceae* resin, starch)
	White	5.5, poppy	beeswax, (linseed oil heat markers, tallow, heated *Pinaceae* resin)
James McGill	Red	2.4, intermediate	(beeswax, linseed oil heat markers)
c.1800–1813	White	1.9, linseed	none
	Black	2.3, intermediate	*Pinaceae* resin, mastic, (beeswax, linseed oil heat markers)
James Sinclair	Red	1.7, linseed	(*Pinaceae* resin)
1808	Flesh	2.7, intermediate	heated *Pinaceae* resin, (mastic)
	Brown	1.9, linseed	(heated *Pinaceae* resin)
	Varnish	--	mastic
Abbé Boissonnault	Black	2.3, intermediate	(linseed oil heat markers, beeswax, heated *Pinaceae* resin, protein, shellac, camphor)
1810	White	3.3, poppy	(linseed oil heat markers, beeswax, tallow, *Pinaceae* resin, shellac, camphor)
	Flesh	5.6, poppy	(*Pinaceae* resin)
	Varnish	--	shellac, camphor
Thomas McCord	Red	3.5, poppy	paraffin wax
c. 1816	Brown	1.0, linseed	paraffin wax
Sarah Solomon	Red	1.9, linseed	(*Pinaceae* resin, mastic)
c. 1818	White	1.9, linseed	(*Pinaceae* resin, paraffin wax)
Joseph Papineau	Brown	2.6, intermediate	(beeswax, tallow, *Pinaceae* resin*)*
LAC, 1825	Grey	2.6, intermediate	(beeswax, tallow)
Joseph Papineau	Black	1.4, linseed	heated *Pinaceae resin*, mastic, beeswax, tallow, (linseed oil heat markers, protein)
MMFA, 1825	Flesh	1.5, linseed	(*Pinaceae* resin, beeswax, tallow)
	Varnish	2.2, intermediate	mastic
Joseph Papineau	Brown	1.5, linseed	beeswax, (linseed oil heat markers, mastic, *PInaceae* resin, tallow)
NGC, 1825	Brown	1.8, linseed	beeswax, protein, (linseed oil heat markers, mastic, *PInaceae* resin, tallow)
	White	2.1, intermediate	(mastic, *Pinaceae* resin, beeswax, tallow)
	Grey	1.9, linseed	(mastic, *PInaceae* resin, beeswax, tallow)
Jean Dessaulles	Yellow	3.5, poppy	(*Pinaceae* resin)
NGC, c. 1825	Red	1.4, linseed	(linseed oil heat markers, *Pinaceae* resin, mastic, beeswax, tallow, paraffin wax)
	Flesh	2.4, intermediate	(linseed oil heat markers, *Pinaceae* resin, mastic, beeswax, tallow)
	Varnish	2.5, intermediate	mastic, *Pinaceae* resin, (beeswax)
Jean Dessaulles	--	--	--
SSH, c. 1825			
Antoine Girouard	Grey	4.0, poppy	(linseed oil heat markers, *Pinaceae* resin, beeswax, tallow)
1826	Yellow	1.9, linseed	(linseed oil heat markers, *Pinaceae* resin, possibly trace beeswax)

*P/S = ratio of palmitate to stearate based on peak areas of methyl esters of the fatty acids. The oil type listed is based on the P/S ratio: linseed = 1–2; nut or mixture = 2–3 (intermediate); poppy > 3.

**Compounds present in trace amounts are in parentheses. When beeswax, which contains significant palmitic acid, is present above trace amounts in a sample, it will increase the P/S ratio. However, in most cases, this increase would not be large enough to change the interpretation of the oil type. An exception is the second brown paint from Isaac Todd where the beeswax may have raised the P/S ratio enough to change the oil type from linseed to intermediate. Compounds originating from organic pigments have not been included; they are discussed in the text in the section on pigments and fillers.

Pigmented glazes were observed on most paintings, and treatment reports cite solvent sensitive paint layers and glazes as the reason not to remove early varnishes. Glazes could be seen with close visual examination; for example, in the portrait of James Sinclair, pooling of a brown glaze is visible within the interstices of the weave texture in the background, and a similar brown glaze was noted over the paint in some areas of the torso. Glazes were also often indicated in UV light by a heavier fluorescence in the clothing and backgrounds. The presence of glazes was confirmed in several cross-sections. As shown in **Figure 13**, cross-sections sometimes showed a complex stratigraphy, with some intermixing among paint, glaze and varnish layers. In some cases, it was difficult to distinguish possible dirt layers from thin paint, glaze or discoloured varnish in the cross-sections.

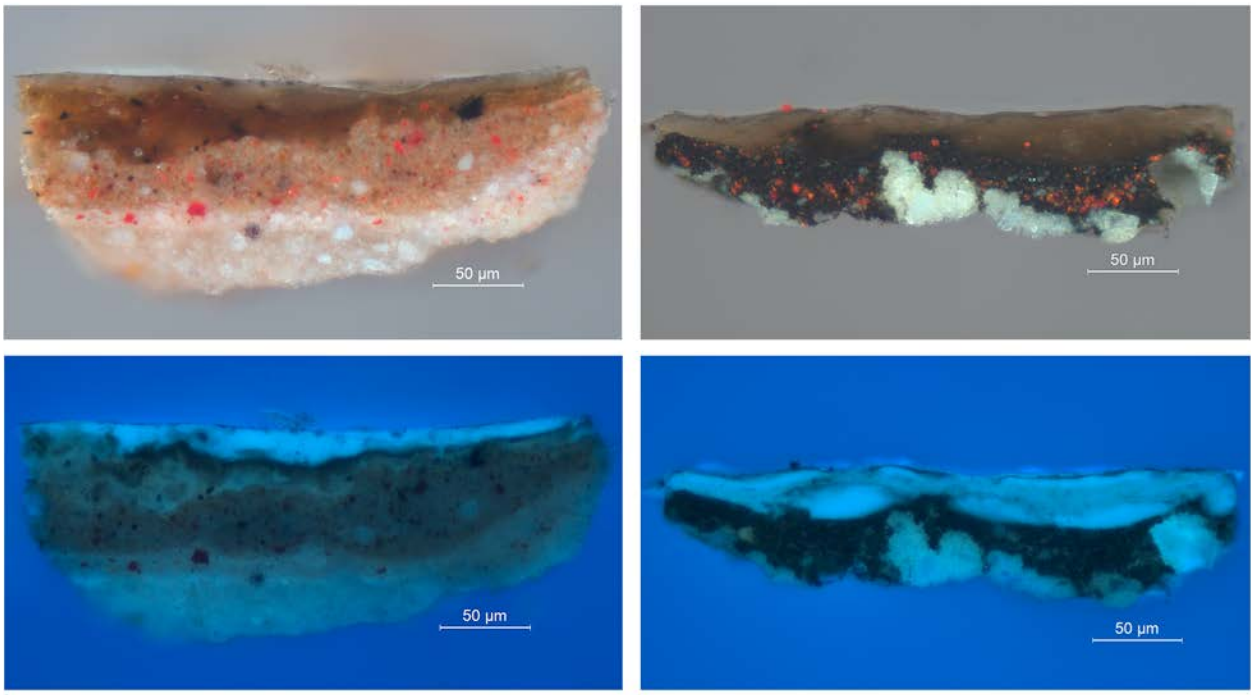

Figure 13. Left: cross-section from hand, SSH version of Dessaulles, showing intermixing of glaze (non-fluorescing) and varnish; incident light (top) and fluorescence (bottom). Right: cross-section from trousers, NGC version of Dessaulles, showing intermixing between dark paint and glaze (both non-fluorescing) and fluorescent varnish layers; incident light (top) and fluorescence (bottom). Photos: © Government of Canada, Canadian Conservation Institute.

