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Gainsborough's 'Dr Ralph Schomberg'

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Schomberg, Gainsborough and portrait painting techniques

Gainsborough lived in Bath from 1759 to 1774 and it was towards the end of this period that he painted the full-length portrait of Dr Ralph Schomberg (Fig.1) [1]. Schomberg (1714–1792) was a physician who had himself settled in Bath around 1761: he is said to have been related to the Duke of Schomberg, William the Third's general, in whose family's house in Pall Mall, London, Gainsborough later lived. Like Gainsborough, Schomberg was a great friend of Garrick, the actor: he was also an enthusiastic amateur playwright and frequently submitted his works to Garrick who, equally frequently, refused them [2].

The precise date and circumstances of the painting of the portrait are not recorded, but it has been suggested that it was a gift, given in gratitude for Schomberg's help in curing Gainsborough's younger daughter Margaret of a delirious fever in 1771. The usual family physician, Moysey, had been unhelpful when Margaret succumbed, 'declaring that it was a family complaint [. . . .] he did not suppose that she would ever recover her senses again' [3]. Schomberg, urgently called in with another doctor, was able to cure her, but Moysey's blunt diagnosis of a recurrent congenital instability seems to have been correct [4].

Whether it was a gift or a commission, Gainsborough's portrayal of Ralph Schomberg is lively, informal and affectionate, still in the robust style that characterizes the Bath period portraits: the paint is fluid and brilliantly handled and has not yet acquired the cool, silver tonality and feathered impressionistic brushwork that were to develop later in London.

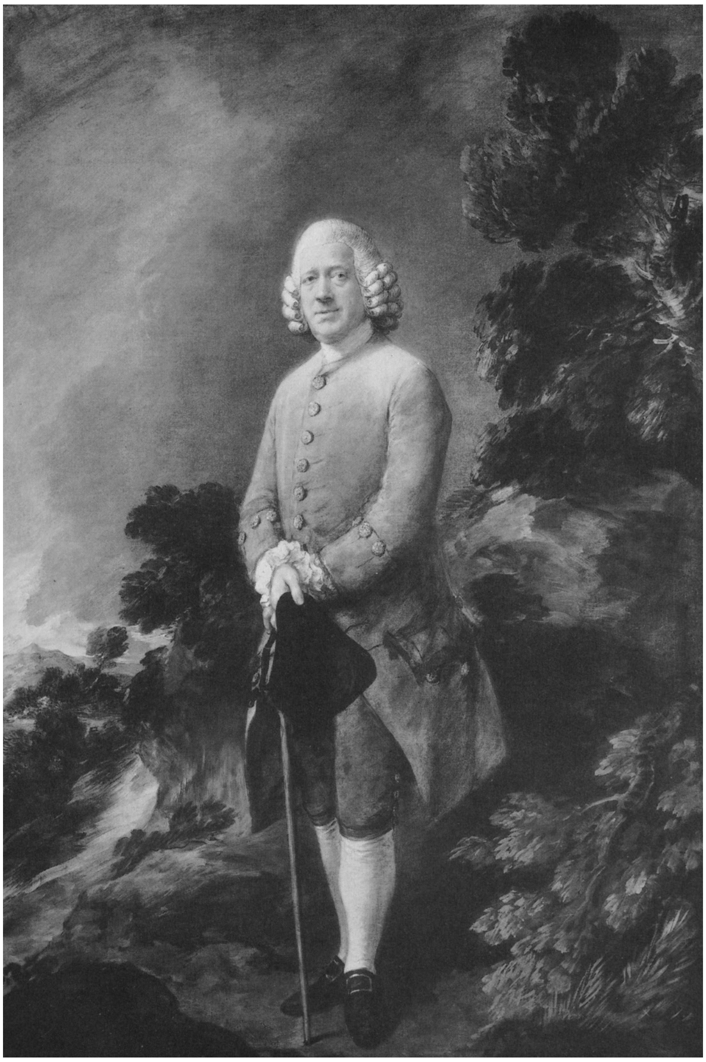
There is a painted sketch of *Dr Schomberg*, attributed to Gainsborough and corresponding closely in design if not in detail to the finished portrait (Fig.2) [5], which provides evidence of his rapid sureness in arriving at an appropriate composition. There is also documentary evidence which throws light on Gainsborough's portrait painting methods, consisting mainly of descriptions in the letters and diaries of friends and relatives who observed him at work. The most vivid account is that of Ozias Humphry who, writing in the 1760s, said, 'exact resemblance in his portraits was Mr. Gainsborough's constant aim' [6]. Humphry describes how Gainsborough, having roughly marked the position of the sitter's head on the canvas with chalk, would then arrange the canvas on the easel so that the head area was as close as possible alongside the subject: this enabled him to compare closely the sitter and the portrait, both near and at a distance. With 'three-quarter' size (that is head-size) canvases this close juxtaposition was not a problem; but with half-lengths or full-lengths, the position of the head was usually too far from the edge of the canvas to make it possible. Thus, for larger portraits, he often painted with the canvas loosened from its strainer and secured by cords at the back: in this way, the portrait head could be moved right to the edge of the strainer and placed alongside the sitter's head.

