



## **Contexts for Conservation**

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**Fields Of Colour: The Conservation Of Matt, Synthetic Paintings By Michael Johnson.**

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#### **ABSTRACT**

Three paintings by Michael Johnson, *Frontal 2* 1968, *Night* 1968, and *Matthew's cavern* 1974, are representative of the artist's work in acrylic and vinyl emulsion paints during the late 1960s to early 1970s. They incorporate broad colour areas of highly pigmented paint with matt surfaces and multilayered paint films.

The matt surfaces of the paintings are extremely fragile. Accidental contact has caused abrasions and scuffs to all the paintings. *Frontal 2* 1968 had additionally been scratched with a pencil. *Matthew's cavern* 1974 has been retouched with poor matching of the original matt surface. All these small damages were visually disturbing due to the flat and even surfaces of the paints.

This paper describes the complex multidisciplinary research required to undertake appropriate and successful conservation treatments on vulnerable and ageing synthetic paint mediums. This includes several interviews with the artist and the comparison of the artist's recollection of his paint mediums against instrumental analysis.

The retouching of the damages on the paintings was undertaken with Aquazol 500®, Poly (2-ethyl-2-oxaline), and pigments. The treatment required finding a balance between minimal retouching, while reducing broad areas of surface disturbance.

#### **KEYWORDS**

Michael Johnson; painting; contemporary; synthetic polymer paint; aquazol 500®; Art Gallery of New South Wales

#### **INTRODUCTION**

In undertaking conservation and restoration treatments of artworks made with synthetic polymer paints, the principle of minimalism and the use of analysis are essential. Synthetic paints are relatively new products and it is still largely unknown how they will age or react with common conservation products. As on-going research on the cleaning of synthetic paintings has shown (Ormsby and Learner 2009; Digney-Peer 2004), the nature of the

components can have a significant impact on the treatments applied. During the period of the paintings in this study there were two types of synthetic emulsion paints available to artists: polyvinyl acetate and acrylic. Acrylic paints were themselves generally of two types; both methyl methacrylates, but copolymerised either with *n*-butyl acetate or ethyl methacrylate (Learner 2004). Therefore, before starting the conservation work of Michael Johnson's *Frontal 2* 1968, *Night* 1968 and *Matthew's cavern* 1974, identification of the type of synthetic paints was critical to inform the conservation treatment. Careful decision making, in collaboration with the artist and curator, was also important to determine the extent of restoration of damages that was appropriate. The least contact of the fragile matt surfaces of the paintings caused abrasions and scuffs that were visually disturbing. *Frontal 2* 1968, also had an 'A' shape mark done with a pencil in the centre of its lower half. With such large flat paint surfaces, damage in the form of scuffs and abrasions are a very likely occurrence. The artists own thoughts on the paintings condition, on how they should now be presented and his ideas about how he would like to see them restored, were critical in determining the conservation treatment.

In 2010, Michael Johnson was interviewed by painting conservators Simon Ives and Stewart Laidler regarding the condition of *Frontal 2* 1968 and *Night* 1968. In 2011, painting conservator Andrea Nottage and Head Curator of Australian Art Wayne Tunnicliffe also met with the artist. To supplement the information gathered during these interviews, all the colours of the three paintings were analysed with Fourier transform infrared (FTIR) spectroscopy and X-ray fluorescence (XRF).

The paintings were treated by dusting and the main damages were retouched with Aquazol 500®, Poly (2-ethyl-2-oxaline), and pigments. Aquazol 500® was chosen as a retouch medium due to its controlled gloss level to match that of the paintings and its reversibility when used for retouching polyvinyl acetate and acrylic paints. The artist was invited to view the completed treatments and comment on the outcome. This meeting was also the opportunity to collect samples of paints, donated by the artist. These samples will become part of the Artists' Materials Archive at the Art Gallery of New South Wales. This archive is used to develop an analytical reference library of known artist's materials that will be of value in future research on artists' materials.