Prior to conservation treatment, examination of the SSH version of Jean Dessaulles revealed the presence of minute, resinous "strings" associated with the varnish layer (**Figures 14** and **15**). These unusual features varied in prominence and appearance over the surface; in some areas, they appear to be ridges of a poor drying glaze that has contracted upon drying, while in others, they resemble long, dark strings or filaments. Analysis showed that the "strings" are an agglomeration of a brown, pigmented glaze. A varnish of variable thickness separates the glaze from the paint layers, but in a few areas, the glaze appears to be directly on the paint. In some areas, glaze and varnish are intermixed, making it impossible to remove the varnish without removing the glaze. There is little doubt that these layers are the first coatings applied to the painting. Similar resinous "strings" were also observed on a number of the other portraits. On some paintings, dark layers exuding through cracks in the upper paint surface have a similar appearance to this string-like accretion. **Figure 15 right** shows a ridge of exuding paint and glaze in a cross-section from the MMFA version of Joseph Papineau in an area on the chair where these features were noted. The "strings" on the Boissonnault portrait differ from the others as they appear more like an agglomeration of discoloured varnish than glaze or paint (**Figure 16**).

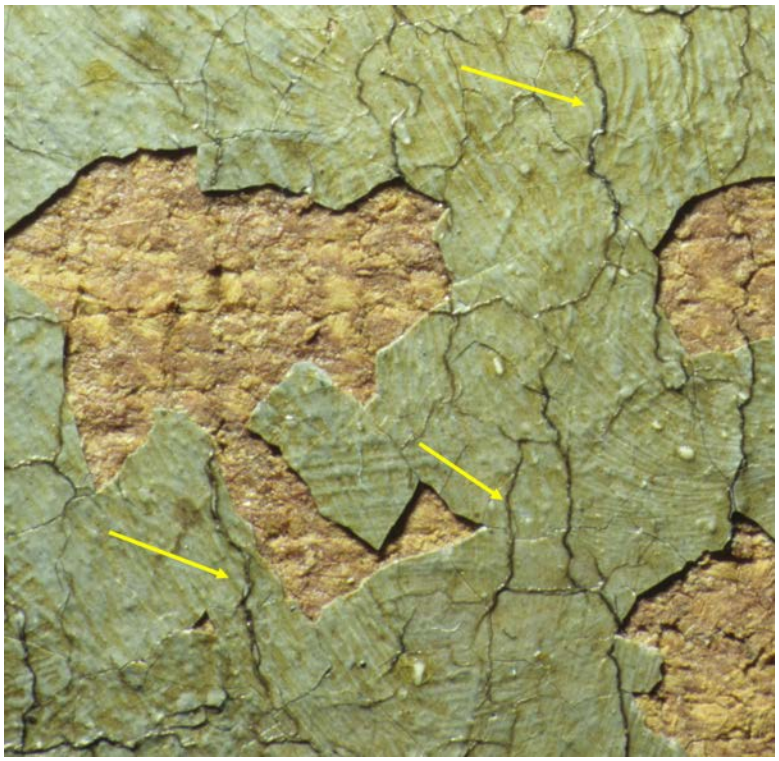

Figure 14. Detail from SSH version of Dessaulles, background, normal light, showing "resinous strings" within the varnish. Photo: © Government of Canada, Canadian Conservation Institute.

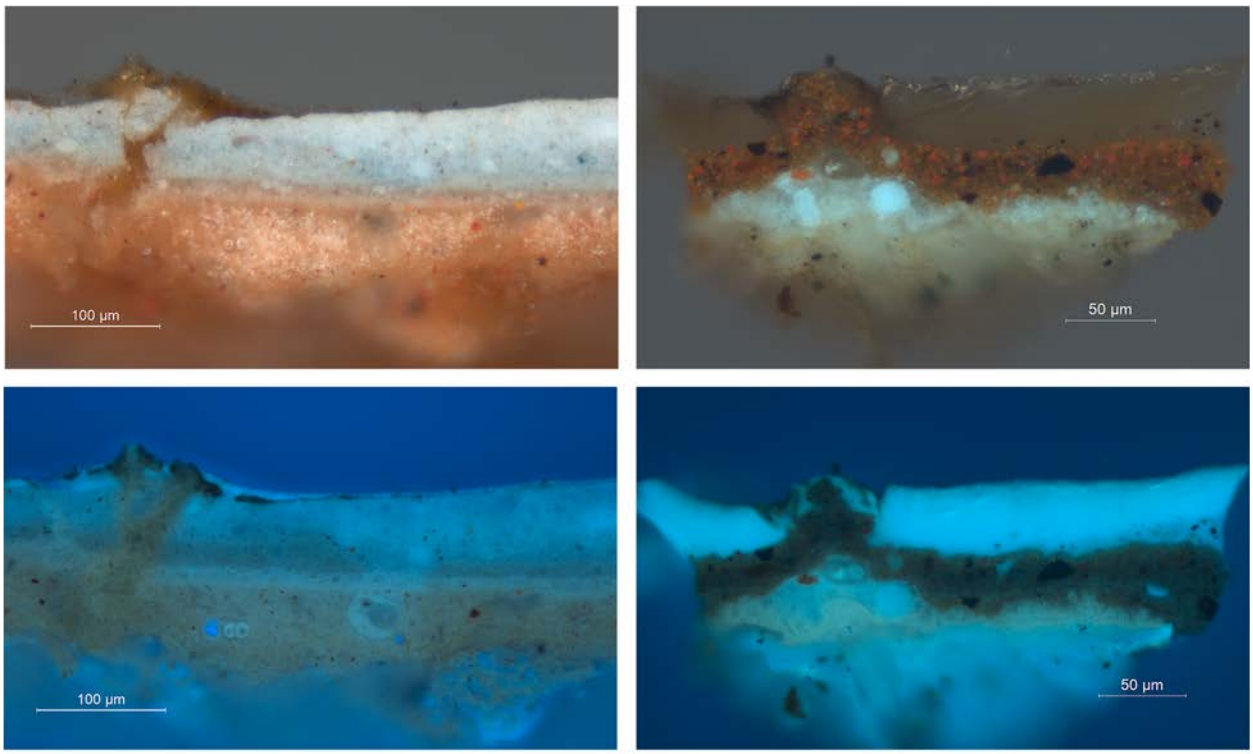

Figure 15. Left: cross-section from SSH version of Jean Dessaulles in an area of "resinous strings"; incident light (top) and fluorescence (bottom). Right: cross-section from MMFA version of Joseph Papineau showing a ridge of exuding paint and glaze in an area of "resinous strings"; incident light (top) and fluorescence (bottom). Photos: © Government of Canada, Canadian Conservation Institute.