J. T. Smith, writing later, describes a variation in which Gainsborough placed his canvas at right angles to the subject and used long brushes 'full six feet in length'; he was thus able to stand equidistant from his painting and the sitter. This account is generally supposed to be accurate — he is also said to have sketched with chalk held in long tongs or on the end of a stick — but may well refer to Gainsborough's practice later than the portrait of Schomberg and other Bath period portraits [7].

One aspect of Gainsborough's studio that caused comment by sitters and friends alike was the dimness of the lighting. Humphry remarks that portraits 'were often wrought by candle light [. . . .] his painting room even by day (a kind of darkened twilight) had scarcely any light.' Sometimes, apparently, the subjects and their pictures were 'scarcely discernible.' The logic behind this practice seems to have been that subdued and directed lighting allowed Gainsborough to visualize and map out the main forms, contours and tones more easily. Then, 'having thus settled the Ground Work of his portraits', Humphry continues, 'he let in (of necessity) more light for the finishing of them' [8]. Reynolds also commented on Gainsborough's candle-light painting method in his fourteenth discourse and pronounced it 'very advantageous and improving to an artist' [9].

Whether Gainsborough painted Ralph Schomberg in this way can, of course, only be guessed at. The figure at first appears to be standing in broad daylight, but the light falling on the head and shoulders is, in fact, highly directional and clearly the stormy sky and broken cloud at the left are contrived in order to justify the sudden shaft of sunlight slanting down from the upper left. The accentuated modelling of Schomberg's head undoubtedly owes more to studio artifice than to natural daylight.

The landscape background, too, is a contrived one, roughed out in the preliminary sketch and providing, even in the finished state, nothing more realistic than a stage set. Gainsborough was already a more than accomplished landscape painter, incorporating both real and idealized elements in his work. In his earlier years in Suffolk and at Bath he made some drawings from nature, but many of his compositions are imaginary. He used to fashion small landscapes in his studio 'on a little, old-fashioned, folding oak table', out of coal, stones, sand, mosses and lichens with mirrors for water and distant trees of broccoli [10]. The landscape behind Dr



generally acknowledged that those of his works painted by candle-light looked better when viewed by artificial light. But it was the matter of hanging heights that preoccupied Gainsborough more and, years later (in 1784), led to his withdrawing his pictures from the Royal Academy and never sending any more. The standard hanging height for full-lengths was above the level of the doorways at Somerset House (about 9 feet from the floor) and Gainsborough thought this too high for his work to be seen properly. He wrote to the Council of the Royal Academy: '[Mr Gainsborough] begs leave to *hint* to them that if the Royal Family, which he has sent for this Exhibition [....] are hung above the line with full-lengths, he never more, whilst he breaths will send another picture to the Exhibition. This he swears by God' [14]. In the following year he again demanded that a picture should be hung lower, was refused, and withdrew all his paintings [15].

The portrait of Dr Schomberg was painted more than a decade before these events. It has been suggested that it may have been at the Royal Academy in 1770 or 1772 [1], but these associations are only speculative. However,

Figure 1 Gainsborough, *Dr Ralph Schomberg* (No.684), canvas, 233 × 153.7 cm, after cleaning and restoration.