## **MICHAEL JOHNSON, THE 1960s-1970s**

Michael Johnson was born in Sydney on the 17<sup>th</sup> of March 1938. His father, Percy Samuel Johnson, was an illustrator who taught him the theory of colours and instructed him in drawing. In 1952, he left school and started working for Lintas Advertising Company in Sydney. One of his co-workers was Brett Whiteley with whom he became very good friends. In 1956, he left Lintas and began freelancing as an illustrator. He took drawing classes in art schools, at the Julian Ashton Art School and the National Art School.

In 1960, Michael Johnson moved to London. He spent his time painting and working as a studio assistant for artists such as the sculptor Brian Wall in 1962, the painter Michael Kidner in 1963 and the sculptor Anthony Caro in 1964. Michael Johnson's paintings from this period were made of multiple stretched canvases joined together into a single work. The paint layers were brushed, producing matt surfaces. His main medium was synthetic emulsion paint. The first type of synthetic emulsion paint he used was Vinavil™, an Italian polyvinyl acetate product that he mixed with pigments. Vinavil™ was quickly replaced with acrylic paint. As Michael Johnson considered the English range of acrylic colours to be poor, he bought the

French brand, Lefranc & Bourgeois. He described his paintings from this time as matt, 'very dry, chalky and very scratchable and markable' (Johnson 2010). Acrylic served the aesthetic and intellectual purpose he wanted at that time. The work was quick, efficient and he could obtain paint layers that soaked readily into the canvas. During these early experiments with polyvinyl acetate and acrylic emulsions he continued to also use oil paint. Oil paint was, and remains, his favourite paint medium.

The biggest nightmare of my life was when I was getting out of watercolours into oil. I fear oil, even though it is the most natural thing to paint with and I love it. But I fear its trickery. You can never get too clever with it. (Johnson cited in Pearce 2004)

In 1966, Michael Johnson sent nineteen 1964 paintings to Sydney for exhibition. These were done with synthetic emulsion or a combination of oil and synthetic emulsion. Some paintings had at least thirty layers of paint on them. His technique changed depending on the type of paint he used. For example, with synthetic emulsion paint he used masking tape to create the edges of the geometrical shapes while the oil paint enabled him to paint edges freehand with a brush. In spring 1967, Michael Johnson returned to Australia. He stopped using brushes and began applying his paint by spray gun. He was using the acrylic paint Chromacryl® manufactured by Chroma, that he applied in several thin layers. In 1968, the National Gallery of Victoria and the Art Gallery of New South Wales hosted the *The Field* exhibition. This presented works by contemporary Australian artists that had a shared contemporary artistic style. Michael Johnson's painting *Frontal 2* 1968, was included alongside works by Dick Watkins and Sydney Ball.

From 1969 to 1975, Michael Johnson lived in New York where he had several exhibitions and worked for dance companies among other things. In 1975, he moved back to Australia. His exhibition *Taylor Square* at the Gallery A in 1979 marked the end of his geometrical paintings. In 1981, he gave up acrylic paint because he no longer liked its inertness. He wanted to find his touch again. He has used oils exclusively since then.

### ***FRONTAL 2 1968, NIGHT 1968, AND MATTHEW'S CAVERN 1974***

Michael Johnson considers *Frontal 2* 1968 (Figure 1) a landmark painting for his career. It was he said the beginning of something new in his work. The idea for the painting developed in the early 1960s in London. Five years later, back in Australia, he began the work using his notes. The artist conceived of it as a symbolic house. The symmetrical composition and the matt surface are intended to give the viewer a desire to be drawn into it and even to touch it. It is made of four canvases: a brown painted squared one in the centre, surrounded by two blue rectangles on the sides and a black one at the top.

*Night* 1968 (Figure 2) was purchased by the Art Gallery of New South Wales in November 1968, following his exhibition at the Gallery A. It was his first painting to enter a public collection. *Night* 1968 is made of six canvases on which the colours were brushed in a few layers, a central purple canvas onto which are attached three blue horizontal canvases, and two black canvases on the sides of the painting. Unlike *Frontal 2* 1968, that is more directly painted, the final colours for *Night* 1968 are made from the layering of different colours. According to the artist, there is a red layer under the blue. The blue colour that looks like a Prussian blue is black.