Figure 16. Detail from portrait of Abbé Boissonnault, normal light, showing an unpigmented, string-like inclusion in the varnish. Photo: © Government of Canada, Canadian Conservation Institute.

Paint Medium

Using FTIR spectroscopy, the medium of the paint and ground layers in all paintings was determined to be drying oil. Many samples also contained lead fatty acid salts (lead soaps), produced by reaction of lead white with fatty acids in the oil. A selected number of samples were also analyzed using Py-GC-MS or GC-MS to characterize the oil medium in more detail. The results are summarized in **Table III**. Of the 30 paint samples that were analyzed using chromatographic techniques, almost half had palmitate to stearate (P/S) ratios between 1 and 2, consistent with linseed oil. Eight samples produced P/S ratios higher than 3, consistent with poppyseed oil.[28] In a number of the samples where the P/S ratio indicated poppyseed oil, trace amounts of characteristic markers indicative of heated linseed oil were also present.[29] This could indicate that a small amount of heated linseed oil was mixed with the poppyseed oil, or that the sample contained residues of a linseed oil-containing varnish. Nine samples showed an intermediate ratio (P/S between 2 and 3), which could indicate the use of nut oil or an oil mixture, such as linseed oil mixed with poppyseed oil. Nineteenth-century treatises suggest that poppy or nut oil should be used in light colours since, although they dry more slowly than linseed oil, these oils yellow less with age.[30] However, based on the results in **Table III**, Dulongpré does not appear to have consistently used poppy or nut oil in lighter colours.

In addition to fatty acids from the drying oil, small amounts of several other components were also identified; these are listed in the last column of **Table III**. These additional components are primarily waxes (beeswax, tallow and hydrocarbon wax) or natural resins (*Pinaceae* resin, mastic and shellac). While certain compounds could potentially be original constituents of the paint[31] or residues of original varnish, they may also be related to previous interventions, such as wax-resin lining or revarnishing. Lining adhesives may have impregnated the paint layers, and, because of the small size of the samples, the varnish could not always be separated from the paint completely.

Of the works analyzed, the components identified in the samples from the portrait of James Sinclair and the MMFA version of Joseph Papineau are the most likely to represent original modifications of the oil. These paintings are both unlined and, at the time of study, had undergone minimal or no conservation treatment. In the case of the portrait of James Sinclair, the *Pinaceae* resin is undoubtedly an original constituent of the oil medium. The varnish on this painting was identified as mastic, so the presence of mastic in one sample could be from residual varnish. In the case of the MMFA version of Joseph Papineau, mastic, *Pinaceae* resin, beeswax and traces of tallow were found in the paint samples. The varnish layers on this painting contain mastic, indicating that the *Pinaceae* resin, beeswax and tallow may possibly be original components of the paint.

Pigments and Fillers

Dulongpré's choice of pigments would have been dictated by a combination of his personal preference along with the availability of materials. During the first quarter of the nineteenth century, many artists' materials imported to Lower Canada came from Britain, although pigments from other sources were also used.[32] **Table IV** is a chronological chart of all the pigments that were identified in the twelve portraits. The table illustrates the overall palette for each work; individual colours in the compositions are mixtures of these various pigments. The pigments and fillers identified are discussed in detail below.

White Pigments and Fillers

Dulongpré used lead white and calcium carbonate[25] in all the portraits examined. Many paints are composed of lead white and a smaller amount of calcium carbonate with various coloured pigments added to produce the desired shade. Silicates and quartz, identified in all paintings, were generally found associated with iron oxide pigments. These compounds are common accessory minerals in natural iron oxide pigments.[33] Fillers that were identified less often are gypsum, barium sulfate and lead sulfate. Gypsum and barium sulfate were each found in about half the paintings. In paintings where they were identified, both were present in minor quantities in only a few samples. There did not appear to be a chronological pattern to their use. Lead sulfate was identified in only two paintings and, in both cases, was associated with Naples yellow; this is discussed further in the section describing yellow pigments.

Black and Brown Pigments

Bone black, produced by calcining ivory or bone, was the primary black pigment in all six of the early portraits as well as in the LAC and MMFA versions of Joseph Papineau. The NGC portrait of Papineau, on the other hand, includes both bone black and a carbon-based black; bone black was identified in paint from the sitter's jacket, while a carbon-based black was found in other areas. Only carbon-based black was used in the portraits of Jean Dessaulles and Antoine Girouard.

Dulongpré used an organic brown pigment in a majority of the portraits examined. Identification was based on the morphological and optical properties observed using polarized light microscopy. In several samples, further analysis using Py-GC-MS revealed tannins and hopanes, which are characteristic markers of the organic pigment Vandyke brown (also known as Cassel earth or Cologne earth). Vandyke brown is obtained from lignite or peat deposits[34-36] and, as such, contains soil-derived aromatics such as tannins along with hopanes and other triterpenes.[36]

The brown iron oxide pigments referred to as "umbers" contain manganese compounds in addition to iron. Umbers contain on the order of 5–20% (by weight) manganese. The manganese oxides and oxyhydoxides in umber are generally finely divided, of low crystallinity, and are intimately mixed with the iron oxides.[33] In **Table IV**, umber is listed as present in a painting when a minor quantity of manganese and a major quantity of iron were identified using SEM/EDS in yellow-brown to red-brown iron oxide particles.

