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# Aelbert Cuyp's *Large Dort*: Colour Change and Conservation

MARIKA SPRING AND LARRY KEITH

Aelbert Cuyp's *Distant View of Dordrecht, with a Milkmaid and Four Cows, and Other Figures* (*The Large Dort*) (PLATE 1) was probably painted in the late 1650s, and is his most monumental treatment of a subject he often depicted. The painting, which entered the National Gallery Collection in 1876, marks a turning point in his career after which he began to exploit the so-called Italianate lighting effects of contemporary artists such as Jan Both.[1] The picture has suffered, however, from changes in its appearance that are typical of work by this artist, which result mainly from the alteration of unstable pigments such as yellow lake, the extensive use of which is highly characteristic of his technique.[2] In the case of *The Large Dort* its deterioration contributes to a blanched, chalky appearance which is particularly disturbing in certain areas of the green foreground landscape. Before the recent restoration, the painting also displayed the more usual changes brought about by the discoloration of the old varnishes and retouchings used in earlier conservation treatments.

PLATE 1 Aelbert Cuyp, *A Distant View of Dordrecht, with a Milkmaid and Four Cows, and Other Figures (The Large Dort)* (NG 961), *c.*1650. Oil on canvas, 157.5 × 197 cm. After cleaning and restoration.

The decision to restore the painting presented the opportunity to explore the picture's technique in depth, and thereby to understand the differences between the visual effect of changes within the original painting materials and those resulting from the picture's restoration history. While some works by the artist from the National Gallery and other collections have changed in ways very similar to *The Large Dort*, others have not altered nearly as much, and the available information suggests that this variation in condition may largely be explained by their differing histories of display, or by the specific pigment mixtures used by Cuyp in each work, rather than by their conservation treatments. The information gained from both technical and comparative research has also proved invaluable for the recent restoration, whereby a more precise understanding of the changes to the picture, combined with the examples provided by relatively unaltered paintings, have fundamentally informed the approach taken in its retouching.

Aelbert Cuyp was born in Dordrecht in 1620, and died there in 1691. His earliest biographer was Arnold Houbracken (also from Dordrecht), who gave an account of Cuyp's life in *De groote Schouburgh der Nederlantsche Konstschilders en Schilderessen* (1718–21). He came from a family of artists; both his father Jacob Gerritsz. and his uncle Benjamin were established painters in Dordrecht. Aelbert's first training and activity must have been in his father's workshop, while his first independent production seems to have been undertaken in the early 1640s. Beginning in a chromatically restrained style broadly related to the work of painters like Jan van Goyen, Cuyp gradually became more influenced by the Italianate landscape painters active in Utrecht, particularly artists such as Cornelius van Poelenburgh and Jan Both, who had returned there from Italy in 1642.[3]

**Cuyp and the English market**

Cuyp's patrons were for the most part the prosperous merchants and landowners in and around Dordrecht itself, and the essentially local market for which he painted meant that his works remained concentrated in that area well into the eighteenth century.[4] By 1785 Johan van Slingeland, a rich iron merchant in Dordrecht, owned 41 paintings attributed to Cuyp[5] – but when his estate was auctioned that year most of the pictures went to Britain, and by the late eighteenth century a particularly strong British interest in paintings by Cuyp had developed. Cuyp was, together with Rembrandt, one of the first Dutch artists collected in Britain in a significant way, and even came to be thought of as an essentially 'English' artist who was seen as a Dutch incarnation of another famously adopted 'English' painter, Claude – and was so described by John Boydell in 1769.[6] Writing about Cuyp in a volume of reproductive engravings of old master paintings that he compiled, Boydell writes proudly of England's discovery – while chastising Cuyp's unappreciative countrymen for their neglect:

> That his merit should have been overlooked by his countrymen is not at all surprising. The boldness of his pencil, and the freedom of his touches were not calculated to please a people who have been accustomed to the exquisite finishings of the most laborious class of artists that the world has produced: but that pictures of such extraordinary merit should have so long escaped the attention of collectors of other nations… appears incredible… It is entirely owing to the taste of the British nation, that his pictures have been retrieved from obscurity, their value enhanced, and places allotted them in some of the first Collections in this Kingdom.[7]

The earliest known date for the arrival of a painting by Cuyp in England is 1741; by the 1760s they were being acquired in larger numbers, and their fame (and value) was assured by the arrival in around 1760 of the *River Landscape with Horseman and Peasants* (NG 6522, PLATE 2) – the very picture to inspire Boydell's 'Dutch Claude' accolade. The painting was acquired by Captain William Baillie for the Marquess of Bute, and has been in the National Gallery since 1989.[8] Cuyp's characteristic bucolic countryside scenes of arcadian shepherds with aristocratic hunting parties, typically bathed in a warm Italianate light, resonated as strongly with the English landowning gentry as they had with their Dordrecht counterparts a century earlier.[9] Indeed, Cuyp himself appears to have identified strongly with this latter group: following his marriage to Cornelia Boschman (a woman from a wealthy landowning family) in 1658 he virtually gave up painting to focus his energies on the management of their estates.[10]

Cuyp's paintings were held in high esteem by British collectors throughout the nineteenth century. *The Large Dort* is known to have been in Britain since at least 1823 and sits comfortably within the larger narrative of Cuyp's popularity with English collectors. It was probably inherited as part of a larger estate by Sir Henry Hervey Bruce in 1823 from the 4th Earl of Bristol and Bishop of Derry, and so presumably would have come into Britain some years before.[11] In 1849 it was sold at Christie's to Thomas Brown, in London, and in 1856 it was acquired by Wynn Ellis, who bequeathed the painting to the National Gallery in 1876.[12] The

PLATE 2 Aelbert Cuyp, *River Landscape with Horseman and Peasants* (NG 6522), *c.*1658–60. Oil on canvas, 123 × 241 cm.

Gallery had already acquired five paintings by Cuyp by this time; two from the Angerstein collection in 1824, and then three more from Sir Robert Peel in 1871.[13]

**Preparatory drawings**

The composition of *The Large Dort* is typical of Cuyp's working method in that it was conceived through the imaginative combination of numerous separately drawn studies – sketches of livestock, individuals, plants and specific landscape views made from life that Cuyp kept and reused in the studio. Many of these drawings have survived, and they can often be linked to individual pictures. Houbracken relates an amusing anecdote about Cuyp's sketching of horses and cattle in the Dordrecht markets (and his tightfistedness):

> The most important of his Art works are probably those in which he depicts the Dordrecht Cattle Market, as well as the Riding Ring, in which he was able to use the picturesque Horses that were usually there, so that one could recognise the same. That no models or drawings by other masters were found in his place after his death is proof that he followed nature only. Nor was it in his nature to spend money on these [models or drawings], for he always had as his motto: *Moths don't consume hard Ryksdaalders* [coinage].[14]

Cuyp's drawings of cattle are particularly arresting; he may have provided some of the drawn models for a series of engravings of animals made in 1641 by his father, Jacob, the *Diversa animalia quadrupedia ad vivem delineata a Iacopo Cupio*;[15] other scholars have completed the circle by tracing the use of Jacob's etchings as source material in later paintings by Aelbert.[16] A surviving group of drawings of burdock leaves can also be grouped with specific paintings (PLATE 3). Although none relate to *The Large Dort*, they are strikingly similar to the foliage in the foreground of that picture, and the fact that they were demonstrably used for other paintings makes it entirely reasonable to suppose that similar drawings once existed for *The Large Dort* as well.

Cuyp's preparatory drawing was not restricted to studies of small compositional details; he also produced large landscape views of high topographical accuracy. In the early 1650s he made a tour of the Rhineland between Nijmegen and Cleves, sketching picturesque views of the Rhineland cliffs that were sometimes used in his paintings.[17]

Several drawings can be directly linked to *The Large Dort* including a *View of Dordrecht* and a *Sketch of a lying Cow* (PLATES 4 and 5), both now in the British Museum.[18] There are also other paintings by Cuyp which contain compositional elements closely related to features found in *The Large Dort*. Although no drawings are now known to be extant for all of these particular shared elements, it is reasonable to infer that the common sources for the motifs were to be found in such preparatory drawings.[19] Recycling of drawn studies was routine for Cuyp, a fact which can sometimes sit a little uncomfortably with current notions of both originality and pastiche.[20]

Although *The Large Dort* is very obviously also such an assembled composition, it remains one of Cuyp's

PLATE 3 *Study of leaves, possibly butterbur*. Black chalk, grey wash, heightened with watercolour in green and yellow, heightened with white, partly brushed with gum arabic, on paper, 14 × 19.4 cm. Paris, Institut Néerlandais, Collection Frits Lugt.