Schomberg is just such an invented model, composed to a formula, the figure conventionally framed by near trees, bushes and rocks at the right and a distant prospect of hills and water to the left.

It was painted with enormous speed and sureness, with great fluid brushstrokes. Gainsborough is known to have used very liquid paint, presumably thinned with turpentine, and this is immediately evident on the portrait of Schomberg: in the foreground, at the bottom left, dark paint has run down the canvas and Gainsborough either did not notice or did not care to correct it. It is possible that he re-worked the paint on the canvas with a brush dipped in turpentine [11] but his paint was already very liquid on the palette. His daughter Margaret described how 'his colours were very liquid and if he did not hold the palette right would run over' [12].

When Gainsborough painted Dr Schomberg, he had recently increased his scale of charges for portraits. Until the time of the first Royal Academy exhibition in 1769, he charged 60 guineas for a full-length, and 15 to 40 guineas for a half-length. From the beginning of the 1770s until 1787, he asked 100 guineas for a full-length, 60 guineas for a half-length and 30 guineas for a head-size, which were high rates indeed for the time [13].

Even after parting with his works, Gainsborough had very definite ideas on how they should be hung. It was

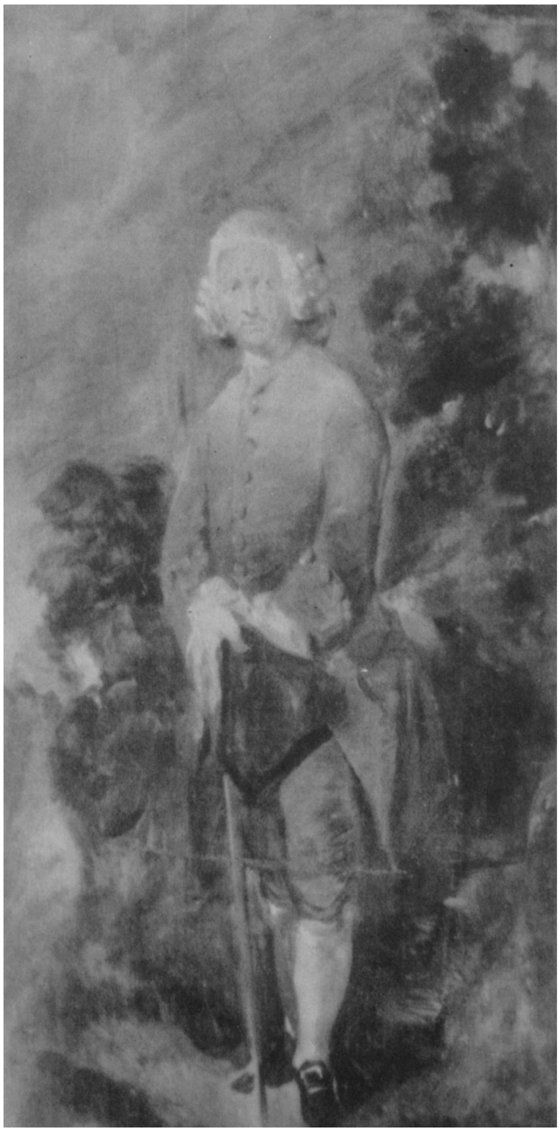


Figure 2 Gainsborough, *Dr Ralph Schomberg*, 27 × 14 cm, private collection, England.

the argument about hanging heights does remind us that portraits were often viewed under quite different conditions to those in which they are now seen.

History and condition

The portrait remained in the Schomberg family until it was purchased by the National Gallery in 1862. It had almost entered the Gallery Collection in 1835 when it was presented by H. C. Schomberg in the name of the family; but one of his brothers objected and the portrait was returned to the family in 1836. Twenty-six years later the Gallery did acquire it from J. T. Schomberg.

The condition of the painting at that time is not recorded. It was certainly lined by then and had already sustained a long tear or deep scratch, running vertically to the left of Schomberg's head and shoulders. This seems to have been a different damage to one mentioned in a letter to *The Times*, dated 2 March 1957, in which a correspondent wrote:

> Some 50 years ago, an elderly gentleman, standing next to me in front of Gainsborough's 'Portrait of Ralph Schomberg' in the National Gallery remarked: 'That, Sir is a portrait of a distant relative of mine. Do you see the slight injury to the canvas in the right foreground, very well restored long ago? It was caused by my young sister, who in our nursery threw her slipper at me; it missed my head but hit the picture.