While umber was frequently used in the nineteenth century and was found in most of the portraits examined, the identification of manganese black or brown in several paintings is less common. Coarse black to dark brown particles that contained primarily manganese with only small amounts of iron were observed in cross-sections from three paintings. The Raman spectrum of one of the black particles (**Figure 17**) indicated that it is composed of manganite (a manganese oxyhydroxide).[37] The identification of manganite is unusual; manganese browns and blacks have been very occasionally found in nineteenth-century paintings, but in these cases, the identification was inferred solely from the presence of a high concentration of manganese.[31]

Red and Orange Pigments

Dulongpré used red to orange iron oxides and vermilion[38] in all twelve paintings that were studied. A number of the red to orange iron oxide pigments included coarse, rounded translucent particles that, based on SEM/EDS results, contained minor quantities of arsenic, lead and sometimes zinc along with a major quantity of iron. These minor elements are probably natural impurities related to the source of the earth. Further research could determine if the elemental composition of the earth pigments is specific to a certain period or geographical location. While iron oxide pigments were certainly imported to Lower Canada during the nineteenth century, there were also sources of iron oxides in Quebec that may have been exploited on a small scale to make pigments.[32]

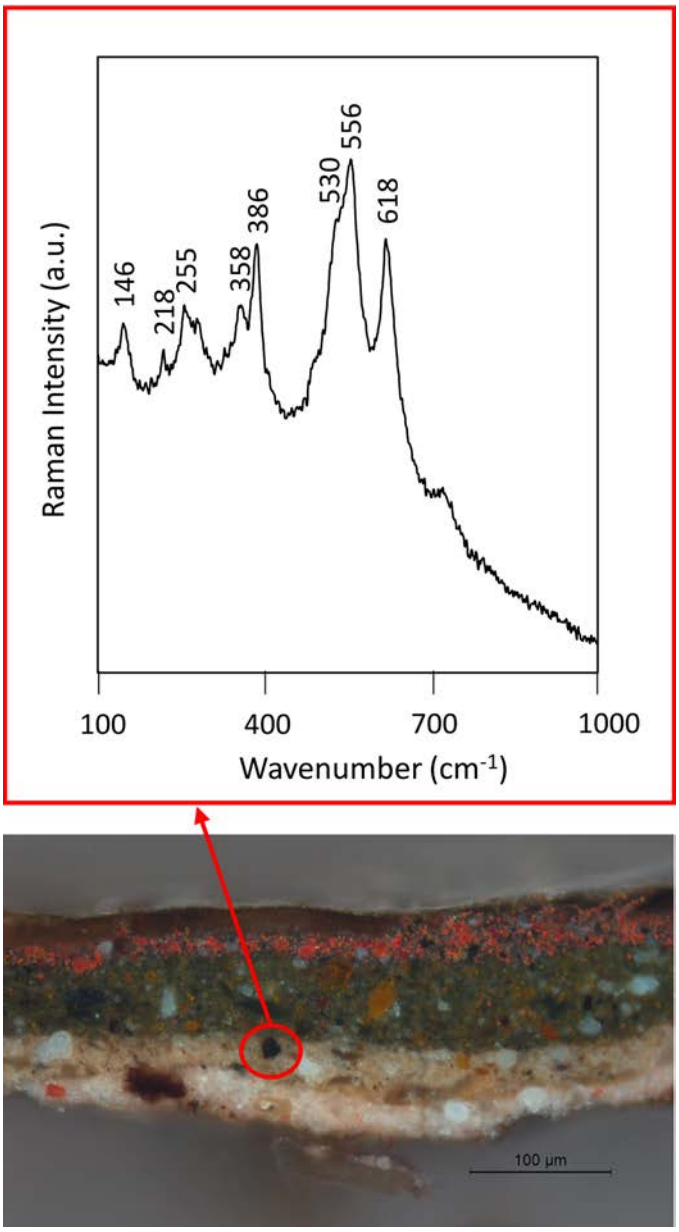

Figure 17. Raman spectrum of black particle in cross-section from LAC version of Joseph Papineau. Images: © Government of Canada, Canadian Conservation Institute.

A bright crimson lake was found in the six works from Dulongpré's early period as well as one of the versions of Dessaulles (c. 1825). In five cases, it was possible to characterize the red lake as carmine; this was based on either the identification of a marker for carminic acid using GC-MS or by the presence of specific bands in the infrared spectrum. The particles of red lake showed a high concentration of aluminum using SEM/EDS, indicating an aluminum-containing substrate.[39]

Yellow Pigments

Similar to the red iron oxides, yellow iron oxides were identified in all twelve portraits. In five of the six early paintings, a second yellow pigment, either patent yellow or Naples yellow, was also used. None of the six paintings from 1825–26 included a yellow pigment other than yellow iron oxide.

Patent yellow, also known as Turner's yellow or mineral yellow, is a relatively rarely identified synthetic pigment composed of lead oxychloride.[40] Dulongpré used this yellow pigment in two of his early portraits (Todd and McGill). **Figure 18** is a cross-section from a green area on the portrait of Isaac Todd created with a mixture of Prussian blue and patent yellow. The patent yellow particles, most evident in the backscattered electron image, are coarse and of variable size and colour. Dulongpré may have used patent yellow imported to Lower Canada from abroad, and indeed, this pigment is listed for sale in Quebec newspapers in the first quarter of the nineteenth century.[31] However, patent yellow was also made locally by "chemists" and possibly by some artists themselves; in a 1792 journal entry, François Baillairgé describes obtaining the recipe for this pigment from the chemist Mr. Taylor in exchange for painting his portrait along with a certain sum of money.[32]

Naples yellow, or lead antimonite yellow, was found on three of the early portraits (Sinclair, Boissonnault and Solomon). In the portraits of James Sinclair and Sarah Solomon, the Naples yellow was associated with lead sulfate. The presence of lead sulfate in Naples yellow pigments is

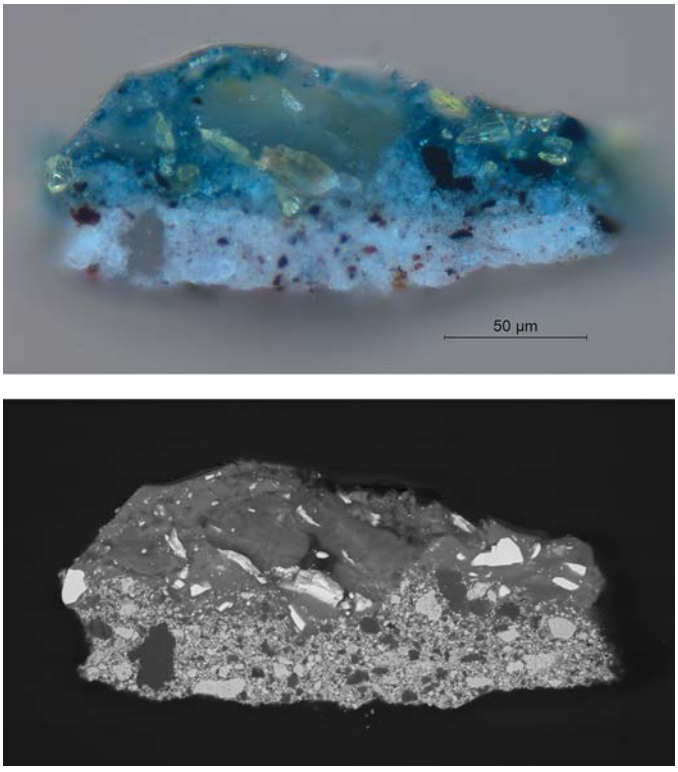

Figure 18. Cross-section showing mixture of patent yellow and Prussian blue in Isaac Todd's vest; incident light (top), backscattered electron micrograph (bottom); the patent yellow particles appear white. Photos: © Government of Canada, Canadian Conservation Institute.