PLATE 4 *View of Dordrecht*. Black chalk and grey wash on paper, signed *A.C.*, 15.1 × 30.3 cm. London, British Museum (Reg. no. 1895,0915.1140).

PLATE 5 *Sketch of a lying cow*. Black chalk, touched with red, with pen and black ink on paper, 8 × 13.9 cm. London, British Museum (Reg. No. 1836,0811.111).

most striking and original works – perhaps because it is in the nature of that assembly that some of its most powerful and effective qualities can be found. The topographical accuracy of the distant townscape and the closely observed realism of livestock, people and vegetation are impressive in their own right. Yet it is the combination of dramatic juxtapositions of scale – with the foreground *repoussoir* of enormous burdock leaves[21] setting the stage for cattle which dwarf even the bulky silhouette of Dordrecht's Grote Kerk – together with a shifting cloudscape that emits diagonal shafts of light dramatically illuminating the scene below which results in an assemblage that is far greater than the sum of its parts.[22] The effect is a highly naturalistic celebration of the agricultural prosperity that had resulted from the recently reclaimed land around the city of Dordrecht, but it also manages to evoke the timeless quality of the pastoral, arcadian imagery which was a popular theme in contemporary Dutch written and visual culture.[23]

## *The Large Dort*: conservation history and cleaning

By the middle of the nineteenth century the painting seems to have already suffered considerable damage. Annotations made in a 1849 catalogue by the dealer John Smith (who in the 1830s had compiled one of the first catalogues of paintings by Cuyp) describe the painting as being 'in a bad state'.[24] The painting was purchased at the auction by Thomas Brown, a dealer and 'picture cleaner' who apparently made an unsuccessful attempt to sell the picture in Paris in about 1854. Subsequent to its acquisition by the National Gallery the picture was glue-paste lined, cleaned and restored in 1888, and was cleaned again in 1949. By 2007 it was decided that the picture needed further treatment, as the mastic varnish applied in 1949 had yellowed and become extremely foggy and opaque, and many of the retouchings had darkened significantly.[25]

While reduction or removal of most of the disturbing varnish and retouchings presented no particular problems, the cleaning of parts of the foreground was less straightforward. Both close visual inspection and X-radiography indicated considerable local damage, particularly in the leaves and branches of the left foreground, and the various subsequent cycles of restoration had left a confusing combination of partially removed old varnishes and extensive repaintings. These were distinguishable from original paint, however, by their differing pigment compositions, binding media, and position within the paint layer structure.[26] Similar investigation also confirmed the suspicion of repaint in the shadow cast by the cow in the left foreground and the extent of damage within the body of the dog.

In the photographs of the left foreground taken in 1949 after cleaning but before restoration, it is clear that this area was only partially cleaned; in the cross-sections of paint samples from the same area, taken before and during the recent cleaning, as many as three campaigns of restoration were visible. Generally a thick layer of varnish, highly fluorescent under ultraviolet light and sometimes slightly pigmented, lay directly on the surface of the original paint beneath the overpaint, with further layers of varnish sometimes also present between the overpaint layers. The different campaigns of restoration were distinguishable by the specific pigment mixtures that had been used. The most recent overpaint in the left foreground was a greenish colour, consisting mainly of Prussian blue mixed with a bright iron-oxide yellow. The earlier campaigns were a duller green or brown colour, based mainly on yellow and brown earth pigments, but still also contained the anachronistic pigment Prussian blue.[27] The priming on the canvas, a thick beige-coloured layer composed mainly of lead white mixed with a little umber,[28] dominates the image in the X-radiograph, so that even the main features of the composition, such as the cows and the milkmaid, are barely visible. Although the extensive repaint in the left foreground could be seen in the X-radiograph, aside from an obvious larger loss with an old filling towards the right of this area, only a few of the small losses that extended through the priming layer to the canvas were visible, and the state of the original paint remaining beneath the restoration was not clear. Reassuringly, in almost all the cross-sections from this area some original paint was present beneath the restoration, even if in some places, particularly at the edge of cracks, it was abraded so that the priming layer had become exposed at the surface.[29]

Analysis of the organic materials in scrapings from different areas of restoration in the left foreground identified the natural resins dammar and fir balsam as well as heat-bodied linseed oil and a trace of beeswax.[30] The scrapings included the varnish and overpaint from all the restoration campaigns seen in the cross-sections as it was not possible to separate them. However, as they were taken after the most recent mastic varnish had been removed, the resins are likely to originate from the old varnish layer that lies beneath the overpaint directly on the original paint. This was found to be an oil-resin varnish with heat-bodied linseed oil present within this layer, although in some of the samples analysed the linseed oil detected may also be related to the overpaint from the 1949 restoration where the retouchings are recorded as being in oil.

The severity of the blanching of the original green paint in the right foreground made it difficult to determine simply from the appearance on the surface

PLATE 6 Detail of the foreground landscape at the right of the painting during cleaning, showing blanching in the green mid-tones, and the patchy dark brown remains of an old varnish.

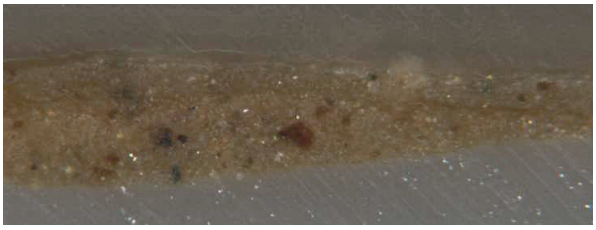

PLATE 7 Cross-section from the brownish-green paint of the landscape at the left of the painting, showing a translucent yellow unpigmented layer between original paint layers. Original magnification 400×; actual magnification 335×.

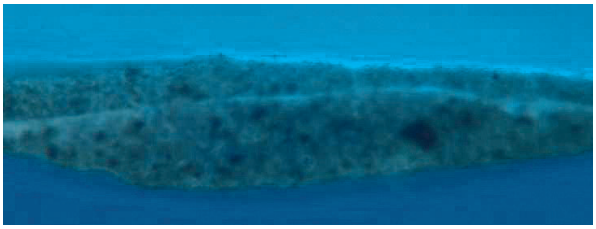

PLATE 8 Cross-section illustrated in PLATE 7 in ultraviolet light, showing the whitish fluorescence of the unpigmented layer between original paint layers. Original magnification 400×; actual magnification 335×.

whether translucent greenish-brown patches scattered over this area were the remains of an older varnish or were a result of uneven degradation of the paint (PLATE 6). In cross-section, however, it was clear that these were the remains of an old degraded varnish, which ran over cracks in the original paint. This had a similar strong fluorescence under ultraviolet light to the varnish layer found directly on the original paint beneath the overpaint in the left foreground, and again fir balsam, dammar and some heat-bodied linseed oil were identified by GC–MS analysis.[31]

Many nineteenth-century varnish recipes mention the addition of oleoresins such as fir balsam to dammar or mastic because they were believed to act as a plasticiser and to make the film less brittle.[32] The restoration recorded in 1888 was carried out by Horace Buttery. A varnish applied by him in the same year to Gaspard Dughet's *Landscape with a Storm* (NG 36) has been analysed and found to be mastic mixed with a little heat-bodied linseed oil, and further analyses of surface coatings on National Gallery paintings that Buttery is known to have treated around this time established that he was fond of using this type of varnish.[33] This could suggest that the remains of varnish on *The Large Dort* are not from Buttery's restoration but date from an even earlier treatment, perhaps before the painting entered the National Gallery in 1876.[34] In any case, the damage to the left foreground of the painting must have occurred before the fir-balsam-containing varnish was applied and therefore at quite an early date.

In one or two of the cross-sections a much thinner fluorescent layer, rather different in appearance from the nineteenth-century varnish, was seen between paint layers that were certainly original (PLATES 7 and 8); it seems likely that this is an intermediate varnish or 'oiling out' layer. Although the practice of 'oiling out' is associated more with eighteenth-century painting, examples have also been reported in seventeenth-century paintings.[35] Several documentary sources of the period mention application of a thin layer of varnish in a solvent, or mixed with oil, to a paint layer before applying further paint, either to saturate paint that has become matt or to prevent sinking of subsequent layers.[36] It is interesting that in *The Large Dort* intermediate varnish layers were seen only in samples from the dark green and brown areas of the foreground, where the paint is rich in pigments with a high oil absorption such as umber, green and yellow earth, the iron phosphate mineral vivianite, and yellow lake, so that it may well have been prone to sinking or drying with a matt surface.