The portrait has been repaired and retouched in a number of places and it is difficult now to be sure which injury is being referred to here.

However, when the portrait was examined in 1985 prior to its recent cleaning, it was not damage that was the most notable feature of its condition, but material changes in the original paint layers themselves. Two areas were of particular interest: firstly the sky, particularly around Schomberg's head and shoulders, and secondly his coat and breeches — which, even through the then darkened varnish, appeared strangely discoloured.

That part of the sky nearest to the figure had been broadly overpainted to conceal an extensive network of wide drying cracks. The overpaint was removed during cleaning and the cracks were revealed: they appeared especially prominent because the ground was light-coloured (Fig.3).

There are several reasons why drying cracks might develop in a painting [16]. The cause of these particular cracks may well be connected with Gainsborough's practice of over-thinning his paint. If too much volatile diluent and not enough binding medium is present, then the cohesive strength of the paint film will be insufficient to hold it together as it dries and contracts: it will then fracture and crack along lines of weakness. The nature of the underlying layer is also significant. This is apparent from a *pentimento* of Schomberg's left shoulder (the dense silhouette of which is visible just outside the present line) over which the cracking of the sky is less severe. There is also a particularly prominent crack which follows precisely the outline of the *pentimento*, as if the edge of the underlying paint has caused directly the line of fracture in the upper layer.

There is no remedial treatment for unsightly shrinkage cracks, other than the cosmetic one of inpainting them with a fine brush: they are usually an aesthetic problem rather than a structural one. Those in the sky of the Schomberg portrait were reduced by inpainting after the recent cleaning, but not totally concealed.

Schomberg's coat and breeches presented a different technical problem. Even before varnish removal, the colour appeared to vary markedly from place to place. The coat was essentially a dull beige with creamy-pink highlights, but had bright pink irregular patches overlying it in some areas (Plate 10, p.57). At the bottom where it passed into shadow and in the breeches, the basic colour was light brown, but here too there were patches of a much more intense deep crimson colour on top. Much of this superimposed pink and crimson paint seemed to consist of fairly random brushstrokes, but in one or two places it did have a design function: the top corner of Schomberg's coat pocket is delineated by broad sweeps of deep crimson and a *pentimento* of his left cuff has been overpainted with bright pink.

In the preliminary examination, before cleaning, these highly coloured passages were noted and assumed to be rather garish retouchings. However, as cleaning proceeded, it was immediately clear that they were original paint. How, then, were they to be explained? Had Gainsborough intended this chromatic disparity, or had some later colour change occurred? In view of the well-known tendency of some red lake pigments to fade, this seemed a likely explanation. But then, why had some apparently random areas retained their intense colour?

In order to answer these questions and to elucidate more general aspects of Gainsborough's materials and technique for *Dr Schomberg*, a detailed technical examination was carried out. Results were correlated with known documentary and technical evidence.

The materials and technique of the picture

The techniques of eighteenth-century English portraiture are not well-understood in detail, and although the period produced two outstanding painters, both of large output, their painting methods are in great contrast. Gainsborough and Reynolds shared a clientele, but their attitudes to painting and the effects they wished to achieve could scarcely be less similar. The technical failings of pictures by Reynolds are well-known. In Gainsborough's working formula for both his landscapes and portraits, however, the disfiguring effects of poor drying pigments such as bitumen and the unstable layer structures which sometimes resulted from Reynolds working and re-working his pictures are seldom to be seen. The portrait of *Dr Ralph Schomberg* is no exception to the generally reliable and stable technique Gainsborough adopted, and this is borne out by the observations made here during cleaning and restoration of the picture. However, in the present portrait there is at least one technical fault — in the choice by Gainsborough of a fugitive pigment to glaze Dr Schomberg's coat. We have shown by thin paint cross-sections and by colour measurement on the picture a significant degree of fading in a carmine lake on the coat (see Plates 10, 11a and 11b, p.57 and below). Loss of colour in red lake glazes was a well-known phenomenon to eighteenth-century painters, and in portraits by Reynolds for

Figure 3 Detail of Dr Schomberg's head and surrounding sky, after cleaning, before restoration, showing pronounced drying cracks which reveal the light-coloured ground.

example the subject was both commented upon at the time and a matter of concern to the artist himself [17].

