



NATIONAL GALLERY TECHNICAL BULLETIN

VOLUME 28, 2007

National Gallery Company
Limited

Distributed by
Yale University Press

This volume of the *Technical Bulletin* has been funded by the American Friends of the National Gallery, London with a generous donation from Mrs Charles Wrightsman.

Series editor Ashok Roy

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First published in Great Britain in 2007 by
National Gallery Company Limited
St Vincent House, 30 Orange Street
London WC2H 7HH

www.nationalgallery.co.uk

British Library Cataloguing in Publication Data
A catalogue record for this journal is available from
the British Library

ISBN 978 1 85709 357 5
ISSN 0140 7430
525049

Publisher Kate Bell
Project manager Jan Green
Editor Diana Davies
Designer Tim Harvey
Picture research Suzanne Bosman
Production Jane Hyne and Penny Le Tissier
Repro by Alta Image, London

Printed in Italy by Conti Tipocolor

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Monet's Palette in the Twentieth Century: *Water-Lilies* and *Irises*

ASHOK ROY

THE NATIONAL GALLERY possesses two large late paintings by Claude Monet dating from the years in which he was working on his grand Water-Lily Decorations which were ultimately donated by the artist to the French state.¹ The National Gallery *Water-Lilies* (NG 6343; Wildenstein no. W1978; ² PLATE 1) was painted as one of many variations of the water-lily pond theme in the third – and largest – specially designed studio he had built from 1914 in the garden of his house at Giverny, and must therefore date from after the spring of 1916 when the construction of the building had finally been completed.³ However, the picture was not destined to be included in the final state-commissioned decorative scheme for the Orangerie building in Paris. The second painting, *Irises* (NG 6383; Wildenstein no. W1829; PLATE 2), which was painted between 1914 and 1917 and shows a winding garden path with a profusion of flowers at its borders,⁴ is smaller in overall scale and more upright in format, but is of the same height (200.7 cm) as the *Water-Lilies*, which Monet had fixed as a standard height for the finished Water-Lily series and for many of the associated pictures he developed over this period.

Water-Lilies (also known later as ‘*Nirvana Jaune*’) is on long-term loan to Tate Modern in London, where it is currently shown in conjunction with paintings by Jackson Pollock, Mark Rothko and Joan Mitchell as part of Tate’s recently revised hang;⁵ *Irises* forms part of the main floor display at Trafalgar Square, allowing visitors to make comparisons with earlier works by Monet and other nineteenth-century pictures.

The painter’s great celebrity, success and reputation in the latter part of his career engendered much interest in his work and in his attitudes to painting; this resulted in a flow of friends and distinguished visitors to his Giverny studio.⁶ The studio itself consisted of a single large room 23 × 12 m and 15 m high, with blind walls and natural light admitted through two rows of windows in the roof. Some control of the light and its diffusion was achieved by unfurling a large translucent white ruched fabric blind which could be drawn horizontally across the glazing (FIG. 1).⁷ This arrangement can be seen in a number of photographs of the studio, both where it is unoccupied and when Monet is present.⁸ The very large mounted canvases for the Water-Lily paintings were 200 × 425 cm (as the National Gallery picture) and were ranged around the studio in various semicircular



PLATE 1 Claude-Oscar Monet, *Water-Lilies* (NG 6343), after 1916. Oil on canvas, 200.7 × 426.7 cm.

PLATE 2 Claude-Oscar
Monet, *Irises* (NG 6383),
c.1914–17. Oil on canvas,
200.7 × 149.9 cm.



sequences held upright on specially made easels, each supported by at least two low wooden platforms fitted with casters. Some had as many as five wheeled supports. The contemporary photographs also give a clear impression of the physical arduousness of painting on this scale as well as the very large quantities of materials involved: considerable areas of canvas to cover, and jars crammed with dozens of brushes, piles of boxes of tube paints and so on (FIG. 2).⁹ Where Monet himself is included in a photograph he is generally not at work, but standing in front of his paintings with a large palette often with the centre hidden under a great mound of white paint with which to mix the surrounding patches of colour. As the art dealer René Gimpel noted in his diary¹⁰ in November 1918 following a second visit to Giverny,

Monet's palette was:

...couverte de couleurs par petits tas espacés: du cobalt, du bleu d'outremer, du violet, du vermillon, de l'ocre, de l'orange, du vert foncé, un autre vert pas très clair, du jaune d'ocre, et enfin du jaune d'outremer. Au milieu, des montagnes de blanc des sommets neigeux.

However, in spite of many contemporary accounts of Monet's activities, documented interviews with the artist, correspondence and photographs taken in the studio, there is little that deals directly with the painter's technical practice at this period and there is frustratingly little on Monet's specific choices of painting materials. Exceptionally, in response to an



FIG. 1 Monet's third studio at Giverny, about 1924–5. Photograph by Henri Manuel.

enquiry by Georges Durand-Ruel, in June 1905 Monet wrote in quite an irritated manner reluctantly reporting that his palette consisted of: 'Blanc d'argent, jaune cadmium, vermillon, garance foncée, bleu de cobalt, vert émeraude et c'est tout'¹¹ ('lead white, cadmium yellow, vermilion, deep madder lake, cobalt blue and viridian, that's all'). Whether this very restricted list should be taken as an accurate record is not clear, since in the same letter he also says: 'As for the paints I use, is it really as interesting as all that? I don't think so, considering one could do something even more luminous and better with another palette.'¹² A more reliable account, perhaps, is not Monet's own, but the recollection of his colour supplier Moisse, who stated to Adolphe Tabarant that in his later years Monet used:¹³ '...blanc d'argent, violet de cobalt clair, vert émeraude, outremer extra-fin. Quelquefois – rarement – du vermillon. Puis une trinité de jaunes de cadmium: clair, foncé, citron. Je lui vends aussi un outremer jaune citron, depuis quelques années.'