Guided by the information obtained through examination and analysis of the relevant cross-sections, the most recent cleaning was able to safely distinguish the older restoration varnishes and retouchings, and reduce or remove much of this material. As a result the painting gained appreciably in legibility, and the impression of depth and aerial perspective was considerably heightened. Yet the picture's appearance, while much improved, was nonetheless quite different from how it must have originally appeared, not just because of the accidental damages and rough treatment, but because of changes within the painting materials themselves. Some of these changes are subtle; for example, the blue cobalt-containing glass pigment smalt, which is well know to have a tendency to degrade and lose colour, was used in the sky and although it has been protected to some extent here by

being mixed with lead white,[37] some change in colour has occurred. It can be difficult to determine simply by the colour of the pigment particles seen in samples under the microscope whether the smalt has in fact changed, or whether a greyish appearance is a result of use of one of the paler grades of smalt that were available to artists at that time.[38] However, it is possible to distinguish between a deliberately pale smalt and one that has deteriorated by analysis of the composition of the glass; the low potassium content in the smalt in the sky of *The Large Dort* is a clear indication that it is degraded and would originally have been a stronger blue colour.[39]

**The use of vivianite**

The blue pigment in the milkmaid's skirt (PLATE 9) in *The Large Dort* is the iron phosphate mineral vivianite (hydrated iron phosphate).[40] The use of this pigment in seventeenth-century Dutch paintings was first discovered in 2001 in paintings by Aelbert Cuyp, but since then it has been found in paintings by Carel Fabritius, Rembrandt, Vermeer and Gerard Dou, as well as in the work of four of the artists of the Oranjezaal, the central hall of the Royal Palace Huis ten Bosch in The Hague, painted between 1648 and 1652.[41] It was evidently quite widely employed when a soft greyish blue was required, by painters from many different parts of the Netherlands. Cuyp used it very frequently throughout his career, especially in the mixed greens of his landscapes; it appears in eight of the eleven paintings that were studied in preparation for the 2001 Cuyp exhibition, including the early *Landscape with Two Windmills* of around 1640–1 (Copenhagen, Statens Museum for Kunst) and the much later *River Landscape with Horsemen and Peasants* (NG 6522), which is thought to date from the 1660s.[42] The earliest of the Dutch seventeenth-century paintings in which vivianite has been identified so far is Rembrandt's *Susanna* (The Hague, Mauritshuis) from 1636,[43] a few years before the earliest of Cuyp's paintings known to incorporate the pigment. However, vivianite is known to have been used in paintings from all over Europe from as early as the eleventh century up to the eighteenth century.[44]

The relatively low number of paintings of this period in which the pigment has been reported so far is probably not a true reflection of the degree to which it was used, but relates to the difficulty of recognising it in paint samples under the microscope, especially when it is a component of complex mixtures, and when it is of the earthy type with a particle size of only a few microns, as it is in these paintings. Earthy vivianite deposits are found in peat bogs where iron-rich waters can react with phosphate in the organic matter to form the mineral. This seems the most likely source of the pigment used by Cuyp, since not only was peat abundant in the Netherlands but there was an active peat industry around Dordrecht as well as elsewhere in the Netherlands.[45]

PLATE 9 Detail of PLATE 1 showing the milkmaid.

The mineral was not given the name vivianite until the nineteenth century.[46] By the late eighteenth century its chemical composition was evidently appreciated, since the mineralogy literature describes a blue earth that is an iron phosphate, and already earlier in the century a blue iron earth is mentioned, which suggests that vivianite was being described and that it was known that it contained iron. At the beginning of the eighteenth century Simon Eikelenberg mentions a pigment that he calls 'blue ashes' which is likely to be vivianite, as he says it can be found in a ditch near the 'Kolver Weyd'.[47] The seventeenth-century documentary sources on painting materials, however, generally refer only to colour names, which often cannot be associated with a specific material, although sometime clues can be gained from the context or price, and occasionally they

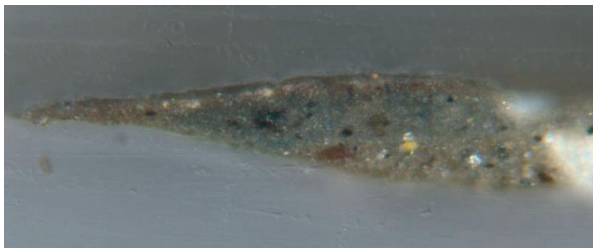

PLATE 10 Cross-section of a paint sample from the milkmaid's skirt. The grey-blue vivianite layer lies over the brownish-green paint of the landscape. The surface of the vivianite layer has altered to a brown colour. Original magnification 400×; actual magnification 335×.

PLATE 11 Detail of the foreground landscape at the right of PLATE 1 showing flattening of the blanched paint and the way in which the cooler greyer greens further back in the landscape (towards the top of the image here) and the mid-tones (at the bottom of the image) are now similar in tone.

go on to give additional information on the properties of the pigment or where it might be found. Only one documentary source of the period has been found that mentions a blue pigment that might reasonably be thought to be vivianite. Richard Symonds, in the 1650s, recorded a conversation with a Mr Remee (probably the French artist Remy van Leemput, who was working in London) about a pigment that he calls 'Harlems Oltramarin' which was a 'blew clay earth that is washt…..& tis not any way produc'd from Lapis Lazzuli'.[48] The perhaps equivalent term 'terra de Harlem' is mentioned in several sources (without being further described), most notably in some notes made by the artist Daniel King around the middle of the seventeenth century about the practice of a landscape painter referred to as 'seigneur Otto', probably the Dutch painter Otto Hoynck, who recommends a mixture of 'terra de Harlem pink lake' for 'farthermost trees and dusky places'.[49] A link can perhaps also be made to the 'Haarlem ashes' mentioned by Samuel van Hoogstraten (who, like Cuyp, was a Dordrecht painter) as one of the three types of blue ashes available at the time,[50] as well as the blue ashes described by Eikelenberg. Like most painters, Aelbert Cuyp was likely to have obtained his pigments from an apothecary or grocer, such as the merchant Cornelis van Bolenbeek, who is recorded as selling painting materials in Dordrecht.[51] The vivianite in his paintings may well have been bought as a blue ash, and while Cuyp would not have known what the composition of the pigment was, the variety of blue ash that he chose was consistently composed of vivianite over a very long period of time since it appears in his paintings throughout his career.

When vivianite is first extracted it is colourless but it quickly oxidises to a blue colour suitable for use as a pigment. However, it has been known to deteriorate, as it has in the medieval wall paintings in Winchester Cathedral, where it has become yellow, giving a greenish cast to the paint.[52] The oxidation of vivianite has been discussed extensively in the mineralogy literature, where it is suggested that it is converted to metavivianite (which is yellow) and, on further oxidation, to the amorphous brown ferric hydroxyl phosphate hydrate santabarbaraite.[53] Although the change in colour is not as dramatic as that in the wall paintings at Winchester, alteration of vivianite has also been observed on several seventeenth-century paintings such as those in the Oranjezaal and on Vermeer's *Procuress* (Dresden, Gemäldegalerie).[54] The milkmaid's skirt in Cuyp's *Large Dort* has a patchy brownish-blue appearance which suggests deterioration of the pigment has occurred (PLATE 9). This was confirmed by the cross-section of a sample of the paint (PLATE 10), where the bulk of the layer is a greyish blue, but the upper part of the layer has become brown.[55] It is difficult to judge, however, what the original hue would have been, since mineral vivianite can range from a relatively strong blue to a rather dull greyish colour.

## Degradation of green paint in the foreground landscape

While much of the remarkable sense of distance within *The Large Dort* is achieved through its dramatic juxtapositions of scale, space was also achieved through more subtle gradations of colour applied to the landscape, and it is in these areas that the visual impact of the changes to the pigments is most keenly felt. The blanching in the green middle distance has the effect of suppressing the tonal variations originally painted within it; as a result the area has become a flattened, almost two-dimensional shape (PLATE 11). There are

PLATE 12 *Landscape near Rhenen: Cows Grazing and a Shepherd playing the Flute*, 1650–5. Oil on canvas, 170 × 229 cm. Paris, Musée du Louvre (Inv. 1190).

strange inversions of expected lights and darks, whereby some darker areas have lightened in value as a result of the blanching while other darker greens are relatively unchanged, creating an odd blotchy effect which is further exacerbated by areas of glaze which have been protected by old extended fills and retouchings, now visible after cleaning as darker, more saturated blotches within the now chalky areas. Adding to the confusion is the fact that some of the originally darker colours which have lightened now have values close to the lighter, rather acidic mixed greens that Cuyp favoured for the more distant landscape, so that higher keyed colours that are for the most part unchanged sit oddly with the blanched tones now present in the nearer distance. The nature of these visual disruptions is more easily understood by comparison with similar paintings by Cuyp in which the colours are in the main well preserved, for example the *Landscape near Rhenen: Cows Grazing and a Shepherd playing the Flute* now in the Louvre (PLATE 12). Dating from about the same time,[56] the painting employs a similar spatial construction: the distant landscape is dramatically thrust back by the prominent livestock of the foreground, and the figures are roughly the same scale and arranged in a similar way within the depicted space as their National Gallery counterparts. Unlike the London picture, however, in *Landscape near Rhenen* figures and cattle inhabit a notably verdant and coherent setting in which the painted transitions and gradations within the landscape appear to be remarkably well preserved, particularly so in the parts analogous to the blanched areas of *The Large Dort*.