Painting methods in the later part of the eighteenth century in England were for the first time widely circulated in published treatises and, as we have noted in our earlier study of Hogarth, these at the least record the materials and working procedures for the artist, which are in agreement with the results of analysis of paint samples from pictures of the period [16]. The published accounts tended to list the available pigments, their uses in different media and suggested formalized ways in which portraits, draperies, landscapes and so on are to be painted. They also often included a commentary on artists' colours, their origins whether manufactured or mineral, their applications and defects, and sometimes something of their chemistry, however sketchy. Gainsborough's palette unfortunately does not seem to have been recorded by the artist himself. From this portrait though, it has been shown to have been selected from the range of generally available pigments discussed in such contemporary handbooks as Thomas Bardwell's *The Practice of Painting and Perspective Made Easy* [18], Robert Dossie's *Handmaid to the Arts* [19], and the English edition of Constant de Massoul's *A Treatise on the Art of Painting and the Composition of Colours* [20]. This is perhaps unsurprising since the colour trade in England had by that time reached some degree of organization and professionalism, partly as a result of the activities and interests of bodies such as the Royal Society in London and the Society for the Encouragement of Arts, Manufactures and Commerce [21], and partly due to the increased demand for reliable supplies of artists' materials which followed the growth of amateur painting.

The advice of the painting treatises was interpreted in differing ways. It is interesting that Gainsborough and Reynolds in having access to similar materials should have produced pictures so strikingly different in their physical stability. The explanation lies in Gainsborough's manner of oil-painting, which has a greater affinity with the traditional watercolour technique of thin translucent washes over a light-coloured ground than with the canvases heavily laden with pigment, sometimes in unsound experimental media, that Reynolds produced. Gainsborough's daughter Margaret's recollection that her father worked with very dilute paint [12], accords with the thin, glaze-like treatment of much of *Dr Schomberg*, particularly in the sky, landscape and the sitter's coat. The paint was presumably considerably diluted with oil of turpentine, mentioned as a suitable thinner for oil-paint in the painting literature, for example by Dossie, who regarded it as of assistance in hastening drying [22]. In fact, as mentioned above, in the lower left corner of the thinly painted dark brown foreground the paint seems to have run on the canvas, whilst fairly broad shrinkage cracks in part of the sky (Fig.3) and the landscape to the left are probably the result of evaporation of a solvent during drying of the diluted paint film. There are passages more solidly painted — the highlights on the foliage and sky, the buttons on the coat and the sitter's cuffs and wig — but these are generally only where opaque lead-containing pigments are present, and even in the stockings, executed mainly in lead white, the paint has been applied as such a thin scumble that the off-white ground is only partially covered.

The results of medium analysis have been reported by J. Mills and R. White in an earlier volume of this *Bulletin* [23]. A sample of green from the landscape at the left edge was found to be leanly bound in linseed oil, whereas Dr Schomberg's white stockings are probably in poppy oil, which was recommended as less yellowing than linseed oil for the light colours, and generally agreed to be the least changing of the drying oils [24].

Although there is no note of Gainsborough's palette amongst his surviving papers, one is cited in William Whitley's biography of the artist, based on the memory of a young painter called Mr Briggs, a neighbour of Gainsborough's daughter. It is worth quoting since it largely coincides with the pigments we have found in samples from *Dr Schomberg*:

> Yellows: yellow ochre, Naples yellow, yellow lake and for his highlights (but very seldom) some brighter yellow, probably a preparation of orpiment, raw sienna; Reds: vermilion, light red, Venetian, and the lakes; Browns: burnt sienna, cologne earth (this he used very freely, and brown pink the same). He used a great deal of terre verte, which he mixed with his blues, generally ultramarine. Latterly he used Cremona white [. . . .] It was the purest white I ever used, and accounts for the purity of Gainsborough's carnations [flesh tints]. [25]

Neither orpiment nor ultramarine were found in the picture, the only blue pigment being Prussian blue, but the remainder are present with a few additional colours not mentioned. Their uses are noted below in the various sections of the picture from which samples were taken. Pigment identifications were by our usual methods of microscopy, chemical and instrumental analysis described elsewhere [26].