This list suggests that the palette consisted of lead white, cobalt violet light, viridian, fine quality French (synthetic) ultramarine, vermilion (rarely), a trio of shades of cadmium yellow (light, dark and lemon-yellow) and another yellow pigment (*outremer jaune citron*), probably zinc yellow or a similar material.¹⁴

While it cannot be certain that either of these recorded lists – Durand-Ruel's or Moisse's – tell a wholly convincing story of Monet's palette in the first decades of the twentieth century, it is fairly clear that, having had bad experiences in the past with certain pigments, for example 'a dreadful chrome yellow', he had some interest in using materials of high chemical stability and guaranteed general durability, although late in life he stated that he left such considerations rather to chance.¹⁵ It was an interest, however, that



FIG. 2 Monet's studio at Giverny with paintings from the *Grandes Décorations*, 11 November 1917. Photograph by Joseph Durand-Ruel.

had become a subject of general concern among artists in the latter part of the nineteenth century as demonstrated, for example, by the publication in 1855 of Jules Lefort's *Chimie des couleurs par la peinture à l'eau et à l'huile*¹⁶ and the later appearance in print in 1891 of a series of public lectures given by J.G. Vibert at the Ecole des Beaux-Arts under the general title 'The Science of Painting'.¹⁷ Similarly, a late nineteenth-century compendium for artists on the behaviour of painting materials published in Antwerp by Jacques Blockx provided detailed information on the stability of pigments, their various compatibilities and incompatibilities (described in chemical terms) and also commentaries on the painting practices and methods, both sound and unsound, of earlier masters.¹⁸

It is interesting here to be able to compare the limited contemporary documentation of Monet's technical practice, the recommendations for the construction of a permanent palette as given by Vibert, Blockx and others, and the actual materials detected by analysis in two pictures of this late phase of Monet's career. It is worth stating that some cautious attention to pigment nomenclature is required when considering the French contemporary terminology and English translations.¹⁹

Monet's *Water-Lilies* has a long history of technical study, having been the subject of preliminary pigment analysis in 1971 using a newly devised electron microprobe in Oxford, capable of elemental analysis on microsamples;²⁰ the picture was studied subsequently by the present author using LMA²¹ (1978–9) and EDX analysis in the scanning electron microscope (1991 and 2006). An early paint medium analysis was carried out by J.S. Mills using gas-chromatography also in 1971 in conjunction with the cleaning of the picture soon after its acquisition by the National

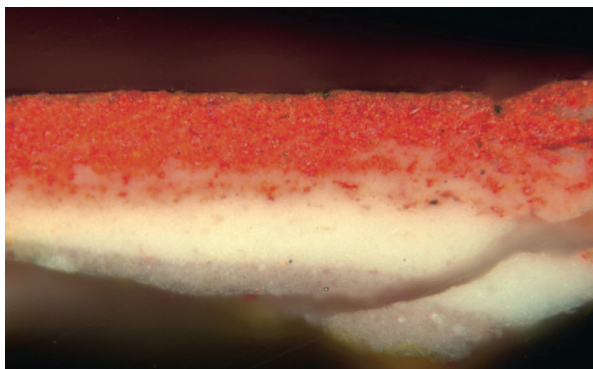


PLATE 3 Paint cross-section of brilliant scarlet (vermilion) surface in *Water-Lilies* (PLATE 1). Original magnification 195 \times ; actual magnification 170 \times .



PLATE 4 Detail from *Water-Lilies* (PLATE 1) showing Monet's use of virtually pure vermilion (see also PLATE 3).

Gallery.²² Initial pigment identification for *Irises* was carried out first in 2001 by Rachel Grout and further studies followed for this article in 2006 using cross-sections and EDX analysis. New paint media results have also been obtained in 2006.²³ The central purpose of our more recent studies has been to elucidate the development of Monet's practice toward the latter part of his career, his paintings in the National Gallery from 1869 to 1879 having been the subject of detailed technical investigations in 1990,²⁴ and to provide comparative information for material to be included in new comprehensive catalogues of the Gallery's nineteenth- and twentieth-century paintings currently in preparation by Christopher Riopelle.