The appearance of the Louvre picture is therefore very helpful for understanding the visual impact of the changes which have occurred to the National Gallery painting, and it may also offer some indirect circumstantial evidence about the possible causes of those changes. The combination of heat and moisture which results from glue-paste lining processes is often suggested as a cause of blanching in seventeenth-century paintings, especially those containing green earth pigments.[57] This seems unlikely to be the principal agent of blanching here, however, for although the National Gallery painting was relined with glue paste in 1888, the Louvre painting also has a documented history of similar (and arguably more extreme) structural intervention using both heat and moisture, having been transferred to a new canvas support in 1939.[58]

Furthermore, panel paintings by Cuyp exist with blanching as great if not greater than that in *The Large Dort*. Two examples include the *Landscape with Two Windmills* in Copenhagen and *View on a Plain* now in Dulwich Picture Gallery,[59] both from the early part of his career, since from the mid-1650s onwards he painted almost exclusively on canvas. These, and other paintings, give evidence that the paint has been protected from deterioration where it has been covered with a frame, suggesting that light exposure, and perhaps other environmental factors, are primary agents in the degradation.[60] Earlier technical studies of Cuyp's paintings, which included *The Large Dort*, have established that Cuyp generally used complex mixtures of pigments for his green landscape paint, based on mixtures of yellow lake, vivianite, yellow earth,

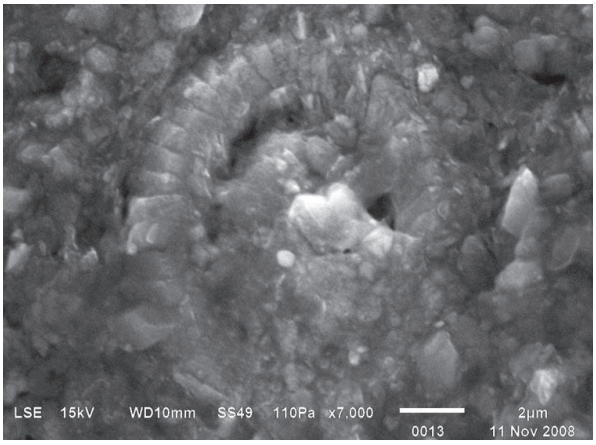


FIG. 1 Secondary electron image in the SEM showing a coccolith in the chalk substrate of a yellow lake pigment in the green paint of the landscape.

green earth, brown umber, lead-tin yellow, black and occasionally azurite, in varying proportions to modify the hue.[61] The restoration of *The Large Dort* provided the opportunity for further investigation, carried out partly to establish where the paint was blanched and where Cuyp had deliberately used a grey-green colour, to inform the retouching of the painting, and also to obtain some impression of how degradation had affected the colours in the landscape. Comparison of blanched and unblanched paint, and identification of the materials, was also a first step towards understanding the cause of the deterioration.

Yellow lake is a major component of the paint of the foreground landscape, particularly in the darker green areas. Energy dispersive X-ray analysis (EDX) in the scanning electron microscope (SEM) and Fourier transform infrared microscopy (FTIR) detected a large amount of calcium carbonate, evidently present in the form of chalk of natural origin since coccoliths were visible in the secondary electron SEM images (FIG. 1). The chalk, in this case, is the substrate for a yellow lake pigment. It is not always straightforward to confirm that yellow lake is present in the type of complex pigment mixture used for green paint by Cuyp, as chalk can be present in the paint as an extender, or as an impurity associated with a natural mineral pigment. Here, however, dyestuff originating from the weld plant was found to be present in the paint by High Performance Liquid Chromatography (HPLC) analysis, as was found in other paintings by Cuyp during the study of his materials carried out for the catalogue of the Cuyp exhibition in 2001.[62]

Weld was the most stable of the common flavonoid dyestuffs used to make yellow lake pigments at that time, but would still have been the most fugitive of the pigments present in Cuyp's green paint mixtures. Although it was widely recommended for use in mixed greens in landscape painting in the seventeenth century,[63] the pigment already had a poor reputation for light fastness, with some writers suggesting that the use of chalk as a substrate could be to blame.[64] Some of the recipes for yellow lake from this period add alum as well as chalk to the solution of dyestuff extracted from the plant. The aluminium in the alum can bond to the dyestuff forming a complex when the pigment precipitates, while with chalk it is likely that the dyestuff is mostly only adsorbed onto the surface of the particles, particularly where it is used in excess. In fact analyses of yellow lakes in seventeenth-century paintings have shown that they almost always contain predominantly chalk; in *The Large Dort* only a little aluminium was found associated with the yellow lake. Artificial ageing experiments on yellow lakes made from a variety of historic recipes differing in the proportions of alum and chalk, as well as type of dyestuff, showed that the substrate has more influence on the stability of the pigment than the dyestuff, and that the pigments containing mostly chalk were less stable than those prepared with alum, bearing out the opinions expressed by seventeenth-century writers that yellow lake prepared with chalk was more fugitive.[65] However, yellow lakes prepared with alum tend to be a brownish yellow, while those with a high proportion of chalk are a brighter more acid yellow-green colour that would explain its appeal to painters. In addition, a transparent yellow was a vital component of the subtle soft green colours that seventeenth-century landscape painters were aiming to produce, and by mixing yellow lake with other pigments limitless variations in exact tone and transparency could be achieved.

The green paint in *The Large Dort*, as well as in most of Cuyp's other landscapes, contains vivianite which (as noted above) is also a pigment of only medium stability. It has certainly deteriorated in the milkmaid's skirt, where in the lighter areas it was used alone, but although the paint has a patchy brownish-blue appearance, it has not altered in the same way as the paint in the landscape; there is a change in colour but without loss of integrity of the paint film, while in the blanched dark green paint in the foreground landscape the surface appears to have a greyish veil which gives the impression that the paint has become more scattering due to some physical change rather than simply loss of colour of pigment. Green earth, which has been implicated in earlier studies of blanching, is also present in the green paint mixtures in *The Large Dort*. However, although it may well contribute to the deterioration, the most severely blanched areas of the foreground were the

brownish-green paint immediately below the cow at the left edge of the painting and the areas in the right part of the landscape that were probably originally the mid-tones of the foreground, and in these yellow lake is the major component. In addition, other works by Cuyp exist which have suffered badly from blanching, despite the fact that green earth was not used in the green paint mixtures.[66]

The darker brown areas, which contain a higher proportion of umber, black and yellow earth, are not so obviously affected by blanching, which has led to strong contrasts such as that between the dark brown background of the landscape and the now grey-green dock leaves, creating an effect that was probably not originally intended.[67] The severely blanched brown area immediately below the cow at the left is a slightly lighter yellow-brown colour as the uppermost paint layer contains a greater proportion of yellow lake than the darker brown areas. It also contains vivianite, some green earth and some lead-tin yellow, but in the cross-section of a paint sample the upper part of the paint has clearly lightened and is a cooler greyer green colour that suggests it is a yellow colouring component that has been lost (PLATES 13 and 14). In the cross-sections from the blanched area at the right of the foreground, the lightened zone at the surface extends even further into the paint layer, to a depth of around 20 microns at its most extreme (PLATE 15) indicating that the blanching is due to a deep-seated change in the paint layer.

Although fading of the fugitive weld lake pigment will certainly have occurred, it seems unlikely that it is the only process that has taken place in the deteriorated paint. Previous studies of blanching have suggested that physical changes in the paint can also be responsible, such as cracking on a fine scale, or breakdown of the paint binding medium, resulting in scattering microvoids that make the paint appear lighter. Paint medium analysis found that, although the binder was heat-bodied linseed oil throughout, the paint was leaner in the blanched areas than in the unblanched areas, perhaps indicating that some breakdown of the oil had indeed taken place.[68] The surface of an unmounted fragment of paint from a blanched area, imaged in the SEM, was similar to that reported in previous SEM studies of blanched paint,[69] with some small voids visible, but as in this painting there were no unblanched areas that would make a direct comparison (such as paint that had been protected by a frame rebate), it was difficult to draw firm conclusions from the image. Further evidence of the friable nature of the paint was seen in paint cross-sections under the optical microscope since small fine cracking, not only vertically but also sometimes horizontally, with some spalling from the

PLATE 13 Detail of the foreground at the left of PLATE 1 showing blanched greyish-green paint.