Table IV. Pigments identified in the twelve portraits.*

		Early period						Papineau			Dessaulles, Girouard		
		Todd 1800	McGill c. 1800–1813	Sinclair 1808	Boissonnault 1810	McCord c. 1816	Solomon c. 1818	Papineau (LAC) 1825	Papineau (MMFA) 1825	Papineau (NGC) 1825	Dessaulles (NGC) c. 1825	Dessaulles (SSH) c. 1825	Girouard 1826
White and fillers	Lead white												
	Calcium carbonate												
	Kaolin/other silicates												
	Quartz												
	Barium sulfate												
	Gypsum												
	Lead sulfate												
Black and brown	Bone black												
	Charcoal/carbon-based black												
	Organic brown												
	Umber												
	Manganese brown/black												
Red and orange	Red/orange iron oxide												
	Vermilion												
	Red lake (C=carmine)	C	C	C		C	C						
Yellow	Yellow iron oxide												
	Naples yellow												
	Patent yellow												
Blue	Prussian blue												
	Indigo												
Green	Green earth												

*Colour tone indicates whether the pigment was identified: full colour = pigment present; mid tone = pigment present in only trace amounts and/or the identification is tentative; white or very pale = pigment not present. For the red lakes, "C" indicates that the lake was identified specifically as carmine. The table does not include the components in the ground layers.

common and has been hypothesized to be a by-product of synthesis using antimony sulfide rather than antimony oxide as starting material.[41,42] In the portrait of Sarah Solomon, the Naples yellow may have been supplied mixed with both gypsum and lead sulfate, as this combination was found in several areas of the painting.

Blue and Green Pigments

Prussian blue was the most frequently identified blue pigment; it was the principal blue colourant in nine of the twelve portraits. In three of the early works, on the other hand, indigo was used in place of Prussian blue. Only one painting included both Prussian blue and indigo; although Prussian blue was the main blue pigment in the NGC version of Papineau, a small amount of indigo was identified in one sample of grey paint. While green tones in the portraits were generally yellow-blue mixtures, there was a single occurrence of a green pigment; the background paint on the portrait of Abbé Boissonnault contains green earth, a naturally occurring green pigment coloured by the clay minerals glauconite and/or celadonite.[43]

Overall Trends and Pigment Mixtures

The results in **Table IV** illustrate an overall trend towards a more limited range of coloured pigments in the portraits from 1825–26 as compared to the earlier works (1800–1818). Carmine, indigo, patent yellow, Naples yellow and green earth were identified in early portraits, but these pigments were absent, or only used to a very limited degree, in the later works. Possible reasons for a more limited range of pigments in Dulongpré's works from 1825–26 could include a change in his financial situation, a more limited access to materials or a simplification of his technique in these later paintings.

There are some commonalities in Dulongpré's pigment mixtures. In all twelve portraits, many colours are composed of complex combinations of pigments; some of the more highly mixed colours, for example brown and black shades, include almost all the pigments in his palette. While these highly blended colours are clearly an intentional choice, it is possible that certain pigments present in only trace quantities could be the result of using a dirty brush or accidental mixing on the palette.

Connections among Paintings

Although there was considerable variation in materials and techniques within the study group, it was possible to make connections among some of the paintings.

James McGill and Isaac Todd

There are substantial similarities in the materials and techniques used in the portraits of James McGill and Isaac Todd, who were friends and associates at the North West Company. The paintings are of almost identical size. The canvases for the two portraits are comparable in texture and thread count. Both portraits were prepared with a single application of red ground with a virtually identical composition. This red ground provides an undertone to the paint in areas of both works. Dulongpré used an identical palette of pigments for the paint layers. Patent yellow was employed in both and was not found on any of the other portraits studied.[44] Certain of the pigment mixtures were also similar. For example, the brown background in both works is coloured with a mixture composed primarily of bone black, yellow and brown iron oxides and an organic brown pigment, along with small amounts of other pigments. Both paintings include thin, translucent lines of crimson paint, pigmented with carmine, to depict patterned fabrics.

The strong similarities in materials and techniques, combined with stylistic parallels pointed out by Derome,[10] suggests that these portraits were painted at around the same time and that they originally formed a pair. This is consistent with the fact that the sitters are facing in opposite directions (Dulongpré's convention for pendant paintings), are placed at a similar height in the composition, and are both placed in front of a uniform, brown background. The reason for the grid lines under the composition of the McGill portrait, observed using infrared photography, deserves further research. It is possible that the grid lines are evidence that the portrait of McGill was painted after that of Isaac Todd, and that the lines ensured a matching composition. However, the grid lines could also be evidence of a copying or enlarging technique. There could, perhaps, be a relationship between the Dulongpré portrait and two miniatures of McGill, dating from around 1800–1805 and tentatively attributed to Berczy.[6]

Versions of Joseph Papineau

As described earlier, Dulongpré is known to have painted four versions of the portrait of Joseph Papineau. Of these, three are currently known and were examined as part of this project. The three versions of Papineau are comparable in dimension and design, with only small variations in colour and in the placement of objects. There are some commonalities in the materials and techniques. In all three portraits, the canvas was sized with a starch/protein mixture and the ground was applied after the canvas had been cut and attached to its stretcher. The three paintings also have a similar, restrained palette, based primarily on bone black, iron oxide pigments, organic brown, vermilion and Prussian blue.

The NGC and MMFA versions of the Papineau portrait have a number of other features in common. The early, likely original, stretchers have the same type of construction, including joints with an unusual oblique cut. The canvases have very similar weave, weight and thread count. They each exhibit a selvage at the top edge indicating that the warp runs horizontally. The ground layers on both paintings are off-white, lightly tinted with scattered particles of iron oxides and black pigment. In terms of painting technique, the facial features are defined primarily by the juxtaposition of shadow and highlights with little modelling or blending. The paint has been built up in a direct, efficient manner with short, deliberate brush strokes.

While the NGC and MMFA portraits show similarities in materials and techniques, the LAC portrait differs from them in a number of respects. The LAC version of Papineau is painted on a canvas with a significantly higher thread count, and the warp runs vertically rather than horizontally. The LAC portrait also has a pink ground, unlike the off-white grounds

used for the NGC and MMFA versions. The facial features show somewhat more blending and reworking of paint, and, compared to the other two versions, the brushstrokes in the face are heavier and are not placed as precisely. Dulongpré also appears to have made more extensive use of first-colouring layers in the LAC version of the portrait.