Apart from the decisive changes Monet made to his palette in the later part of his career, the most striking difference in painting practice that emerges from comparisons between relatively early works and the later paintings is Monet's tendency to use much purer colour in the 1900s. Where we have examined works by Monet in the collection from the 1860s and 1870s, a common feature noted was the use of highly mixed paints – some colours and tints consisting of up

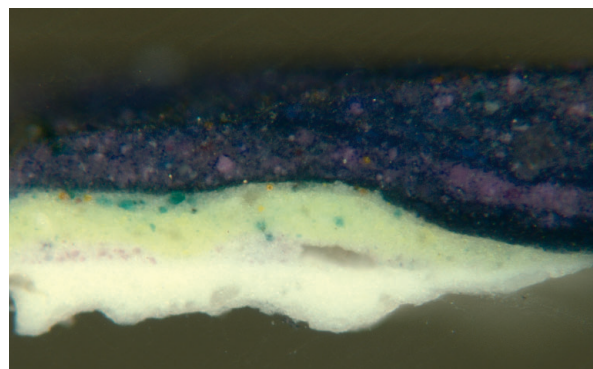


PLATE 5 Paint cross-section from deepest mauve flower (French ultramarine with cobalt violet) in *Irises* (PLATE 2). There is a distinct layer structure between the surface and underlying paints. Original magnification 195 \times ; actual magnification 170 \times .

to seven or eight distinct pigments combined on the palette as well as a good deal of working of the paint wet-into-wet on the canvas.²⁵ For his later works for any particular area or touch of paint on the canvas, Monet often employed single pigments, or perhaps just two pigments together, often mixed also with lead white (PLATES 3 and 4). Areas of colour, once applied, were left to dry or to dry partially, before another layer was applied; this way of painting is evident from paint cross-sections which tend to show quite distinct applications of the layers (PLATE 5), and imply, also, that Monet worked on several of his large compositions at one time as the arrangement of pictures in the studio recorded in contemporary photographs also suggests (FIG. 2).

Both *Water-Lilies* and *Irises* are painted on luminous white grounds. For the former, the canvas is primed with a single layer solely of lead white which, in combination with the oil binding medium, has developed a slightly off-white tone. It seems most likely that this is a commercially applied ground. *Irises* has two priming layers on the canvas: a lower creamy white composed of lead white in oil, and a second upper layer, also of lead white but possibly leaner in binding medium and rather cooler in tone. It is possible that the lower layer is a commercial ground, while that on top was applied by Monet in his studio on the stretched canvas, since it does not quite reach the edges of the picture plane (PLATE 6).

For the paint layers of *Water-Lilies* an early series of medium analyses by gas-chromatography revealed the binder to be poppy oil in three samples (a green, a mixed green and a yellow); this has been confirmed in several new samples (red, lilac and green), while the binder for a white paint was shown to be linseed oil. Poppyseed oil was also found to be the binder in



PLATE 6 Detail of lower right corner of *Irises* (PLATE 2) showing uncovered ground and fluidly brushed paint.

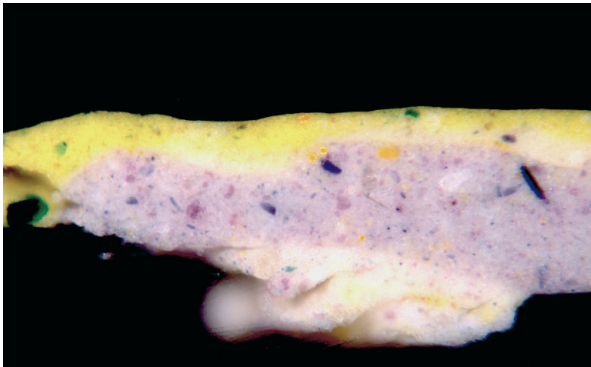


PLATE 7 Paint cross-section from brightest yellow (virtually pure cadmium yellow) surface paint in *Water-Lilies* (PLATE 1). A more mixed paint containing lead white, cobalt violet, French ultramarine, cobalt blue and cadmium orange is present beneath. Original magnification 215 \times ; actual magnification 190 \times .

several paints from *Irises*. In both pictures the paint layers display a rather dry, desiccated look, particularly the surface paints, although there is no evidence from analysis that the samples are particularly lean in binding medium, or that Monet may have partially extracted the oil binder by blotting his tube paints on absorbent paper, as he is sometimes said to have done.²⁶

Examination of paint cross-sections shows that the initial layers for *Water-Lilies* are composed of more mixed paints than the surface touches, and that they are more broadly brushed out and less pastose (PLATE 7). The white canvas ground is entirely covered, although the surface colour, applied in more broken brushwork over partially dried underpaints, allows these colours to be glimpsed through the surface. Similar effects are used in *Irises*, but there Monet left the white ground uncovered in places (PLATE 6), particularly in the lower right corner and along the lower edge, and the brushwork is very loose and open



PLATE 8 Detail from *Irises* (PLATE 2) showing surface brushstrokes dragged over dried lower layers.

at the right edge of the picture; it is not clear whether Monet regarded this painting as finished since it remained in the studio (with the National Gallery *Water-Lilies*) until after his death. *Irises* was evidently a rapidly executed work, with the garden path laid in first and the flower border worked over its edges. The most fluidly applied, rapidly dashed-in section consists of swirling blues and greens in the lower right corner. As with *Water-Lilies*, it is clear that in *Irises* the thickest surface impasto was applied over partially dried paint beneath (PLATE 8).