For example that blueberry-type painting in the Gallery called *Night* – the green, and the blueberry and the black on it - I had all the forms built and I thought, what now, what colour?...I went out into the night and looked up at the sky. I could see all the particles of energy, and felt this great mass of colour, felt it... it was a black night, so the colours I imagined rather than saw. I put down a blue under a red, and a green under the same red, which became the blueberry. (Johnson 2002)

*Matthew's cavern* 1974 (Figure 3) entered the Art Gallery of New South Wales collection in 2011. Its title comes from the camp Michael Johnson's son set up in the loft on top of his studio in New York. He painted it in approximately three days. Currently it takes him three months to complete a painting. The painting is made of only one stretched canvas. Three stripes, blue, green and red are painted on the black background.

## THE ARTIST'S INTERVIEWS

Prior to any conservation treatments, the painting conservators and curator of the Art Gallery of New South Wales met with the artist. It was the opportunity to supplement the knowledge about these paintings from the primary source. The artist was interviewed again after the conservation treatments in order to obtain his point of view on the conservation work done on the paintings.

Since they were acquired *Frontal 2* 1968 and *Night* 1968 have rarely been displayed due to their poor condition. In 2010 the idea of treating *Frontal 2* 1968 and *Night* 1968 was first raised. The damages of *Frontal 2* 1968 were scuffs, abrasions and a pencil 'A' shaped graffiti. The main damages on *Night* 1968 were scuffs, abrasions and the top edges of the multiple canvases were dusty and discoloured. Their matt, even, synthetic polymer paint surfaces make them difficult to treat.

For this reason, it was decided to talk to the artist prior to any treatment. Simon Ives and Stewart Laidler, painting conservators at the Art Gallery of New South Wales, interviewed Michael Johnson in 2010. Several topics were discussed during the interview. These were: what did Michael Johnson think about the damages, especially in terms of his work aesthetic? Were they disturbing his message and the way in which the public should see and enjoy his paintings? In regard to conservation treatments, has he ever done any himself? If yes, what kind? What treatments would he think of for these two paintings, and what were his ideas about the storage and display of his paintings?

Michael Johnson responded that one of the purposes of his matt field paintings was to make the viewer want to physically enter them. He is amused when people touch his paintings and does not mind when it is done by a child. As long as 'the grain of the canvas is not damaged' he doesn't think the damage is serious (Johnson 2002). Even so, he also feels that a mark on them can be very disturbing visually. Although he believes that most of the time an artist should be kept from working on their paintings once finished, he has restored his own paintings on a few occasions. His treatment of abrasions and scuffs generally involved retouching the damaged area or repainting a whole section. If he is not the one restoring his paintings, he would prefer if he were consulted about it. Regarding the display of his paintings, he doesn't like Perspex® boxes but understands that his paintings are very fragile and need some kind of protection. He acknowledges that placing his works behind Perspex® would provide protection and reduce the need for conservation treatment.

When the painting *Matthew's cavern* 1974 entered the Art Gallery of New South Wales collection in 2011, Wayne Tunnicliffe (Head curator of Australian art) and Andrea Nottage (painting conservator) met with the artist in order to talk about conservation treatment. On viewing the painting Michael Johnson immediately observed that the painting was upside down and that the orientation of the staples was not his. Apparently the canvas had been unstretched and restretched with the strainer upside down. Other treatments had also been undertaken on the painting, a tear repair and retouching in the green stripe.

Michael Johnson's main concerns about the painting were the abrasions in the black in the centre, and the abrasions and retouching in the green stripe. He didn't mind the other fine scratches and scuffs. He thought the retouching could be done by blowing the same paint through a straw but he didn't feel confident to do it himself. Andrea Nottage subsequently treated the painting with a surface cleaning with a modular cleaning mixture of a buffer (7.5 pH), a surfactant Maypon 4C® and distilled water.