A letter written by Joseph Papineau's son, Louis-Joseph, indicates that Dulongpré completed one of the portraits first, and it was presented to the family while the other versions were still in progress.[1,3] A previous study of the LAC and NGC portraits concluded that the LAC painting is undoubtedly the original version presented to the family based on the higher quality of the painting technique and the evidence of reworking.[1,3] The fact that the materials of the LAC portrait are distinct from the others, and that the NGC and MMFA versions have many features in common, provides further evidence to support this conclusion.

Versions of Jean Dessaulles and Antoine Girouard

In the portraits of Jean Dessaulles and Antoine Girouard from Saint-Hyacinthe, the sitter is placed in front of a map or plan of the Saint-Hyacinthe seminary, which was founded by Girouard and of which Dessaulles was a benefactor. Sitting in opposite directions, they are painted to the same scale and placed at a similar height in the composition. These portraits were undoubtedly intended as companion paintings for the seminary. There are, however, significant differences in their materials and techniques. The unusually primed canvas for the Dessaulles portrait, with its pre-prepared, starch-based ground layer, is unique among the twelve paintings studied. The Girouard portrait, on the other hand, was prepared with a single application of a pale grey, oil-based ground. Though a discoloured varnish partially obscures the flesh on the Dessaulles portrait, in terms of technique, there is a more delicate, blended application of paint in the face and hands of Girouard, as opposed to the strong, delineating shadows and lines of the face and lack of detail in the hands of Dessaulles. Although the pictorial composition of these portraits indicate that they are a pair, the materials and techniques suggest that they may have been painted in different circumstances.

The NGC portrait of Jean Dessaulles is smaller than the Saint-Hyacinthe version, and the figure is placed more centrally in the composition. The NGC portrait, depicting Dessaulles with a letter rather than a map of the seminary, may have been painted for the family.[45] The two versions show Dessaulles facing in opposite directions, undoubtedly because each work has a companion painting. The NGC portrait, with Dessaulles facing right, is a pair with a portrait of his wife Rosalie (also in the collection of the NGC), who is facing left. The SSH version, on the other hand, which depicts Dessaulles facing left, forms a pair with the portrait of Antoine Girouard, who is facing right. It is interesting to note that the figure of Dessaulles in the NGC and SSH versions are mirror images, flipped along the vertical axis. For example, the NGC painting shows Dessaulles raising his proper right eyebrow, while in the SSH painting, his proper left eyebrow is raised. The fact that the figures are mirror images is strong evidence that one of the portraits was copied from the other.

As well as the distinct ground layers and different scale of the works, differences in painting technique between the two versions of the Dessaulles portrait were observed. The SSH version shows more brushstroke texture and a thicker paint application. By comparison, the paint application in the NGC portrait is smoother and thinner, with more complete modelling of form and a higher level of detail in some areas. There appears to be more revision of the composition in the SSH version, with changes to the position of the buttons, fingers and proper left shoulder. While the question remains as to which version of the Dessaulles portrait was painted first, these observations are a starting point for further research.

CONCLUSIONS

Technical and scientific study of twelve oil-on-canvas portraits by Louis Dulongpré provided detailed information about the artist's materials and techniques.

One of the goals of the research was to gather technical and material evidence that could shed light on deterioration phenomena and inform future conservation treatments of Dulongpré's paintings. A type of degradation found to be common to most of the portraits was the presence of a fine crack network along the threads of the canvas weave. This crack network contributed to minute losses of paint and ground, particularly in the later paintings. In the portrait of Jean Dessaulles from Saint-Hyacinthe, the more extensive cracking and cleavage can be directly linked to Dulongpré's use of a thick, incorrectly formulated starch-based preparation layer. However, this was not the case in the other portraits, which showed typical, thin size layers followed by an oil-based ground. The research also highlighted Dulongpré's use of glazes on many portraits. In glazed areas, cross-sections often showed intermixing of paint, glaze and varnish, which is important to keep in mind during conservation treatment procedures such as varnish removal. The presence of solvent sensitive glazes and the intermixing of paint with the surface layers may preclude the removal of early varnishes in certain areas of his portraits.

Due to the difficulty in confirming attributions to Dulongpré, another goal of the project was to gather evidence that could assist in such investigations. Overall, technical examination of the twelve portraits did show features that are typical of Dulongpré's oeuvre. Many of the portraits have a similar look, both in the physicality of the surface and in the painting style. The ground was usually applied in a single layer, often using a spatula or similar tool. With a few exceptions, most paintings have thin paint and ground layers through which the texture of the canvas is visible. A majority of the canvases were cut to size and attached to a stretcher before application of the ground. Many pigments were consistently identified in the twelve works, and all the paintings show complex mixtures of pigments to create the colours.

However, while similarities were noted, there were also exceptions, and there was considerable variation in materials and techniques among the paintings studied. The dimensions of the paintings, the canvas weave and the colours of the ground layers were not consistent. There were also changes in

Dulongpré's choice of pigments over the course of his career, with a wider range of coloured pigments in the earlier portraits as compared to the works from 1825–26. Carmine, indigo, patent yellow, Naples yellow and green earth were identified in early portraits, but these pigments were absent, or only used to a limited degree, in the later works.

While these differences represent acceptable artistic latitude and possible changes in his methods or circumstances over the course of his career, they also highlight the importance of circumspection when interpreting the material and technical evidence. The variability in Dulongpré's materials and techniques reinforces the importance of combining the results of technical studies with curatorial expertise when investigating questions of attribution and copies.

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APPENDIX: ANALYTICAL METHODS

The samples were analyzed using a combination of some or all of the following techniques: Fourier transform infrared spectroscopy (FTIR), polarized light microscopy (PLM), Raman spectroscopy, scanning electron microscopy/energy dispersive X-ray spectrometry (SEM/EDS), pyrolysis-gas chromatography-mass spectrometry (Py-GC-MS), gas chromatography-mass spectrometry (GC-MS) and X-ray diffraction (XRD). Cross-sections were prepared by embedding a portion of the sample in polyester resin and grinding and polishing using silicon carbide abrasive papers. The cross-sections were observed using incident light and fluorescence microscopy (autofluorescence excited with a UV or blue bandpass filter). Selected layers in the cross-sections were examined using SEM/EDS and Raman spectroscopy.

For FTIR, fragments of the samples were analyzed with a Bruker Hyperion 2000 microscope interfaced to a Tensor 27 spectrometer. In a few cases, a Bomem Michelson MB-100 spectrometer with a microbeam sample compartment was used instead. In all cases, a portion of the sample was positioned on a diamond microsample cell and analyzed in transmission mode by co-adding 150 or 200 scans. Spectra were collected from 4000 to approximately 430 cm^{-1} using a wide band MCT detector.