From a representative range of samples taken for analysis it is possible to deduce the full palette for the London *Water-Lilies*: lead white, cobalt violet (light) (PLATE 9), viridian, cobalt blue, French ultramarine, vermilion, cadmium yellow, zinc/barium yellow. (The chemical identity of these materials is given below the Table.) No red lake was found in the samples, although one does occur in *Irises* (see below and p. 81). The list of pigments employed for *Water-Lilies* is very close to Moisse's recollection of the materials he had supplied to Monet (see above), the only notable discrepancy being the presence of significant quantities of cobalt blue in the picture (PLATE 10), a pigment which it is quite evident Monet used comprehensively in the *Water-Lily* series generally. Although the colour scheme of the National Gallery picture is largely yellow and violet, with a more subsidiary role for blue, red and green, the final Orangerie series, with the exception of one of the smaller panels in Paris, *The Setting Sun*, is dominated by tones of blue and the play of blue against mauves and greens.²⁷

Irises reveals the use of a similar range of materials. Here again, the samples are thought to be representative of the whole, and the palette detected by analysis consists of: lead white, cobalt violet (light), viridian, cobalt blue (PLATE 11), French ultramarine, cadmium

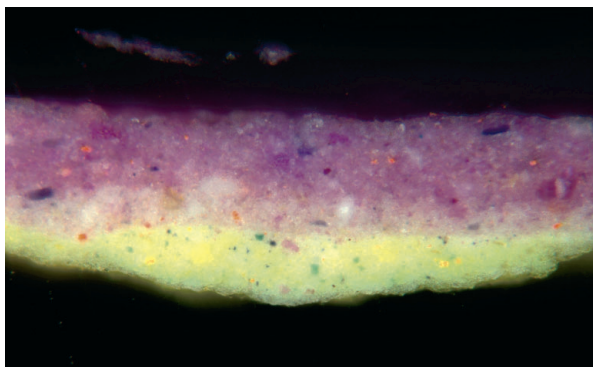


PLATE 9 Paint cross-section of strongest mauve surface colour (principally cobalt violet) in *Water-Lilies* (PLATE 1). The layer beneath contains cadmium yellow, zinc yellow and some viridian. Original magnification 230x; actual magnification 200x.

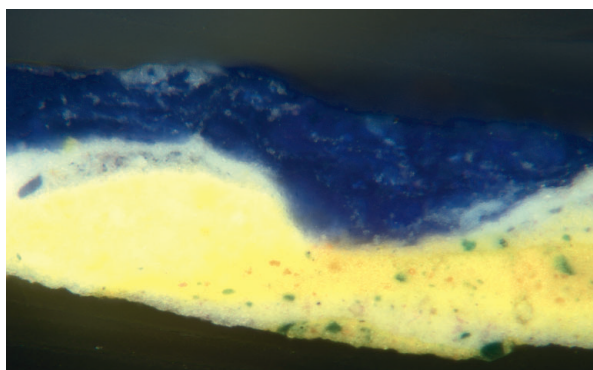


PLATE 10 Paint cross-section from strongest blue surface touch (cobalt blue with some lead white) on *Water-Lilies* (PLATE 1). The lower layer consists of cadmium yellow. Original magnification 205x; actual magnification 180x.

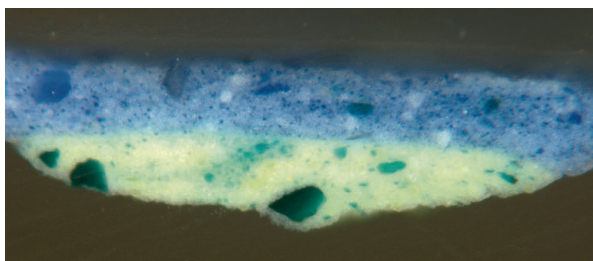


PLATE 11 Paint cross-section of pure mid-blue (cobalt blue with lead white) in *Irises* (PLATE 2), over a mixture of zinc yellow and viridian. Original magnification 180x; actual magnification 160x.

yellow, cadmium orange, zinc/barium yellow and red lake pigment. No vermilion occurs in *Irises*.

It is perhaps a sign of Monet's awareness of the technical performance of his paints that the palette used both for *Water-Lilies* and for *Irises* (which as noted above are very similar in themselves) corresponds to the recommendations of contemporary commentators such as Vibert. In an 'Appendix' in his

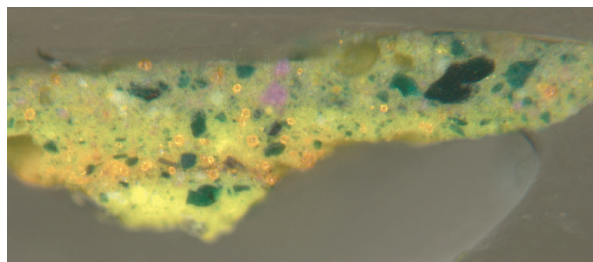


PLATE 12 Paint cross-section of dark olive-green of path in *Irises* (PLATE 2) consisting of viridian, cadmium orange (small spherical particles), cadmium yellow, lead white, cobalt violet and cobalt blue. Original magnification 175x; actual magnification 155x.



PLATE 13 Detail from *Water-Lilies* showing Monet's use of cobalt violet in surface paint.