## **MATERIALS ANALYSIS**

Working on three paintings by Michael Johnson was the opportunity to look closer at his materials and technique. Two analytical techniques were used to examine the three paintings, Fourier transform infrared (FTIR) spectroscopy and X-ray fluorescence (XRF). With the approval of Wayne Tunnicliffe, the curator, a sample was taken from each colour of each painting for analysis with FTIR. With the results of the analysis combined with the artist's information, we were able to increase our knowledge about his materials during this period of his career. All the results are presented in the Table 1.

### **Instrumentation**

$\mu$ FTIR spectroscopy was undertaken with a Thermo Nicolet Centaurus equipped with a MCT/B detector and a KBr beamsplitter. The samples were placed on a diamond window, flattened with a metal roller and placed under the microscope. The spectral range was between 550 and 4000  $\text{cm}^{-1}$  wavenumbers. The detector measured the intensity of the absorbed radiations for every wavelength and transformed them into an electrical signal. The results of the analysis are shown as an absorbance spectrum that represents the different chemical groups present. It is a qualitative and not quantitative analysis method. In order to determine the nature of the components of the paints a library auto search facility in the Omnic software was used. It identified at least one component for almost every sample. To find the other components, Learner's (2004) description of the analysis of modern paint media with FTIR spectroscopy was used as reference, as well as the in-house and purchased spectral libraries.

The portable XRF employed was a Bruker TRACeR III-V with a Si-Pin detector and a Rhodium X-ray tube. Portable XRF analysis is a non destructive technique. The portable analyser installed on a tripod was placed in front of the areas to be analysed, as close as possible to the surface of the painting without touching it. Two series of measurements were made per area, a mid-mass one and a low-mass one. For the mid-mass measures, the voltage was 40 kV and the electrical current of 1.10  $\mu\text{A}$ . The low mass measures had a 15 kV voltage and an electrical current of 15  $\mu\text{A}$ . Each measure lasted 200 seconds.

## Results and discussion

The distinction of acrylic from polyvinyl acetate (PVA) binders with FTIR is challenging as the two spectra share many absorbance peaks. The critical differences as illustrated by Learner (2004 pp. 82-84) is the presence of a triplet of peaks (2875, 2930, 2966) in the C-H stretching frequencies between 2875 and 2966 in the plasticised PVA, compared to a double absorbance peak (2877, 2960) in the butyl metacrylate acrylic co-polymer. A second difference is noted by Learner in the larger absorbance peak in the PVA at  $1240\text{cm}^{-1}$  compared to acrylics. In practice many of the other distinguishing peaks may be difficult to see due to the use of filler pigments in the paints such as gypsum (calcium sulphate) and chalk (calcium carbonate), both of which have large broad absorbance peaks.

The pigment content of the three colours on *Frontal 2* 1968 were identified as ultramarine blue, burnt umber and ivory black (Table 1.). There were no other filler pigments identified in the paints on this work. After excluding peaks associated with pigments, FTIR spectra of the three colours from *Frontal 2* 1968 were found to be similar to each other, suggesting the binder was the same for the three colours on the painting. As the brown paint gave few interfering absorbance peaks related to the umber, this sample gave the clearest spectrum for the binder that matches with poly *n*-butyl acrylate/methylmetacrylate (*n*BA-MMA) (Figure 5). This analytical result corresponds with Michael Johnson's recollections of the paint and pigments he used for the painting in which he noted that it was 'Jim Cobb's paint' (Chromacryl®) (Johnson 2013)

*Night* 1968 gave complex FTIR spectra and some of the detail of the binder absorbance peaks was hidden by the strong response from the chalk filler in all the paint colours. The presence of chalk filler did however indicate that the paints on this work were a different formulation to those on *Frontal 2* that did not have chalk. The pigments on *Night* 1968 were identified as copper phthalocyanine blue (PB15), quinacridone red (PR 122) and the black probably as mars black due to the significant peak for iron in the XRF spectrum. All of the FTIR spectra from this painting showed a triplet absorbance peak in the C-H region and a proportionally large and significant peak at  $1240\text{cm}^{-1}$  suggesting that these paints may be PVA. The difference between the binder absorbance peaks in the two paintings from 1968 are well described by the comparison of the brown paint sample from *Frontal 2* 1968 against the black paint of *Night* 1968 (Figure 5)