The ground

Gainsborough's ground for *Dr Schomberg* was shown by X-ray diffraction analysis to be a mixture of lead white and calcium carbonate (calcite), probably bound in oil, but the medium not analysed. It is evident from the discovery of coccoliths by SEM in a sample of ground (Fig.4) that the calcium carbonate is in the form of natural chalk. The mixture is the same as found for Hogarth [27], although tinted grounds seem to be equally common at the time, and a dull pink priming on the canvas has been noted for Gainsborough's *Pomeranian Bitch and Puppy* of 1777 in the Tate Gallery [11], and also in at least two other works in the National Gallery Collection [28]. The translucency imparted to the priming of No.684 from the admixture of calcium carbonate with the lead white has produced a light greyish cream as the binding medium has aged, although the intention must have been to paint on a white ground. The primed canvas is likely to have been a standard commercial product.

The sky

Samples were taken from several areas of the sky to determine the pigments used to express the transitions in colour from the grey which surrounds Dr Schomberg's head to the stronger blue of the upper right corner. The greyest areas contain no blue pigment at all, but are simply mixtures of charcoal black with white, and in those areas with a warmer tinge a final scumble of the thinnest possible layer of red earth pigment has been applied. A slightly more heavily painted strip of grey outlines the sitter's right shoulder and arm, perhaps to correct the line of the coat. Sky paint comprising charcoal and white is a fairly common feature of Dutch landscapes, for example those by J. van Ruisdael, which are known to have been an influence on Gainsborough

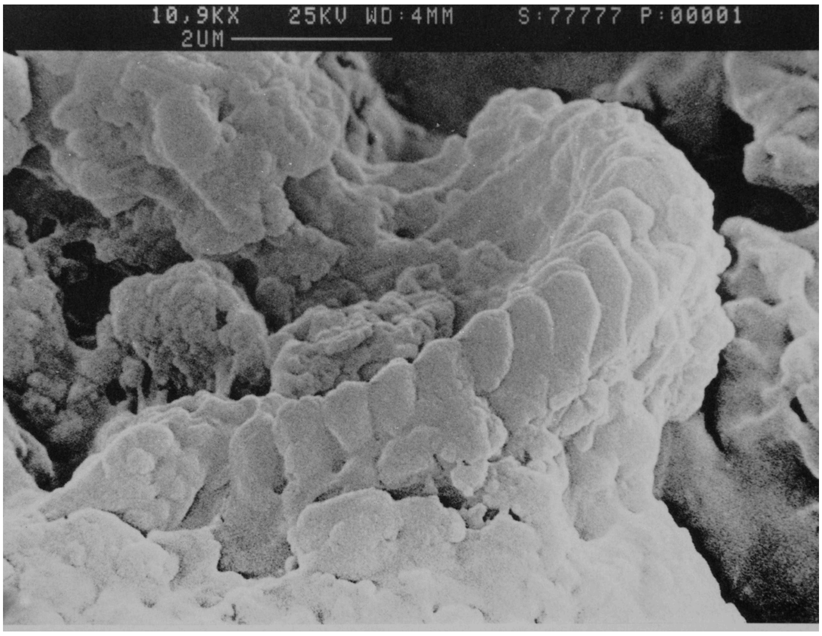


Figure 4 SEM micrograph of dispersed white ground from *Dr Ralph Schomberg*, showing a coccolith present in the chalk content of the ground. Gold-coated, 10,900 ×.

[29]. The bluish cast of the mixture when this black is combined with white renders it suitable as a means of representing stormy skies. The reason for the bluish reflectance of the paint film lies in the greater scattering power of lead white pigment for blue light than for the longer wavelengths in the visible spectrum, in conjunction with the capacity of charcoal black to absorb all visible wavelengths equally. The resulting reflectance of the mixture is thus enriched in its blue component, imparting a bluish tinge to the grey. This optical effect had long been known and had been most strikingly exploited in the construction of mauve draperies by both Rubens and Van Dyck, where lead white, charcoal black, and red lake pigment alone are combined, but no blue pigment at all is present [30]. In the eighteenth century there are references to a pigment described as 'blue-black', which in Dossie is, 'the coal of some kind of wood, burnt in a close heat where the air can have no access' [31], whilst in de Massoul, charcoal derived from vine twigs is specifically meant [32].