Science of Painting, Vibert lists the 'good and bad paints'. Of the 'good' – dismissing a great many as unstable or incompatible in mixtures – he sets his seal of approval only on about ten or eleven pigments: lead white, zinc white, cadmium yellows (of all varieties), vermilion, cobalt blue, ultramarine, cobalt green, viridian and cobalt violet.²⁸ He also recognises the essential stability of many earth colours, and describes madder lakes as 'comparatively substantial'. This list, of course, is highly comparable with Monet's choices at this period, and although no earth pigments were found in the paints examined here, he is known to have used types of yellow ochre in the early decades of the twentieth century.²⁹

Composition of the paint layers (minor quantities noted in brackets)

WATER-LILIES

Painting sample location	Composition	Main peaks in EDX
White ground layer	lead white ¹	Pb
Purest white of water-lily, right, centre	lead white	Pb
Mauve of water, lower left	cobalt violet ² + lead white (ultramarine; ³ cobalt blue; viridian)	Co, As, Pb
Blue-green, right-hand edge	viridian ⁴ + lead white (cobalt blue)	Cr, Pb
Brightest blue of water, right, centre, over pale violet bright yellow (lower layer)	cobalt blue ⁵ lead white, cobalt violet, ultramarine cadmium yellow ⁶	Co, Al, Cd, S
Blue of water, over lime green	cobalt blue + lead white cadmium yellow + viridian	Co, Al, Pb Cd, S, Cr
Bright scarlet of water-lily, left edge	vermilion ⁷	Hg, S
Strong pink of water-lily, left	vermilion + lead white	Hg, Pb
Lime green of water-lily, centre, left	cadmium yellow + viridian	Cd, S, Cr
Bright orange impasto, lower left	cadmium orange ⁸	Cd, S
Bright yellow impasto, right (PLATE 7)	cadmium yellow	Cd, S
Light acid yellow, lower edge	zinc/barium yellow ⁹	Zn, K, Cr, Ba

Notes

1 $2\text{PbCO}_3 \cdot \text{Pb(OH)}_2$ 2 $\text{Co}_3(\text{PO}_4)_2$ 3 $\text{Na}_{8-10}\text{Al}_6\text{Si}_6\text{O}_{24}\text{S}_{2-4}$ 4 $\text{Cr}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$ 5 $\text{CoO} \cdot \text{Al}_2\text{O}_3$

6 CdS

7 HgS

8 CdS

9 $4\text{ZnO} \cdot 4\text{CrO}_3 \cdot \text{K}_2\text{O} \cdot 3\text{H}_2\text{O} + \text{BaCrO}_4$.10 HPLC analysis (p. 91 of this *Bulletin*); Al and S are components of the lake pigment substrate.

11 Microscopical identification only.

IRISES

Painting sample location	Composition	Main peaks in EDX
Lower white ground	lead white	Pb
Upper white ground	lead white	Pb
Pure white highlight on foliage, centre lower left	lead white	Pb
Mid-mauve flower, centre lower left	cobalt violet	Co, As
Dark mauve flower, left-hand side (PLATE 5)	ultramarine + cobalt violet	micr. ¹¹
Reddish-mauve flower, upper left	cobalt violet + lead white (ultramarine)	Co, As, Pb
Deepest cold green foliage, lower left	viridian	Cr
Greyish blue, left-hand edge	cobalt blue + lead white	micr. ¹¹
Darkest blue foliage, left-hand edge	ultramarine (lead white; cobalt violet, viridian)	Na, Si, Al, Pb
Orange highlight on path	cadmium orange	Cd, S
Yellow-green foliage, centre left	viridian, zinc/barium yellow, lead white	Cr, Zn, K, Ba, Pb
Dark olive-green of path, centre (PLATE 12)	viridian, cadmium orange, cadmium yellow (lead white; cobalt violet; cobalt blue)	Cr, Cd
Mid-brown of path, centre	cadmium orange, cadmium yellow, viridian	micr. ¹¹
Mid-tone acid yellow, foliage, upper left	zinc/barium yellow	Zn, K, Ba, Cr
Deep purplish lake, foliage, lower left corner	rose madder lake ¹⁰	Al, S

Notes on the palette

Lead white (*blanc d'argent*)

So-called 'silver white' was a fine quality variety of lead white, the only white pigment of any importance employed by Monet throughout his career, although towards the end of his life he expressed some concerns as to its stability in comparison with zinc white. He was impressed by the covering power of lead white.³⁰

Cobalt violet (*violet de cobalt [clair]*)

Cobalt violet is chemically either cobalt phosphate, a dark variety, or cobalt arsenate, the lighter form, the invention of the former being usually attributed to M. Salvétat in 1859.³¹ The origins of the arsenate pigment are less clear, but it is mentioned by J. Lefort somewhat earlier in 1855.³² Cobalt violet does not appear frequently in French nineteenth-century painting, possibly on account of its fairly high price, but it also seems to have been in short supply. Other than manganese violet, also an uncommon pigment, cobalt violet was the only pure, opaque mauve artists' pigment available and was therefore a great attraction to painters such as Monet working with floral subjects (PLATE 13).³³ Earlier, Monet had used mixtures of cobalt blue and red lake (with and without white) to obtain purple and violet hues, but this is less straightforward than employing a single pigment.³⁴

Viridian (*vert émeraude*)

Viridian is a transparent form of deep green hydrated chromium oxide, of uncertain date of first manufacture, but probably in use from as early as the mid-1820s.³⁵ It is one of the key pigments used consistently by Monet and by the Impressionists generally. There is scope for confusion between viridian (transparent chromium oxide) which in French is '*vert émeraude*', and the English term 'emerald green', which is a distinct pigment, copper acetoarsenite, usually known in French as '*vert Véronèse*'. Monet had used '*vert Véronèse*', as well as *vert émeraude*, earlier in his career,³⁶ but abandoned it on account of its unstable nature, particularly when mixed with certain yellows such as chrome yellow and cadmium yellow, both of which react chemically with the copper-arsenic containing pigment.³⁷ Viridian was also used in a manufacturers' mixture of this chromium green with cadmium yellow, a combination sometimes known as 'cadmium green', and this may account for the composition of some of the paint layers in each of the pictures.