The analysis of the four colours on *Matthew's cavern* 1975 found good FTIR spectral matches with each other for the binders in all the colours. Like those from *Night* 1968, the samples from *Matthew's cavern* 1975 gave FTIR spectra with consistent C-H triplet and a large  $1240\text{cm}^{-1}$  absorbance, suggesting that this work was also painted in PVA. This is consistent with Michael Johnson's recollection that he used Flashe® from Lefranc & Bourgeois for this painting (Johnson 2011), as Flashe® colours are based on polyvinyl acetate binders. The red paint gave a good FTIR spectral match for toluidine red (PR3). While the blue pigment in the green and blue colours could not be identified, the green was found to have a synthetic organic yellow, arylamide yellow PY3. The black had some Prussian blue but may be principally mars black, (although the iron in the XRF cannot be distinguished from iron related to Prussian blue). Three of the colours contained gypsum and two contained chalk as filler pigments.

## THE CONSERVATION OF THREE PAINTINGS BY MICHAEL JOHNSON

The first step of the conservation work done on each painting was to dust them with an antistatic brush and a vacuum cleaner. The dustiest painting was *Night 1968*, which had a thick layer of dust on top of the fold over edges of the horizontal blue canvases. After dusting them, a thin layer of dust remained embedded in the paint film. It had the effect of creating a light grey colour. When Michael Johnson saw *Night 1968*, he immediately noticed it. As the painting is symmetrical, he suggested turning the painting upside down. The colour on the bottom fold over edges of the blue canvases has been preserved from the dust and look much more like the original colour.

The scuffs and abrasions were retouched with Aquazol 500®, Poly (2-ethyl-2-oxaline), mixed with pigments. The Aquazol® is a synthetic adhesive created in 1986 by Dow Chemical Company. It is now produced by Polymer Chemistry Innovations Inc. There are four types of Aquazol® depending on their molecular weight: Aquazol 5®, Aquazol 50®, Aquazol 200® and Aquazol 500®<sup>1</sup>. All of them except from the Aquazol 5® are used in conservation treatments as consolidants, adhesives, filling media and retouching media. It is considered reversible on both acrylic and PVA paints. Light ageing tests suggest it has good stability and should remain water soluble (Wolbers et. al. 1998). As a retouching medium it gives a very matt paint film.<sup>2</sup> The Aquazol 500® was dotted with a very fine brush in the areas of abrasions. As the three paintings were covered with these damages and in order to keep our treatment minimal, only the most visible damages were retouched. Once the treatment was complete, the paintings were taken in the rooms of the Gallery to see how they looked under the lights in the display rooms.

The two most difficult colours to retouch in terms of colour matching were the blue of *Frontal 2 1968* and the green of *Matthew's cavern 1974*. The retouching of the blue colour showed how valuable artists' interviews and materials archives can be. In his 2010 interview (Johnson 2010), Michael Johnson mentioned that he had been inspired by Yves Klein for the ultramarine pigment he used for *Frontal 2 1968*. When testing the different ultramarine pigments available in the lab, the only good match turned out to be an Yves Klein's pigment that is part of an Artists' Materials Archive at the gallery.

Once the paintings had been treated, Michael Johnson was invited to look at them (Figure 5). His response to the conservation treatment was that he was very happy with it and thought the work was subtle. He said he was expecting the worst, although he did not say what he was worried would be done to his paintings. His main concern was their vulnerability in a public gallery and how to ensure their security. Michael Johnson does not like physical barriers that create a visual disruption to viewing his paintings. He would rather Perspex®, perhaps as a floating glass panel extending beyond the artwork and secured to the wall. When he painted the works he did not realize how fragile they would become. The only thing that mattered to him at the time was the experience of painting.