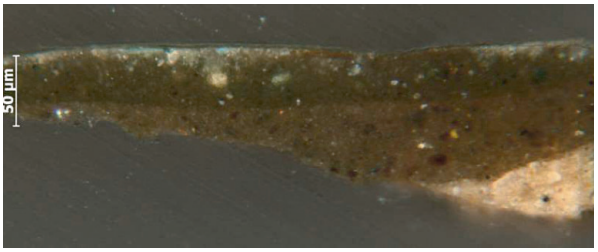


PLATE 14 Cross-section from the blanched paint of the area of the left foreground showing lightening of the surface of the uppermost green paint layer. Original magnification 200×; actual magnification 170×.

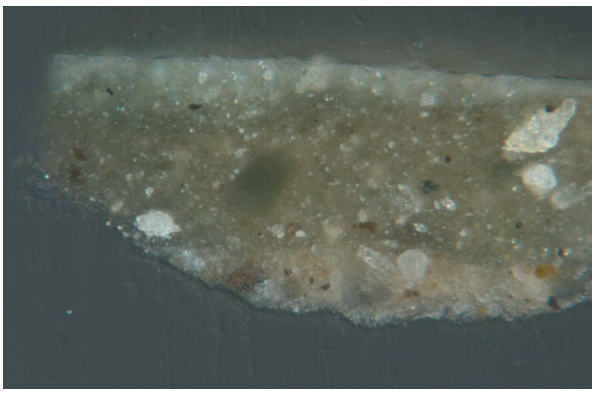

PLATE 15 Cross-section of a paint sample from the blanched paint in the right foreground. The uppermost green layer of paint can be seen to have become lighter through almost half of its depth. Where it has not changed it is a warmer yellower colour. Original magnification 400×; actual magnification 335×.

surface of small flakes of paint, was visible in several of the samples.[70]

Recent studies by van Loon of seventeenth-century Dutch paintings that exhibit blanching have also hinted at the role that migration of lead soaps might play.[71] It is therefore likely to be significant that FTIR microscopy of samples from blanched areas showed large absorption bands that can be assigned to lead soaps, which are not present in samples from the unblanched areas. The main component of the paint in all the samples analysed was yellow lake, with small amounts of other pigments, including some lead-tin yellow. So little lead-tin yellow is present however, that it seems unlikely that it is the source of the lead soaps here. Instead, it may be that lead soaps have migrated through the paint layer from the lead-white-rich priming, as already suggested by van Loon.[72] Another possibility, also suggested by van Loon, is that an oil that has been boiled with lead has been used. The more open structure of the lean blanched paint, which could perhaps encourage migration of lead soaps to the surface, could be an explanation for the fact that they were detected in deteriorated areas.[73]

The fact that a high proportion of Cuyp's paintings suffer from blanching is evidence that the cause lies in his use of unstable materials, no doubt exacerbated in many cases by the environmental conditions, as well as by the restoration procedures, that an individual work has endured. The mixtures that he uses for greens are similar in all his paintings, and so there are works that have suffered from blanching dating from the very beginning of his career, such as the *Landscape with Two Windmills* in Copenhagen mentioned above, as well as works that are thought to date from much later, such as the *Evening Landscape* in the Royal Collection, and the *River Landscape with Horseman and Peasants* in the National Gallery (PLATE 2). Blanching in paintings by Cuyp, including *The Large Dort*, was investigated in connection with the exhibition of his works held in 2001, when yellow lake was already identified as a possible primary cause of the deterioration. However, the opportunity to study this deterioration phenomenon in more detail that was afforded by the conservation treatment of *The Large Dort*, coupled with the further research on blanching that has been carried out in recent years and improved analytical capabilities, has allowed new observations to be made which indicate that the deterioration is even more complex than originally thought. Although the processes that have led to the blanching are still not fully understood, the analysis of the materials was able to establish which areas are blanched and which were originally intended to be a greyish-green colour, which served an important role in informing the retouching strategy.

## Conclusion

The many chemical changes which have occurred in the paint are irreversible, and there was never any question of retouching the painting in such a way as to disguise their visual impact completely. It was felt, however, that there were special considerations in this case that prompted taking an approach that was slightly more interventive than is generally considered the norm. Much of the blanching and fading that have occurred in the paint of the near and middle distance landscape had seriously affected our reading of the intended recession of the depicted space, a dramatic compositional device which was fundamental to the artist's conception of the image. Given that there was a considerable amount of relatively well-preserved comparative material from other pictures, as well as isolated areas on *The Large Dort* that had remained less affected by the changes, it was decided to selectively tone some of the lighter, more obviously affected areas of paint to present a more coherent and properly functioning spatial recession. The blanched areas were toned with translucent cool grey-greens of very low colour intensity; the intent was to aid the spatial illusion not through reconstructing the colours of the unaltered paints, but through re-establishing tonal relationships that functioned well enough to allow the viewer to appreciate some measure of the picture's original splendour.

## Acknowledgements

The authors would like to thank Rachel Morrison for her work on analysis of the binding medium and surface coatings of *The Large Dort*, which makes a significant contribution to several sections of this paper. We are also very grateful to Jo Kirby for her analysis of the dyestuff used to prepare the yellow lake pigment, and for helpful discussion of the history of varnishes, as well as some of the technical historical documentary sources cited. We are grateful to JEOL UK for FIG.1, which was obtained during a demonstration of their 6610LV SEM. The authors would also like to thank Betsy Wieseman, Curator of Dutch Paintings at the National Gallery, Melanie Gifford, National Gallery of Art, Washington DC, and Alan Chong, Curator of the Collection at the Isabella Stewart Gardner Collection, for their helpful observations on the text of this article and the conservation treatment of the painting.

**Notes**

1 N. MacLaren, revised C. Brown, *National Gallery Catalogues. The Dutch School 1600–1900*, London 1998, Vol. 1, pp. 91–2, and Vol. 2, plate 78.

2 M. Spring, 'Pigments and Colour change in the Paintings of Aelbert Cuyp', in A. Wheelock ed., *Aelbert Cuyp,* exh. cat., Washington DC 2001, pp. 64–72. R. Beresford and G. Waterfield eds, *Conserving Old Masters. Paintings Recently Restored at Dulwich Picture Gallery*, exh. cat., Dulwich Picture Gallery, London 1995.

3 See Arnold Houbracken, *De Groote Shouburgh der Nederlantsche Konstschilders en Schilderessen*, Amsterdam 1718–21, ed. Smittens, Maastricht 1943, pp. 196–7. Houbracken's biography of Cuyp is published in translation in H. Horn, *The Golden Age revisited: Arnold Houbracken and his Great Theatre of Netherlandish painters and paintresses,* Doornspijk 2001, Vol. 1, pp. 248–9. See also A. Wheelock, 'Aelbert Cuyp and the Depiction of Dutch Arcadia', in Wheelock 2001 (cited in note 2), pp. 14–33; A. Chong, *Aelbert Cuyp and the Meaning of Landscape,* PhD thesis, New York University 1992.

4 A. Chong, 'Aristocratic Imaginings: Aelbert Cuyp's Patrons and Collectors', in Wheelock 2001 (cited in note 2), pp. 34–51.

5 Chong 2001 (cited in note 4), p. 42, and C. Brown, 'Revising the Canon: The Collector's Point of View', *Simiolus: Netherlands Quarterly for the History of Art*, Vol. 26, no. 3, 1998, pp. 201–12 (Brown gives the number of Cuyps in Van der Slingeland's collection as 38).

6 Brown 1998 (cited in note 5), pp. 201–12; Chong 2001 (cited in note 4), p. 42, and note 7, p. 210, for the full Boydell text and Waagen's similar views.

7 Quoted in Chong 2001 (cited in note 4), p. 43. The Dutch were well aware of the comprehensive acquisition of Cuyp paintings by the English; in Cornelius Apostool's 1793 *Beauties of the Dutch School*, he wrote of Cuyp that 'his best works are now in England.' Quoted in B. Cornelius, 'Review: Aelbert Cuyp. London and Amsterdam', *Burlington Magazine,* 144, 2002, p. 243. See also F. Simpson, 'Dutch Paintings in England before 1760', *Burlington Magazine*, 95, 1953, pp. 40–2.

8 MacLaren, revised Brown 1998 (cited in note 1), pp. 91–2.

9 See Chong 2001 (cited in note 4), p. 42: 'Horses, hunting and husbandry were the common preoccupations of painter, patrons, and later collectors.'