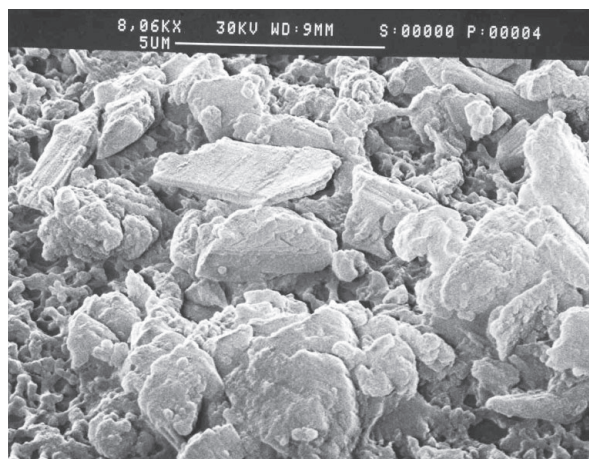


FIG. 3 Scanning electron micrograph of particles of vermilion from *Water-Lilies*. The particle morphology suggests the dry-process form of the pigment (Chinese vermilion). Original magnification, 8,060x.

Cobalt blue (*bleu de cobalt*)

Cobalt blue had always been an important component of Monet's palette, and that of his Impressionist associates. Although a relatively expensive colour, it had been used by Monet early on.³⁸ It was the only spectrally pure blue colour available to painters other than genuine lapis lazuli ultramarine (which was prohibitively expensive) and had been manufactured commercially soon after the first preparation of the pigment by Thénard in 1802/3.³⁹

French ultramarine (*outremer [fine]; outremer Guimet*)

Synthetic, that is, French ultramarine had been available from soon after the date of invention in 1827/8. Guimet refers to the best-known inventor of the pigment.⁴⁰ Certain of the paints examined here contain homogenous combinations of French ultramarine with cobalt blue; these could be manufacturers' mixtures. However, ultramarine mixed with other pigments in the absence of cobalt blue occurs in *Water-Lilies* and it must therefore have been used by Monet as a single blue pigment.

Vermilion (*vermillon [anglais; de chine; français]*)

Excepting lead white, vermilion is the only traditional pigment used by Monet in *Water-Lilies*; its qualities were well known and, other than the new pigment cadmium red, only introduced around 1910,⁴¹ it was unique in its opacity and intense spectral colour. Various varieties were available; examination of the particle form of a Monet sample in the SEM indicates that it was of the dry-process, sublimed form, so-called Chinese vermilion (FIG. 3).

Cadmium yellow (*jaune de cadmium [clair; foncé; citron]*)

Monet appears to have started to use cadmium yellow colours as early as the beginning of the 1880s, and then used various varieties consistently until the end of his life.⁴² These cadmium sulphide pigments were thought to be more stable⁴³ than chromium-based yellows, particularly lead chromate (chrome yellow), which was known to darken, and could be obtained in a number of shades of yellow from a mid-primrose colour, a more acid tone to a dark to orange-yellow. The cadmium sulphide yellow was manufactured by precipitation and the shade of colour was dictated by the conditions of preparation.⁴⁴

Cadmium orange

The orange form of cadmium sulphide, prepared in acid solution.⁴⁵

Zinc/barium yellow (*jaune de zinc; outremer jaune*)

Lead-based chromium yellows had developed a poor reputation by the 1880s, but other chromium yellows were less criticised. Barium chromate (barium yellow or, sometimes, 'lemon yellow') and zinc yellow (zinc potassium chromate, also called 'lemon yellow') were regarded as more reliable pigments,⁴⁶ although the reality is more complicated and zinc yellow, in particular, is liable to greenish-grey discoloration and fading in certain circumstances.⁴⁷ The samples analysed here contain zinc, potassium, chromium and barium (but no sulphur) and are therefore likely to be manufacturers' mixtures of zinc and barium yellows, rather than zinc yellow extended with barium sulphate.

Red lake (*laque garance rose*)

In the early twentieth century the madder lakes used by artists were still prepared from dyestuff extracted from the madder root, although the methods of chemical extraction had developed during the previous century in order to give a range of products containing a high concentration of dyestuff that were more efficient to use. One of these, Kopp's purpurin, contained a high proportion of pseudopurpurin (purpurin-3-carboxylic acid), together with purpurin and only very little alizarin. It was used to give rose pink madder lakes, and analysis by high-performance liquid chromatography suggests that a madder product of this type was used to make the lake Monet used here. The high sulphur content may be partly connected with the method of producing Kopp's purpurin, but it also suggests that the pigment substrate is a type of alumina similar to the modern light alumina hydrate, which contains some sulphate (see also p. 91 in this *Bulletin*).⁴⁸

Acknowledgements

I would like to express my thanks to John House for suggesting improvements and to Jo Kirby for her useful comments on the contemporary literature as well as her analysis of the red lake pigment used in *Irises*. David Pegg kindly communicated his work on medium analysis.