## CONCLUSION

*Frontal 2 1968*, *Night 1968*, and *Matthew's cavern 1974* are good examples of Michael Johnson's paintings during the 1960s and early 1970s. Like many artists at this time, he discovered the synthetic emulsion paints and used them extensively in his work. The three

paintings have geometrical shapes on which the artist painted even matt surfaces. As they presented the same types of damages, scuffs and abrasions, the simultaneous conservation of all three paintings was justified. One of the wonderful outcomes of working with contemporary art work is the exchange with artists. All the details Michael Johnson gave about his techniques and materials are valuable information for conservators. Michael Johnson kindly agreed on three occasions to answer the numerous questions the conservators from the Art Gallery of New South Wales put to him. His answers were used to decide what conservation treatments and will also be useful in the future.

During the last interview with the artist, whose purpose was to gain his thoughts about the conservation treatments undertaken, the artist agreed to give the Art Gallery of New South Wales materials (paints, brushes) that he has used to form part of a growing Artists' Material Archive.

## **ACKNOWLEDGEMENTS**

We would like to thank Michael Johnson for sharing his memories and experiences with us. This collaboration has been very interesting and fruitful and we hope to have the opportunity to work with him again. The authors would also like to thank Andrea Nottage, Wayne Tunnicliffe and Stewart Laidler for the interviews they conducted with Michael Johnson. The information they gathered was valuable help in our work.

## **BIOGRAPHY OF THE AUTHORS**

### *Céline de Courlon*

Céline de Courlon is a French Paintings Conservator doing a one-year Contemporary Art Fellowship at the Art Gallery of New South Wales. After B.A. Degree in Art History at the Sorbonne in Paris in 2005, she gained a Masters in Conservation of Paintings at the Institut national du patrimoine in Paris in 2012. She has undertaken a number of internships in both private and public practice in France and England including the Centre Pompidou in Paris in 2010 and Tate Modern in London 2011.

### *Simon Ives*

Simon Ives is a Paintings Conservator at the Art Gallery of New South Wales. He gained a Masters degree Fine Art Conservation with a specialism in easel paintings at the University of Northumbria (UK) in 1994. He worked at the Tate Gallery in London before returning to Australia in 1995 when he first worked at the Art Gallery of New South Wales. He has worked at the National Gallery of Australia and in private practice in Australia. He has a Masters degree in Painting and is completing a degree in Fine Art Education. He has written a number of articles for Look, Artonview and Artists Profile magazines on artists' materials and techniques.

### *Paula Dredge*

Paula Dredge is Head of Paintings Conservation at the Art Gallery of New South Wales where she has worked since 1990. She has a Bachelor of Applied Science in Conservation of Cultural Materials from the University of Canberra and a Bachelor of Arts in Art History

from the University of Sydney. She is currently completing her PhD with the centre for Cultural Materials Conservation at the University of Melbourne. The title of her thesis is Sidney Nolan and paint. A study of an artist's use of commercial ready-made paints in Australia 1938-1953.

## ENDNOTES

<sup>1</sup> Compared to Raman analysis, FTIR is usually a good technique to differentiate the different types of acrylic. Unfortunately in this case, it wasn't possible.

<sup>2</sup>The FTIR can be coupled with separation techniques such as size exclusion chromatography. SCALARONE Dominique and CHIANTORE Oscar, "Separation techniques for the analysis of artists' acrylic emulsion paints", in *J Sep Sci*, 27(4), March 2004, p. 263-274

<sup>3</sup>The Raman analysis has proven to be a more efficient analytical technique for the organic pigments and even inorganic pigments such as the blacks.

<sup>4</sup>Product Information Sheet by Polymer Chemistry Innovations Inc.

<sup>5</sup>A research done by the author in 2012 about the retouching of scuffs on matt surfaces showed that Aquazol 500® is very efficient. It forms a matt paint layer that has a good covering and colouring powers and can hide the glossiness of a surface created by scuffs.