For PLM, samples were prepared as dispersions in Cargille Meltmount mounting medium (n = 1.66) and examined using a Leica DMRX polarizing light microscope. Using PLM, pigments can be identified based on their optical and morphological properties.

Raman spectra were collected with a Bruker Senterra dispersive Raman microscope. An excitation wavelength of 785 nm was employed. The laser power at the sample was less than 1 µW. Either a 50× or 100× objective lens was used to produce analysis areas of approximately 2 or 1 µm in diameter, respectively. The spectra were recorded using a grating and CCD detector combination that produced a spectral resolution of approximately 3–5 cm^{-1}.

Most analysis using SEM/EDS was performed with either a Hitachi S-3500N or a Hitachi SU3500 variable pressure SEM integrated with an Oxford Inca X-act analytical silicon drift X-ray detector and either an Oxford Inca Energy+ or an Oxford Aztec X-ray microanalysis system. Using these SEM/EDS techniques, elemental analysis of volumes down to a few cubic micrometres can be obtained for elements from boron (B) to uranium (U) in the periodic table at a level of approximately 0.1–1% or greater. In a few cases, an Hitachi S-530 SEM with a Tracor Xray lithium-drifted silicon detector with a Noran instruments Voyager II X-ray microanalysis system was used, in which case, only elements from sodium (Na) to uranium (U) were detected. In all cases, the SEM was operated at an accelerating voltage of 20 kV. Some cross-sections were examined without coating at a pressure of 60 Pa, others were carbon-coated and analysed in high vacuum mode.

For GC-MS, samples were extracted and derivatized with Meth-Prep II (m-(trifluoromethyl)-phenyl trimethylammonium hydroxide, TMTFTH, 0.2 N in methanol) and toluene (1:1) and then analyzed using an Agilent 6890 gas chromatograph (GC) interfaced to an Agilent 5973 quadrupole mass spectrometer (MS). The GC oven was fitted with an Agilent HP-5MS column ((5% phenyl)-methylpolysiloxane; 30.0 m, 0.25 mm internal diameter, 0.25 µm film thickness), and for all analyses the following temperature program was used: 50°C to 200°C at a rate of 10°C/minute and then from 200°C to 300°C at a rate of 6°C/minute and a final hold time of 15 minutes; total run time of 46.67 minutes. A split-splitless injector was used in splitless mode at 250°C, and the MS interface was set at 280°C. Ultra-high purity helium carrier gas was used with a constant flow of 1.0 mL/minute. The MS was run in scan mode from 50–750 amu, with the source and quadrupole temperatures set at 230°C and 150°C respectively. The MS was operated in the electron impact positive ion mode (70 eV). Data were processed using Agilent Chemstation software, v.E.02.02 (Agilent Technologies, Inc., Santa Clara, California).

For Py-GC-MS, samples were placed in a micro-vial (Agilent Technologies, part no. 5190-3187) with 2 µL of tetramethylammonium hydroxide (TMAH, Supelco, Bellafonte, PA) in methanol (1:25). The vial was inserted into a thermal separation probe (TSP, Agilent Technologies, Inc.,

Palo Alto, CA) installed in a multimode inlet on an Agilent 7890A GC interfaced to a 5975C MS. The multimode injector with TSP was operated in splitless or split mode depending on the sample size and ramped from 50°C to 450°C, at a rate of 900°C/minute to perform the pyrolysis. The final temperature was held constant for three minutes and then decreased to 250°C at a rate of 50°C/minute. For the GC separation, a Phenomenex ZB-Semivolatiles fused silica column (30 m x 0.25 mm i.d., 0.25 µm film thickness; Phenomenex Inc., Torrance, CA) was used. Ultra-high purity helium carrier gas was used with a constant flow of 1.2 mL/minute. The oven was programmed from 40°C to 200°C at 10°C/minute and 200°C to 300°C at 6°C/minute with a hold time of 20 minutes (52.67 minutes run time).The MS was operated in EI positive mode (70 eV). The MS transfer line temperature was 280°C; the MS ion source was held at 230°C and the MS quadrupole at 150°C. The MS was run in scan mode from 50–550 amu (5–25 minutes), 50–750 amu (25–30 minutes) and 50–800 amu (35–63 minutes). Data were processed using Agilent ChemStation software, v.E.02.02.

Most X-ray diffraction patterns were obtained with a Bruker D8 Discover with GADDS (General Area Detector Diffraction Solution) equipped with a rotating anode and cobalt target. The patterns were measured at 45 kV and 75 mA, or at 40 kV and 85 mA, using a 0.5 mm collimator. A few patterns were obtained using a Rigaku RTP 300 RC rotating anode generator with a cobalt target using a microdiffractometer and a 0.1 mm collimator. The generator was operated at 45 kV and 160 mA.

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19 A form, specifically designed for the project, provided cues to ensure the examination and documentation of details were as complete and consistent as possible. The form was created in collaboration with Barbara Klempan, who had had experience examining portraits by Dulongpré during her time as paintings conservator at Library and Archives Canada.

20 Wehlte, Kurt, *The Materials and Techniques of Painting* (New York: Prentice Hall Press, 1975), p. 345.

21 The stretcher for the SSH version of the portrait was a 2-key corner joint. The stretcher for the NGC version, unavailable at the time of examination, is also presumed to be a 2-key stretcher, but was described as having open key slots when the painting was acquired. National Gallery of Canada (NGC) Conservation File for Portrait of Jean Dessaulles (18039), accessed February 2016.

22 The fabric has a pattern of narrow blue stripes, 0.65 cm wide, composed of a thick central stripe with a thin stripe on each side. This pattern continues across the entire canvas with a centre-to-centre repeat of 1.3 cm.

23 Thread counts were generally measured from exposed tacking margins or were taken from before treatment condition reports. Several measurements were taken, and an average value was used. The thread count for the portrait of Antoine Girouard was measured through the paint layer. For the portrait of Abbé Boissonnault, the lining made detailed observation of the canvas impossible. However, an exhibition catalogue from 1980 indicated that the thread count was 17 warp threads by 13 weft

threads per centimetre. See: Musée du Québec and Laboratoire de recherche des musées de France, *Analyse Scientifique des Œuvres d'Art* (Québec, QC: Musée du Québec, 1980), pp. 61–75. This reference also provides an image of the X-radiograph of the portrait of Abbé Boissonnault, showing its even density.

[24] In five of these six paintings, the tacking margins were present and the lack of ground on the margins was observed directly. In one case (portrait of Thomas McCord), a raised lip of ground along the lower and right edge indicates that the ground was applied only up to the edges of the auxiliary support. This painting also showed a change in density in the X-ray at the inner edge of the original stretcher bar indicating that the ground was applied with the canvas attached to the stretcher.