Notes

- 1 Monet first announced his plans to donate the *Water-Lilies* decorative scheme in 1918 and the gift was finalised in April 1921. Initially, the government made plans to house the paintings in a pavilion in the grounds of the Hôtel Biron (now Musée Rodin), but in 1921 a new plan was made to display the work in the Orangerie in the Tuileries Gardens. It was opened to the public on 16 May 1927.
- 2 See D. Wildenstein, *Monet: Catalogue Raisonné*, Vol. 4, Taschen, Wildenstein Institute, Cologne 1996, pp. 964–5 (*Water-Lilies*); pp. 867–9 (*Irises*).
- 3 The sequence of Monet's various studios is described in J. House, 'Studio Work', *Monet: Nature into Art*, New Haven and London 1986, p. 147. Two photographs of Monet in his 'salon atelier' and in his second studio at Giverny are also published, see p. 149. See also G. Seiberling, *Monet's Series* (PhD dissertation), New York and London 1981, p. 237.
- 4 The planting scheme for the garden is described in Georges Truffaut, 'The Garden of a Great Painter', reprinted in C.F. Stuckey, ed., *Monet: a retrospective*, New York 1985, p. 316.
- 5 Room 7, Tate Modern. The hang deals with Abstract Expressionism and its origins.
- 6 See, for example, Stuckey 1985 (cited in note 4).
- 7 A brief description of the physical lay-out of the studio is given in G. Seiberling (cited in note 3) p. 237. See also the photograph by Henri Manuel, c. 1924, Durand-Ruel Archives, reprinted in Stuckey (cited in note 4), p. 295; the photograph is reproduced in H. Keller, *Claude Monet*, Munich 1985, p. 152.
- 8 For example, the photograph in G. Geffroy, *Claude Monet, sa vie, son temps, son oeuvre*, Editions G. Cres, Paris 1922, between pages 328 and 329; also Monet on his eightieth birthday, photograph: Collection Viollet, Paris, reprinted in Stuckey (cited in note 4), p. 278; photograph by Henri Manuel, c. 1924–5, Durand-Ruel Archives, reprinted in Stuckey, p. 339.
- 9 Three photographs from the Durand-Ruel Archives dating from 1917 give a good idea of the studio lay-out, equipment and so on, reprinted in Stuckey (cited in note 4), p. 280. See also Durand-Ruel photographs of the Grandes Décorations in the Giverny studio, 11 November 1917, reproduced in P.H. Tucker, *Claude Monet: Life and Art*, New Haven and London 1995, pp. 208–9. René Gimpel's description of the studio is revealing in R. Gimpel, *Journal d'un collectionneur: marchand de tableaux*, Paris 1963, p. 89.
- 10 R. Gimpel (cited in note 9), p. 89.
- 11 Monet's reply (Giverny, 'Archives', I, 3 June 1905, p. 404) is translated in R. Kendall, ed., *Monet by himself*, London 1989, p. 196. 'Vert émeraude' is translated as 'emerald green', although it is clear that viridian (transparent chromium oxide green) is meant.
- 12 R. Kendall (cited in note 11), p. 196.
- 13 Five surviving lists of the constitution of Monet's palette are recorded by J. House (cited in note 3), p. 239, n.10. See also R. Woodhuysen-Keller and P. Woodhuysen-Keller, 'Claude Monet's Series *L'Allée de Rosiers*: history, materials, painting technique – removal of over-paint', in Rodolphe Rapetti et al. (eds), *Monet: Atti del convegno*, Treviso, 16–17 January 2002, Conegliano 2003, pp. 147–8. Moïse of Maison Edouard had also been Renoir's colour supplier, see A. Callen, *The Art of Impressionism: Painting technique and the making of modernity*, New Haven and London 2000, pp. 104–5.
- 14 'Outremer jaune citron' may be a barium-based chrome yellow. René Gimpel calls it a 'lapis lazuli yellow' in Stuckey (cited in note 4), p. 309.
- 15 As in a conversation with the Duc de Trévise in 1920, published in 1927 after Monet's death, see Stuckey (cited in note 4), p. 333.
- 16 J. Lefort, *Chimie des couleurs pour la peinture à l'eau et à l'huile*, Victor Masson Libraire-éditeur, Paris 1855.
- 17 J.G. Vibert, French edition published 1891. English edition: *The Science of Painting*, Percy Young, London 1892.
- 18 J. Blockx, *Compendium à l'usage des artistes peintres et des amateurs de tableaux*, 3rd edition, J.-E. Buschmann, Antwerp 1904. Blockx's theme was taken up