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## **MATERIAL**

Aquazol 500®, Poly (2-ethyl-2-oxaline) from Talas, 330 Morgan Ave, Brooklyn, NY 11211, USA, [www.talasonline.com](http://www.talasonline.com)

## **ILLUSTRATIONS AND FIGURES**

Figure 1: *Frontal 2*, 1968. Synthetic polymer paint on canvas, 198.5 x 214 cm. Collection: Art Gallery of New South Wales. Gift of Michael and Margot Johnson 2000. © Michael Johnson/VISCOPY

Figure 2: *Night*, 1968. Synthetic polymer paint on canvas, 152.4 x 214 cm. Collection: Art Gallery of New South Wales. © Michael Johnson/VISCOPY

Figure 3: *Matthew's cavern*, 1974. Synthetic polymer paint on canvas, 183 x 183 cm. Collection: Art Gallery of New South Wales. Gift of Francis Douglas 2011. Donated through the Australian Government's Cultural Gifts Program. © Michael Johnson/VISCOPY

Figure 4: FTIR spectra of the brown colour of *Frontal 2* 1968 and the black colour of *Night* 1968, binder peaks specified

Figure 5: Michael Johnson in front of *Night*, 1968

Figure 6: A selection of brushes used by Michael Johnson

Table 1: FTIR and XRF analysis of three paintings by Michael Johnson

Table 1: FTIR and XRF analysis of the three paintings

Painting	Sample	FTIR binder (identifying peaks $\text{cm}^{-1}$ )	FTIR pigment (identifying peaks $\text{cm}^{-1}$ )	XRF	Result (possible)
<i>Frontal 2</i> 1968	Blue	(2956, 2927, 2874, 2853, 1735, 1451, 1377, 1239)	Ultramarine Blue (1013, 691, 661)	Al, Si, S, K, Ca, Zn, Fe, [Ti]	Acrylic + synthetic ultramarine, (zinc oxide)
<i>Frontal 2</i> 1968	Brown	Acrylic, butyl methacrylate co-polymer (2958, 2875, 1737, 1450, 1387, 1238, 1166, 844)	Burnt umber (1040, 799)	Fe, Mn, Ca, K [Si]	Acrylic + burnt umber
<i>Frontal 2</i> 1968	Black	(2923, 2855, 1737, 1455, 1417, 1377, 1241)	Ivory black (2013, 1034, 601)	P, Ca, Fe, Zn [S]	Acrylic + ivory black (mars black and zinc white)
<i>Night</i> 1968	Blue	(2959, 2932, 2874, 1735, 1241, 1023)	Chalk (2513, 1794, 1428, 877) Copper phthalocyanine PB15 (1506, 1242, 1167, 1120, 1092, 949)	Ca, Cu, K [Fe]	PVA + phthalocyanine blue PB15 + chalk
<i>Night</i> 1968	Purple	(2960, 2935, 2874, 1736, 1240, 1023)	Chalk (2510, 1794, 1430, 877) Quinacridone red (1604, 1587, 1552, 1458, 1343, 812)	Ca, K [S, Fe]	PVA + quinacridone red PR 122 + chalk
<i>Night</i> 1968	Black	(2959, 2930, 2875, 1736, 1434, 1373, 1240, 1165, 1117, 1025, 947, 877)	Chalk (2513, 1794, 1434, 877, 712)	Fe, Ca [K]	PVA + chalk (mars black?)
<i>Matthew's cavern</i> 1974	Blue	(2962, 2932, 2873, 1740, 1241, 1025, 947)	Chalk (2513, 1796, 1430, 877, 713) Gypsum (3550, 3406, 1620, 1119, 669, 604)	Ca, Zn Ti/Ba, S [Mn, K, Sr]	PVA + chalk + gypsum (zinc white, barium sulphate, manganese blue)
<i>Matthew's cavern</i> 1974	Red	(2960, 2930, 2874, 1738, 1372, 1233, 947)	Chalk (2513, 1797, 1446, 875, 712) Gypsum (3542, 3401, 1109, 668, 601) Toluidine red (1620, 1620, 1563, 1497, 1471, 1446, 1401, 1343, 1323, 1301, 848, 812, 753)	S, Ca, [Sr, Fe, Si, K]	PVA + toluidine red PR3 + chalk + gypsum