10 See Houbracken in Horn 2001 (cited in note 3), p. 249; MacLaren revised Brown (cited in note 1), pp. 86–7; Wheelock 2001 (cited in note 3), p. 16.

11 Chong 1992 (cited in note 3), p. 355: There is an 1818 reference to 'a cattle piece - large and fine' in the Bishop of Derry's collection, which is probably *The Large Dort,* subsequently inherited by his nephew.

12 Ibid, p. 355; MacLaren, revised Brown 1998 (cited in note 1), pp. 91–2.

13 Another Cuyp entered the Gallery with the Salting Bequest in 1910. See Brown 1998 (cited in note 5). By contrast, the first Cuyp entered the Rijksmuseum in 1965; see Cornelius 2002 (cited in note 7), p. 242.

14 '*Onder zyne konststukken zyn wel de voornamste, daar hy de Dortsche Beestemarkt in verbeelt, also ok de Pikeurbaan, daar hy dan de schilderagtigste Paarden die daar gewoonlyk kwamen, in te pas bracht, zoo dat men dezelve kost onderkennen. Dat 'er na zyn dood geen modellen of teekenen van andere meesters by hem gevonden wierden is een bewys dat hy alleen de natuur tot leiding nam. 't Was ook zyn aart niet gelt daar aan te besteeden, want hy altyt tot zinspreuk: 'In harde Ryksdaalders komt de mot Niet.'* Houbracken 1718 (ed. Smittens 1943, cited in note 3), p. 196. English translation from Houbracken in Horn 2001 (cited in note 3), p. 249.

15 Chong 1992 (cited in note 3), p. 255.

16 S. Reiss, *Aelbert Cuyp*, London 1975, pp. 31 and 43.

17 A fine example of the use of such a Rhineland drawing in a painting can be seen in the comparison of the Rijksmuseum's *River Landscape with Two Horsemen* and the drawing of *Wylemeer between Mijmegen and Cleves*, reproduced in Wheelock 2001 (cited in note 2), pp. 178–9. The impact of the Rhineland drawing tour, compositional elements of which occur in the newly monumentally scaled paintings themselves, have contributed to a consensus dating of the mid to late 1650s for *The Large Dort*, as well as other broadly similar paintings in Amsterdam, New York, Washington and Paris. See Chong 1992 (cited in note 3) and Wheelock 2001 (cited in note 2). No landscapes by Cuyp have been found with a painted date accompanying the signature from later than 1642, however (for example, *The Large Dort* is signed but not dated); see Alan Chong, 'New Dated Works from Aelbert Cuyp's Early Career', *Burlington Magazine*, 143, 1991, pp. 611–12.

18 See Reiss 1975 (cited in note 16), pp. 31 and 43.

19 Motifs occurring in *The Large Dort*, such as the standing cow and the cow at the left, reappear in *Peasants and Cattle by the River Merwede* (NG 1289), elements of which are in turn found in the Corcoran Gallery *Landscape with Herdsmen* (illustrated in Wheelock 2001, cited in note 2, p. 143). See Chong 1992 (cited in note 3), pp. 355–6, 373–5, and 379; see also Hans-Ulrich Beck, 'Reviews: Aelbert Cuyp, exhibition catalogue edited by Arthur Wheelock, Jr., with an essay on drawings by Egbert Havercamp-Begemann and drawings catalogued by Wouter Kloek', *Master Drawings*, Vol. 40, No. 3 (Autumn 2002), pp. 265–8, for eight other examples of specific linkages between individual drawings and completed paintings within the 2002 exhibition.

20 Wheelock 2001 (cited in note 2) mentions such obvious assembling giving rise to 'quiet reservations' about the authenticity of the Corcoran Gallery *Landscape with Herdsmen* (cat. 25, pp. 142–3), reservations which he does not share, instead describing Cuyp as 'readapting drawn studies to create a surprising range of compositions with a rather limited range of subject matter'. Another example of such recycling can be found within the National Gallery collection in the comparison of *The Large Dort* and *The Small Dort* (NG 961 and NG 962 respectively). Chong (oral communication) doubts the authenticity of the smaller painting, though the available technical evidence, both within the general use of 'period' grounds and painting materials as well as specific pigment mixtures, with their associated problems, are typical of Cuyp's practice – including such specific elements as the use of vivianite pigment in the boy's breeches. There was something of an industry in the making of Cuyp-like paintings by pupils such as Abraham Calraet, however, and close technical comparative analysis between the two groups of painters is an area calling for further study. See Chong 1992 (cited in note 2), p. 61, on followers and copyists; Spring in Wheelock 2001 (cited in note 2) for more technical information on *The Small Dort*.

21 See E. Havercamp-Begemann, 'The Beauty of Holland: Aelbert Cuyp as Landscape Draftsman', in Wheelock 2001 (cited in note 2), pp. 74–87, on Cuyp's typical combining of realistic observation and imagined spatial constructs within his landscape drawings.

22 Wheelock sees the influence of Simon de Vlieger in such diagonal lighting schemes. See his entry (cat. 19) for Cuyp's *River Landscape with Cows* (Washington DC, National Gallery of Art) in Wheelock 2001 (cited in note 2), pp. 130–1.

23 See Wheelock 2001 (cited in note 2) on the Arcadian element in such paintings: Cornelius 2002 (cited in note 7), pp. 244–5, thinks this interpretation is somewhat overplayed.

24 Chong 1992 (cited in note 3), p. 356.

25 The picture had become unsightly enough not to be included in a show dedicated to the artist held in 2002 at the National Gallery of Art, Washington DC, the National Gallery, London, and the Rijksmuseum, Amsterdam. See Wheelock 2001 (cited in note 2).

26 The analyses of the materials in the painting reported in this article were carried out using optical microscopy, energy-dispersive X-ray analysis in the scanning electron microscope (SEM-EDX), Fourier transform infrared microscopy (FTIR) and gas chromatography-mass spectrometry (GC–MS).

27 The presence of Prussian blue in the overpaint was confirmed by FTIR microscopy, dating it to after the early 1700s. See B.H. Berrie, 'Prussian Blue', in *Artists' Pigments. A Handbook of Their History and Characteristics, Volume 3*, ed. E. West FitzHugh, Washington DC 1997, pp. 191–218. Suspected overpaint in a shadow cast by the kneeling cow was found to contain viridian (FTIR and SEM-EDX) and alizarin crimson (FTIR) in addition to Prussian blue.

28 Relatively translucent yellow-brown particles, as well as more opaque black, yellow and red particles are visible in the ground layer mixed with lead white. Often the more opaque particles seem to be in agglomerates with the more translucent yellow. This suggests that a single rather homogeneous earth pigment has been added to lead white. Iron, silicon and manganese were detected by EDX; the opaque red and yellow particles are Fe-rich, while the more translucent particles contain Si. Spot spectra collected from particles that appear black, which are present within the brownish-yellow agglomerates as well as separately, showed mainly manganese, indicating that they are particles of pyrolusite, natural manganese dioxide. These could be a component of a brown umber that is rather inhomogeneous, or could have been added as a separate black pigment. Manganese dioxide has also been found in other painting of the period, including one by Cuyp. See M. Spring, R. Grout and R. White, '"Black earths": A Study of Unusual Black and Dark Grey Pigments used by Artists in the Sixteenth Century', *National Gallery Technical Bulletin*, 24, 2003, pp. 96–114. Up to three layers of this beige ground layer are visible in cross-sections. A layer of chalk (coccolith-containing calcium carbonate, confirmed by SEM-EDX) is present beneath the beige layers in two of the cross-sections.

29 The painting was also examined using optical coherence tomography (OCT), as part of a Leverhulme-funded collaborative project investigating the application of this imaging technique to conservation. See M. Spring, H. Liang, B. Peric, D. Saunders and A. Podoleanu, 'Optical coherence tomography – a tool for high resolution non-invasive 3D imaging of the subsurface structure of paintings', *ICOM-CC 15th Triennial Conference, New Delhi 22–26th September 2008, Preprints. Vol. II*, pp. 633–40. This technique uses an infrared light source and allows the layer structure of the painting to be imaged non-invasively. Using the real cross-sections as a guide for interpretation of the OCT cross-section images, it was possible to look

at the layer structure over a wider area of the left foreground. A better impression of how much original paint was present beneath the restoration could be gained than from the small paint samples alone.

30 Analysis was carried out by GC–MS. As well as heat-bodied linseed oil, a significant proportion of a degraded pinaceae resin was detected; large peaks for methyl 7-oxodehydroabietate and methyl 7-oxo-15-hydroxydehydroabietate were seen. This was further identified as resin from a species of fir tree by the detection of the characteristic norambreinolide component. In the triterpenoid region of the chromatogram several peaks characteristic of dammar resin were observed, including 20,24-epoxy-25-hydroxy-dammaran-3-one. Traces of beeswax, which seem to be connected to a separate more recent conservation treatment were identified by the pattern of fatty acid methyl esters and hydrocarbons seen in the portion of the chromatogram directly after the peak for methyl stearate.