- by Alphonse Etienne Dinet, who in 1904 published the first edition of a work on 'Les fléaux de la peinture' (the scourge or curse of painting), which dealt with technical failures in artists' materials, good and bad products (for painting), and reliable and unreliable pigments and their mixtures. See E. Dinet, *Les Fléaux de la peinture. Observations sur les vernis, les retouches et les couleurs*, E. Rey, Paris 1904.
- 19 The most common confusion is between 'vert émeraude', 'vert Véronèse' and the English terms emerald green and viridian. Names such as 'outremer jaune' are difficult since they give no clue as to the constitution of the pigment. There are many similar examples in the French nineteenth-century lists.
 - 20 Some experimental analysis was undertaken by R. Hedges with the electron microprobe at the Research Laboratory for Archaeology and the History of Art, Oxford. The results were not published fully, but a summary appears in *The National Gallery Annual Report* (January 1971–December 1972), London 1973, p. 56.
 - 21 Laser microspectral analysis: a technique of elemental analysis based on UV emission spark spectrometry.
 - 22 A binder of poppyseed oil was found in three samples by gas-chromatography. See *The National Gallery Annual Report* (cited in note 20), pp. 56–7.
 - 23 Analysis by gas-chromatography linked to mass-spectrometry, and supplementary work using FTIR, by D. Peggie.
 - 24 D. Bomford, J. Kirby, J. Leighton and A. Roy, *Art in the Making: Impressionism*, The National Gallery, London 1990.
 - 25 D. Bomford, J. Kirby, J. Leighton and A. Roy (cited in note 24), pp. 122–5; 130–1; 147; 170; 187.
 - 26 A. Callen (cited in note 13), pp. 101–2.
 - 27 This is particularly true of the large panels *Morning* and *Morning with Willows*. A summary pigment analysis has been published for the series by J.P. Rioux and S. Delbourgo. Using microscopy, X-ray fluorescence analysis and microchemical tests, the authors deduced Monet's use of lead white, cadmium yellow, a red lake (possibly), cobalt blue, [synthetic] ultramarine, cobalt violet [the arsenate form] and 'chromium green' [evidently viridian]. See M. Hoog, *Musée de l'Orangerie: The Nymphéas of Claude Monet*, Réunion des Musées Nationaux, Paris 2006, p. 127.
 - 28 J.G. Vibert (cited in note 17), English edition, pp. 162–71. Cobalt green, or Rinmann's green, not known to have been employed by Monet, is cobalt-zinc-aluminium oxide.
 - 29 See for example, Woodhuysen-Keller and Woodhuysen-Keller (cited in note 13), p. 148.
 - 30 See comments to Duc de Trévisé quoted in C.F. Stuckey (cited in note 4), p. 333.
 - 31 M. Salvétat, 'Matières minérales colorantes vertes et violettes', *Comptes Rendus des Séances de l'Académie des Sciences*, XLVIII, 1859, pp. 295–7. See also, M.-C. Corbeil, J.-P. Charland and E. A. Moffatt, 'The characterization of cobalt violet pigments', *Studies in Conservation*, 47, 4, 2002, pp. 237–49.
 - 32 J. Lefort (cited in note 16).
 - 33 Cobalt violet has been detected rather rarely in National Gallery paintings, an exception being I.-H.-T. Fantin-Latour's *A Basket of Roses* (NG 3726), signed and dated 1890.
 - 34 See, for example, *Lavacourt under Snow* (NG 3262), 1878–81; D. Bomford, J. Kirby, J. Leighton and A. Roy (cited in note 24), p. 187.
 - 35 Viridian (transparent chromium oxide) has been identified in Corot's *The Roman Campagna, with the Claudian Aqueduct* (NG 3285), painted, probably, about 1826.
 - 36 See D. Bomford, J. Kirby, J. Leighton and A. Roy (cited in note 24), pp. 58–61; 200–1.
 - 37 The danger of mixing emerald green with cadmium pigments, and in fact any pigment containing sulphide, was widely known, see for example A.H. Church, *The Chemistry of Paints and Painting*, Seeley and Co., London 1890, p. 128, in which the pigments are described as 'absolutely incompatible, whether in watercolour or in oil'; see also p. 175.
 - 38 A. Roy, 'Cobalt Blue', in B. Berrie, ed., *Artists' Pigments: A handbook of their history and characteristics*, Vol. 4, National Gallery of Art, Washington, DC, 2007, pp. 183–5.
 - 39 A. Roy (cited in note 38), pp. 167–8.
 - 40 J. Plesters, 'Ultramarine Blue, Artificial', in A. Roy, ed., *Artists' Pigments: A handbook of their history and characteristics*, Vol. 2, National Gallery of Art, Washington, DC, 1993, pp. 55–7.
 - 41 Cadmium red, constitutionally cadmium sulpho-selenide, was introduced commercially in the first decade of the twentieth century. No reports of Monet using this pigment are known.
 - 42 See I. Fiedler and M. Bayard, 'Cadmium Yellows, Oranges and Reds', in R.L. Feller, ed., *Artists' Pigments: A handbook of their history and characteristics*, Vol. 1, Cambridge University Press, Cambridge 1986, pp. 102–4.
 - 43 I. Fiedler and M. Bayard (cited in note 42), p. 71. However, cadmium pigments are not always stable, see L. Bronwyn, A. Burnstock, C. Jones, P. Hallebeek, J.J. Boon and K. Keune, 'The deterioration of cadmium sulphide yellow artists' pigments', in I. Verger, ed., *ICOM Committee for Conservation Preprints*, 14th triennial meeting, The Hague, James & James, London 2005, pp. 803–13.
 - 44 I. Fiedler and M. Bayard (cited in note 42), pp. 78–80.
 - 45 I. Fiedler and M. Bayard (cited in note 42), p. 78.
 - 46 See H. Kühn, 'Chrome Yellow and Other Chromate Pigments', in R.L. Feller, ed. (cited in note 42), pp. 202 and 206.
 - 47 For comments on the instability of zinc yellow in Seurat's *Bathers* (NG 3908), see J. Leighton and R. Thomson, *Seurat and the Bathers*, National Gallery Publications, London 1997, p. 82, and J. Kirby, K. Stonor, A. Roy, A. Burnstock, R. Grout and R. White, 'Seurat's Painting Practice: Theory, Development and Technology', *National Gallery Technical Bulletin*, 24, 2003, pp. 24–5.
 - 48 J. Kirby, K. Stonor, A. Roy, A. Burnstock, R. Grout and R. White (cited in note 47), pp. 25–6; p. 34, notes 55–8.