<i>Matthew's cavern</i> 1974	Green	(2962, 2931, 2870, 1740, 1236, 950)	Gypsum (3546, 3491 3408, 1620, 1119, 669, 602) Arylamide yellow (3113, 1672, 1620, 1593, 1585, 1567, 1535, 1504, 1479, 1442, 1373, 1336, 1280, 894, 754)	Cu, Zn, Ca, S, Ba [Fe, Sr, P, K]	PVA + gypsum + arylaminde yellow PY3 + (barium sulphate, phthalocyanine green PG23)
<i>Matthew's cavern</i> 1974	Black	(2957, 2935, 2975, 1736, 1447, 1376, 1242, 1146, 1028, 950, 876)	Prussian blue (2073)	Cr, Fe, Ca, K, S [Si, P]	PVA + Prussian blue (chrome green, ultramarine blue)

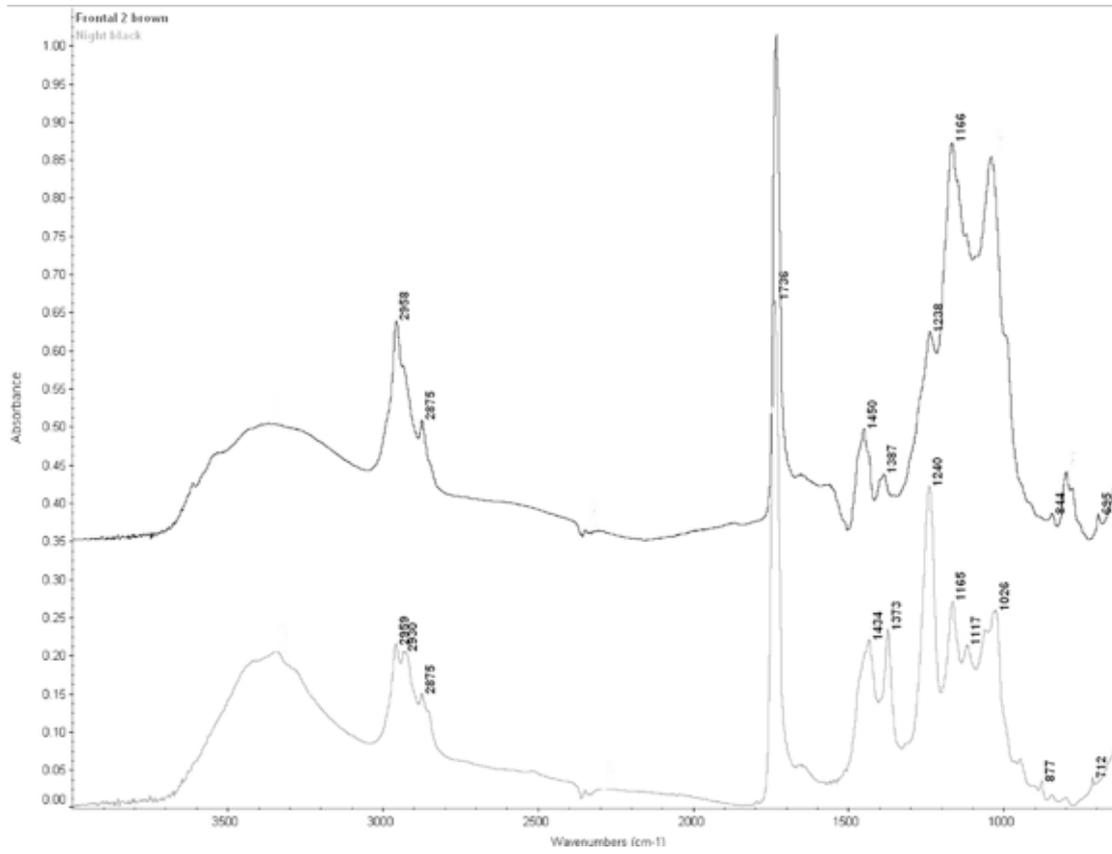


Figure 4: FTIR spectra of the brown colour of Frontal 2 1968 and the black colour of Night 1968, binder peaks specified



Figure 6: A selection of brushes used by Michael Johnson