31 The results were very similar to those reported in note 30.

32 R. White and J. Kirby, 'A Survey of Nineteenth- and Early Twentieth-Century Varnish Compositions found on a Selection of Paintings in the National Gallery Collection', *National Gallery Technical Bulletin*, 22, 2001, pp. 64–84, particularly p. 74 and note 46.

33 White and Kirby (cited in note 32); analysis of the varnish applied in 1888 to Dughet's painting (NG 36) is reported in the table, p. 81. Several of the other varnish layers mentioned in this table can be identified, from the National Gallery conservation dossiers, as having been applied by Horace Buttery, from which his preference for mastic and heat-bodied linseed oil can be inferred (see p. 77 and note 56).

34 White and Kirby (cited in note 32), table and pp. 74–6. Although fir balsam is mentioned as a varnish additive in English documentary sources of the period, the varnish layers on paintings in the National Gallery in which fir balsam is one of the components all seem to be associated with conservation treatments that have taken place in Italy or with Italian restorers working in London. This might suggest that the fir balsam-containing varnish on *The Large Dort* was applied in Paris when the painting was offered for sale there in around 1854.

35 The layer in *The Large Dort* is only one or two microns in thickness. Similar very thin unpigmented layers that are fluorescent under ultraviolet light have been observed between original paint layers in cross-sections from *Portrait of Anna Maria van Schurman* (NG 1095) by Jan Lievens and Aelbert Cuyp's *River Landscape with Horseman and Peasants* (NG 6522), in a sample from the deteriorated paint of the dock leaf in the bottom left corner. It has also been reported in paintings by Frans Hals and Jan Davidsz de Heem (see Margriet van Eikema Hommes, *Changing Pictures. Discoloration in 15th–17th Century Oil Paintings*, Archetype Publications, London 2004, p. 24), as well as several of the seventeenth-century paintings that decorate the Oranjezaal, the central hall of the Royal Palace Huis ten Bosch, The Hague, painted between 1648 and 1652 (personal communication, Lidwien Speleers).

36 M. Beal, *A Study of Richard Symonds: His Italian Notebooks and Their Relevance to Seventeenth-Century Painting Techniques*, London 1984, pp. 150–2 and f. 58, 71 and 142–3. Symonds notes that the Italian artist Canini said he applied varnish to areas of underpaint that had dried matt. Several other English and Dutch sources also mention this practice. See van Eikema Hommes 2004 (cited in note 35) for a discussion of these.

37 M. Spring, C. Higgitt and D. Saunders, 'Investigation of pigment-medium interaction processes in oil paint containing discoloured smalt', *National Gallery Technical Bulletin*, 26, 2005, pp. 56–70. See also J.J. Boon, K. Keune, J. van der Weerd, M. Geldof and J.R.J. van Asperen de Boer, 'Imaging microspectroscopic secondary ion mass spectrometric and electron microscopic studies on discoloured and partially discoloured smalt in cross-sections of 16th century paintings', *Chimia,* 55, 2001, pp. 952–60.

38 Documentary sources list smalt of differing qualities at different prices. The price probably related to the intensity of the colour, which could depend on either the size of the pigment particles or the composition, in particular the cobalt content. See Chapter 2, 'Saffre, smalt, bleu d'esmail et azur', in F. Delamare, *Bleus en poudres. De l'Art à l'Industrie. 5000 ans d'innovations*, Paris 2007, pp. 71–122.

39 The low levels of potassium in many of the smalt particles, as well as the fact that EDX mapping showed that potassium had migrated to the surface of the layer forming what appears to be potassium sulphate (K and S detected by EDX), is a clear indication that the pigment has degraded. As well as the cobalt which is responsible for the blue colour, arsenic, nickel and bismuth were detected. These are associated with the cobalt ore (see Spring, Higgitt and Saunders 2005, cited in note 37).

40 The identification of vivianite is based on the detection of iron and phosphorus together in the blue particles by EDX analysis. The particles are small – averaging a couple of microns in size – suggesting it is of the earthy form. FTIR microscopy confirmed the presence of phosphate, but the bands were not sufficiently well defined to determine whether other iron phosphates are also present. Strictly speaking, vivianite mineral is monoclinic $Fe^{2+}_3(PO_4).8H_2O$, which is colourless, with all the iron in the ferrous form. In practice, $Fe^{2+}$ rapidly oxidises to $Fe^{3+}$ when it is exposed to air and light, developing a blue colour ($Fe^{2+}/Fe^{3+}$ charge transfer). For a recent summary of the literature, see D.A. Scott and G. Eggert, 'The vicissitudes of vivianite as pigment and corrosion product', *Reviews in Conservation*, 8, 2007, pp. 3–14.

41 Spring 2001 (cited in note 2). The published occurrences in seventeenth-century Dutch paintings to date are summarised in M. Richter, 'Shedding some new light on the blue pigment vivianite in technical documentary sources of northern Europe', *ArtMatters, Netherlands Technical Studies in Art*, Vol. 4, 2007, pp. 37–53, and in Scott and Eggert 2007 (cited in note 40).

42 Spring 2001 (cited in note 2).

43 Petria Noble and Annelies van Loon, 'New Insights into Rembrandt's "Susanna"', *ArtMatters, Netherlands Technical Studies in Art*, Vol. 2, 2005, pp. 76–96.

44 See Richter 2007 (cited in note 41) and Scott and Eggert 2007 (cited in note 40) for a summary of published occurrences of vivianite as a pigment. Before being discovered in Dutch seventeenth-century paintings, it had already been found in seventeenth-century paintings from Austria. See H. Paschinger and H. Richard, 'Blaupigmente der Renaissance und Barockzeit in Österreich', *Naturwissenschaften in der Kunst*, ed. M Schreiner, Vienna 1995, pp. 63–6. The scattered occurrences that have been published include works from every century between the eleventh and the eighteenth except the sixteenth. Two unpublished sixteenth-century examples, identified by EDX analysis, are in *Christ and the Virgin* (NG 295), probably 1500–50, catalogued as after Quinten Massys (beneath a red lake glaze in the underpaint of Christ's red robe, mixed with azurite and yellow earth), and Paolo Veronese's *Visitation* (Birmingham, Barber Institute), where it was found mixed with smalt in the shadows of the Virgin's cloak.

45 Richter 2007 (cited in note 41) lists references to vivianite deposits in the Netherlands and discusses locations where it could be found as well as the peat industry in the seventeenth century.

46 The mineral is named after the nineteenth-century mineralogist J.G. Vivian. See Scott and Eggert 2007 (cited in note 40).

47 Richter 2007 (cited in note 41) discusses the documentary sources and quotes the relevant passage in the Eikelenberg manuscript.

48 Beal 1984 (cited in note 36), p. 225. Van Leemput states that this 'blew clay earth' was 'much usd in faces by all ye face makers in London'. Rosamund Harley has already suggested that this blue earth might be vivianite, or another blue earthy mineral, ilsemannite. See R.D. Harley, *Artists' Pigments c.1600–1835, A Study in English Documentary Sources*, 2nd edn, London 1982, p. 59.

49 M. Kirby Talley, *Portrait Painting in England: Studies in the Technical Literature before 1700*, London 1981, p. 194, and pp. 207–27. Daniel King's *Secrets in the noble arte of Miniatura or Limning* which is published in Kirby Talley can be dated to between 1653 and 1657. Although it is mostly based on Norgate's first version of *Miniatura*, it also includes some original notes on oil painting technique, including those on 'seigneur Otto'.

50 Samuel van Hoogstraten, *Inleyding tot de Hooge Schoole der Schilderkonst* (originally published Rotterdam 1678), facsimile edn, Holland 1969, p. 221. See also Richter 2007 (cited in note 41) for a discussion on the term blue ashes in the context of vivianite.

51 Cornelis van Bolenbeek was recorded as selling painting materials, as well as other supplies, in Dordrecht around the middle of the seventeenth century. X. Henny, 'Hoe kwamen de Rotterdamse schilders aan hun verf?', in *Rotterdamse Meesters uit de Gouden Eeuw,* ed. N. Schadee, exh. cat., Historisch Museum Rotterdam, Zwolle 1994, p. 48. Cuyp would not necessarily have bought his supplies in Dordrecht, since documentary sources record instances of artists travelling to other towns to buy materials. See K. Levy-Van Halm, 'Where Did Vermeer Buy His Painting Materials? Theory and Practice', in *Vermeer Studies, Studies in the History of Art*, 55, Symposium Papers XXXIII, Center for Advanced Study in the Visual Arts, ed. I. Gaskell and M. Jonker, Washington 1998, pp. 137–41.