[25] The presence of coccoliths, identified using polarized light microscopy in ground samples from almost all paintings, as well as in a number of the paint samples, indicated that the calcium carbonate is in the form of chalk. See: Gettens, Rutherford J., Elisabeth West FitzHugh and Robert Feller, "Calcium Carbonate Whites," in: *Artists' Pigments: A Handbook of their History and Characteristics*, vol. 2, edited by Ashok Roy (Oxford: Oxford University Press, 1993), pp. 157–190.

[26] Carlyle, Leslie, *The Artist's Assistant: Oil Painting Instruction Manuals and Handbooks in Britain 1800–1900 with Reference to Selected Eighteenth-Century Sources* (London: Archetype Publications, 2001), pp. 57–97.

[27] Carlyle, *The Artist's Assistant*, 2001, pp. 233–237.

[28] Mills, John S. and Raymond White, *The Organic Chemistry of Museum Objects*, 2nd edition (London: Butterworth-Heinemann, 1994), pp. 171–172.

[29] The presence of specific cyclic markers (predominantly methyl 9-(2-propylphenyl)nonanoate and methyl 8-(2-butylphenyl) octanoate) indicate the presence of an oil that has been heated and originally had a high linolenic acid content, indicating heated linseed oil. See: van den Berg, Jorrit D.J., Klaas Jan van den Berg and Jaap J. Boon, "Identification of non-cross-linked compounds in methanolic extracts of cured and aged linseed oil-based paint films using gas chromatography-mass spectrometry," *Journal of Chromatography A*, vol. 950, 2002, pp. 195–211, <doi.org/10.1016/S0021-9673(02)00049-3>.

[30] Carlyle, *The Artist's Assistant*, 2001, pp. 23–26.

[31] Carlyle, *The Artist's Assistant*, 2001, pp. 101–137.

[32] Levenson, Rustin Steele, "Materials and Techniques of Painters in Québec City, 1760–1850," *Journal of Canadian Art History*, vol. 7, no. 1, 1983, pp. 1–54.

[33] Helwig, Kate, "Iron Oxide Pigments: Natural and Synthetic," in: *Artists' Pigments: A Handbook of their History and Characteristics*, vol. 4, edited by Barbara H. Berrie (Washington, DC: National Gallery of Art, 2007), pp. 39–109.

[34] White, Raymond, "Brown and Black Organic Glazes, Pigments and Paints," *National Gallery Technical Bulletin*, vol. 10, 1986, pp. 58–71.

[35] Feller, Robert L. and Ruth M. Johnston-Feller, "Vandyke Brown (Cassel Earth, Cologne Earth)," in: *Artists' Pigments: A Handbook of their History and Characteristics*, vol. 3, edited by Elisabeth West FitzHugh (Washington, DC: National Gallery of Art, 1997), pp. 157–190.

[36] Languri, Georgiana M., *Molecular Studies of Asphalt, Mummy and Kassel Earth Pigments: Their Characterisation, Identification and Effect on the Drying of Traditional Oil Paint* (Amsterdam: FOM Institute for Atomic and Molecular Physics, 2004), pp. 73–115.

[37] Bouchard, Michel and David C. Smith, "Catalogue of 45 reference Raman spectra of minerals concerning research in art history or archaeology, especially on corroded metals and colored glass," *Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy*, vol. 59, no. 10, 2003, pp. 2247–2266, <doi.org/10.1016/S1386-1425(03)00069-6>.

[38] In all paintings, the vermilion displayed coarse, angular particles, consistent with either natural cinnabar or synthetic dry process vermilion. See: Gettens, Rutherford J., Robert L. Feller and W.T. Chase, "Vermilion and Cinnabar," in: *Artists' Pigments: A Handbook of Their History and Characteristics*, vol. 2, edited by Ashok Roy (Washington, DC: National Gallery of Art, 1993), pp. 159–180.

[39] In addition, using GC-MS, tartaric acid and protein were found associated with the red lake in a sample from the portrait of Isaac Todd; these compounds are known to have been additives in the manufacture of carmine lakes during the eighteenth and nineteenth centuries. See: Kirby, Jo, Marika Spring and Catherine Higgitt, "The Technology of Eighteenth- and Nineteenth-Century Red Lake Pigments," *National Gallery Technical Bulletin*, vol. 28, 2007, pp. 69–95.

[40] Pisareva, Svetlana, "Some Occurrences of Patent Yellow," *Studies in Conservation*, vol. 50, 2005, pp. 33–36, <doi.org/10.1179/sic.2005.50.1.33>.

[41] Wainwright, Ian N.M., John M. Taylor and Rosamond D. Harley, "Lead Antimonate Yellow," in: *Artists' Pigments: A Handbook of Their History and Characteristics*, vol. 1, edited by Robert L. Feller (Washington, DC: National Gallery of Art, 1986), pp. 219–254.

[42] Hradil, David, Tomas Matys Gryar, Janka Jradilova, Petr Bezdicka, Veronika Grunwaldova, Igor Fogaš and Costanza Miliani, "Microanalytical identification of Pb-Sb-Sn yellow pigment in historical European paintings and its differentiation from lead tin and Naples yellows," *Journal of Cultural Heritage*, vol. 8, 2007, pp. 377–386, <doi.org/10.1016/j.culher.2007.07.001>.

[43] Grissom, Carol A., "Green Earth," in: *Artists' Pigments: A Handbook of Their History and Characteristics*, vol. 1, edited by Robert L. Feller (Washington, DC: National Gallery of Art, 1986), pp. 141–168.

[44] Consistent with the portraits of Isaac Todd and James McGill, patent yellow has been identified in another early work by Dulongpré, a portrait of Julie Boucher de la Perrière, in the collection of the National Gallery of Canada (accession no. 42907). This painting, dating from *circa* 1805, was not included in the present study because it was acquired by the NGC after the Dulongpré portrait study was already underway. While several paint samples were analyzed at CCI during the conservation treatment of the portrait, it would be interesting to undertake a complete technical examination to determine how its materials and techniques compare with the other early portraits included in this study. See: Helwig, Kate, Jane Sirois and Jennifer Poulin, *Analysis of Samples from* Portrait of Julie Boucher de la Perrière, report CSD 4765 (Ottawa: Canadian Conservation Institute, 6 October 2010). Unpublished report.

[45] A photograph from George-Casimir Dessaulles' dining room in Saint-Hyacinthe, dated 1919, shows what appears to be the NGC version of the portrait, hanging alongside portraits of Antoine Girouard and Rosalie Papineau-Dessaulles. It seems likely the NGC version of the portrait was painted for the family, while the SSH version was painted for the seminary. In this same photograph, it is clear that the portrait of Antoine Girouard differs from the SSH version in scale and composition; it is possible that it corresponds to another version of the portrait of Antoine Girouard that has been lost. See: LeBlanc, Diane, *Le Séminaire de Saint-Hyacinthe*, 2011, p. 28.