52 H. Howard, *Pigments of English Medieval wall painting*, Archetype Publications, London 2003, pp. 35–9. See also H. Howard, 'Techniques of the Romanesque and Gothic wall paintings in the Holy Sepulchre Chapel, Winchester Cathedral', in *Historical painting techniques, materials, and studio practice. Preprints of a symposium, University of Leiden, the Netherlands*, ed. A. Wallert, Marina del Rey, California 1995, pp. 91–104.

53 It is thought that once vivianite has oxidised to the extent that around 40% of the $Fe^{2+}$ has converted to $Fe^{3+}$ (with accompanying conversion of $H_2O$ to $OH^-$), the monoclinic lattice of vivianite collapses and triclinic metavivianite, $Fe^{2+}(3-x)Fe_x^{3+}(PO_4)_2(OH)_x(8-x)H_2O$, with x is greater than 1.4. Further oxidation can lead to the amorphous brownish santabarbaraite $(Fe^{3+}_3(OH)_3(PO_4)_2 \cdot 5H_2O)$. See G. Pratesi, C. Cipriani, G. Giuli, W.D. Birch,

'Santabarbaraite: a new amorphous phosphate mineral', *European Journal of Mineralogy*, 2003, 15, 185–92. It is also possible for other phosphate minerals to form, or for the vivianite to be oxidised directly to amorphous ferric phosphate without passing through metavivianite as an intermediate. See T. Sameshima, G.S. Henderson, P.M. Black, K.A. Rodgers, 'X-ray diffraction studies of vivianite, metavivianite and baricite', *Mineralogical Magazine*, March 1985, 49, pp. 81–5.

54 A. van Loon. L. Speleers, E. Ferreira, K. Keune and J. Boon, 'The relationship between preservation and technique in paintings in the Oranjezaal', in *The Object in Context: Crossing Conservation Boundaries, Preprints of the Munich IIC congress, 28 August –1 September 2006*, ed. D. Saunders, J.H. Townsend and S. Woodcock, London 2006, pp. 217–23. H. Stege, C. Tilenschi and A. Unger, 'Bekanntes und Unbekanntes – neue Untersuchungen zur Palette Vermeers in der "Kupplerin"', in *Johannes Vermeer – Bei der Kupplerin, Gemäldegalerie Alte Meister*, ed. U. Neidhardt and M. Giebe, Dresden 2004, pp. 76–82.

55 In the painting from Winchester Cathedral the deterioration product appeared yellow under the microscope, and was identified by X-ray diffraction as metavivianite. In the seventeenth-century paintings where it appears to have deteriorated, however, the deterioration product has not so far been identified. In *The Large Dort*, the upper part of the vivianite layer is brown rather than yellow, perhaps suggesting it is more likely to be the amorphous santabarbaraite than metavivianite. Vivianite and its oxidation products have been well studied by vibrational spectroscopy: Pratesi et al. 2003 (cited in note 53) and R.L. Frost, W. Martens, P.A. Williams and J.T. Kloprogge, 'Raman and infrared spectroscopic study of the vivianite-group phosphates vivianite, baricite and bobierrite', *Mineralogical Magazine*, December 2002, 66(6), pp. 1063–73. Raman spectroscopy was attempted on the sample from *The Large Dort*, but no results were obtained as the sample fluoresced strongly. FTIR spectroscopy on a fragment from the surface and a second fragment that appeared to still be blue did show some differences, including the expected broadening and shift in the phosphate absorption band to higher wavenumbers, but the spectra were not characteristic enough to identify the deterioration product firmly.

56 *Catalogue sommaire illustré des peinturess du Musée du Louvre: I Ecoles flamande et hollandaise,* Paris 1979, p. 44.

57 See K. Groen, 'Scanning Electron Microscopy as an aid in the study of blanching', *The Hamilton Kerr Institute Bulletin Number 1*, 1988, ed. I. McClure, pp. 48–65. For more general discussion of the possible causes of blanching in seventeenth-century paintings see B. Epley, 'Jan Both's Italian Landscape', *The Hamilton Kerr Institute Bulletin Number 3*, 2000, pp. 121–8, and M. Wyld, J. Mills and J. Plesters, 'Some Observations on Blanching with Special Reference to the Paintings of Claude', *National Gallery Technical Bulletin*, 4, 1980, pp. 49–63. Blanching is common on paintings by Claude and Gaspar Dughet.

58 Louvre treatment report by G. Zezzos, May 1939. The picture was cleaned again in 1971 (report H. Linard, Paris, 15 February 1971), and has not received any significant treatment since.

59 Spring 2001 (cited in note 2).

60 See Wheelock 2001 (cited in note 2). The illustration of *Landscape with Horse Trainers* (Ohio, Toledo Museum of Art), cat. 39, p. 170, shows the bottom left and right corners which have been protected by the frame. See Spring 2001 (cited in note 2) for an illustration of the edge of *View on a Plain* (London, Dulwich Picture Gallery) which has been protected by the frame and is not blanched.

61 Spring 2001 (cited in note 2).

62 Analysis of the yellow lake pigment in *The Large Dort* was carried out by HPLC by Jo Kirby. It can be very difficult to identify the dyestuff in yellow lake pigments as it has often deteriorated. However, it was possible to confirm by HPLC analysis that weld was present in *Landscape with Two Windmills* (Copenhagen, Statens Museum for Kunst), *View on a Plain* (London, Dulwich Picture Gallery), *River Landscape with Horseman and Peasants* (National Gallery, London, NG 6522) and *Landscape with Horse Trainers* (Ohio, Toledo Museum of Art). See also J. Kirby, 'Sir Nathaniel Bacon's "Pinke"', *Dyes in History and Archaeology,* 19, ed. J. Kirby, with C. Cooksey, A. Quye and J. Wouters, London 2003, pp. 37–50.

63 J. Kirby and D. Saunders, 'Sixteenth- to eighteenth-century green colours in landscape and flower paintings: composition and deterioration', *Painting Techniques. History, Materials and Studio Practice, Contributions to the IIC Dublin Congress 7–11 September 1998*, ed. A. Roy and P. Smith, London 1998, pp. 155–9.

64 See Kirby and Saunders 1998 (cited in note 63) for seventeenth-century documentary sources where the fading of yellow lake is mentioned.

65 Kirby and Saunders 1998 (cited in note 63).

66 In *Landscape with Two Windmills* (Copenhagen, Statens Museum for Kunst) the blanched paint contained only yellow lake, with a small amount of vivianite and red lake. See Spring 2001 (cited in note 2).

67 Other paintings in which this effect can be seen include *River Landscape with Horseman and Peasants* (NG 6522), *Landscape with Horse Trainers* (Toledo Museum of Art), and *Lady and Gentleman on Horseback* (Washington DC, National Gallery of Art). In all three of these large burdock leaves in the foreground are surrounded by dark brown paint.

68 This impression was gained from the GC–MS analysis. Although not quantitative, samples of similar size from blanched and unblanched areas were analysed and those in the blanched areas appeared to be leaner. The level of azelate in the blanched paint was also rather lower. This has been observed before in blanched paint. See Groen 1988 (cited in note 57), where it was interpreted as an indication that the binding medium was egg tempera. However, low azelate levels in oil paint can be associated with certain pigments. See M. Spring and C. Higgitt, 'Analyses Reconsidered: The Importance of the Pigment Content of Paint in the Interpretation of the Results of Examination of Binding Media', in *Medieval Painting in Northern Europe: Techniques, Analysis, Art History. Studies in the commemoration of the 70th birthday of Unn Plahter*, ed. J. Nadolny with K. Kollandsrud, M.-L. Sauerberg and T. Frøysaker, London 2006, pp. 223–9.

69 Groen 1988 (cited in note 57).

70 Annelies van Loon has observed similar microcracks in blanched areas on seventeenth-century paintings. See Chapter 4, 'White hazes and Surface Crusts on Dark Oil Paint Films', in A. van Loon, *Color Changes and Chemical Reactivity in Seventeenth-Century Oil Paintings, Molart Report 14*, Amsterdam 2008, pp. 119–204.

71 Van Loon 2008 (cited in note 70).

72 Lead soaps were detected in the priming of *The Large Dort* by FTIR microscopy, therefore this is a feasible hypothesis.

73 The lead soaps are not present as agglomerates, as is usually seen in lead-tin yellow-containing paints, but are dispersed. Yellow lake pigment generally needs a high proportion of oil to make a workable paint. It is also poor drying, so it was perhaps more likely that a leaded oil would be used than in paint containing other pigments.