In the thinnest area of the sky, where it is most cracked, there is only a single layer of charcoal and white, whereas the more solid area combines the same pigments, but in multiple thin layers, perhaps four or five (Plate 11c, p.57). A few scattered particles of red earth or vermilion at the surface are present in all the cross-sections. Most of the sky is painted simply and directly on top of the off-white ground, but beneath the thicker parts of the landscape to the left where it meets the horizon, there is a warm light brown imprimatura composed of white, a little red pigment and some bone black or bone brown. The bluest sections of the sky consist merely of a 'wash' of Prussian blue over the ground with a few particles of charcoal and red earth pigment intermixed. Here, as in all the least opaque areas, a quantity of calcite (calcium carbonate) seems to have been incorporated into the paint to lend a translucency unobtainable with the denser whites, a technique which also probably has its origins in Dutch landscape painting [33]. Where calcite is present the paint film is inevitably not very opaque since the refractive indices of calcium carbonate are close to that of dried oil, and Prussian blue itself, although of very powerful tinting strength, does not scatter light strongly, only having a refractive index of about 1.56.

Prussian blue was the obvious pigment of choice for the eighteenth-century painter working in oils on large-scale subjects; natural ultramarine was prohibitively expensive and difficult to obtain, and smalt undesirable in its poor stability, and also surprisingly costly for a manufactured pigment [34]. Prussian blue had already been in use for some fifty years by the time Gainsborough painted Dr Schomberg, the secret of its improbable preparation having been published in 1724 by Woodward in *Philosophical Transactions*, the journal of the Royal Society [35]. It is mentioned in all the well-known contemporary treatises without any real sense that its permanence was doubtful. Since Prussian blue has a distinctly greenish hue it is suitable in mixture with other pigments for landscape and foliage paint, and finds application here in a number of areas of the mixed greens (see below).

Denser highlights on the cloudy sky of white, pink and yellow contain lead white in varying combinations of vermilion, Naples yellow (lead antimonate [36]) and in one case a small quantity of green earth pigment.

Landscape and foliage

The landscape in the foreground and middle distance is on the whole quite simply painted in the thin technique described above. It is likely that Gainsborough laid out the main elements of landscape, trees and foliage in outline with a broad and cursory brush drawing in dilute paint directly onto the primed canvas. An example can be seen to the right of his unfinished small portrait *The Painter's Daughters with a Cat* (No.3812; Fig.5), although there the ground is of a warm pinkish brown rather than the greyish cream of No.684.

The bluest green middle distance landscape to the left comprises the translucent Prussian blue and calcite mixture, darkened with a little charcoal black almost identical to the bluest paint of the sky, although in the landscape the 'glaze' overlies a warm brown underlayer inclining the area towards green. Elsewhere the landscape and foliage greens are generally quite complicated mixtures of pigment, but in almost all cases combine Prussian blue with one or another yellow. The only exceptions are some dark foliage greens in which green earth (terre verte) and yellow ochre alone appear to be combined, sometimes only as underlayers for the more consistently used mixtures based on Prussian blue.

Gainsborough's palette noted by Whitley is strong in the earth colours — and indeed quite a variety of this range of pigments is represented in the samples, particularly in landscape and foliage mixtures. All the examples subjected to spectrographic analysis show fairly high concentrations of silicon, aluminium, and in certain instances trace quantities of titanium, in addition to the main element iron. These components are characteristic of natural earth pigments, even though synthetic iron oxides (Mars colours) had probably just begun to appear as artists' pigments in the later part of the eighteenth century [37]. In some of the samples the aluminium content may arise not only from clay mineral impurities but also from the substrates for yellow or yellow-brown lake pigments known sometimes to have been used to fortify these colours [38]. All the earth pigments are coloured by the presence of ferric oxide whether hydrated or anhydrous, but the large number of names for these materials indicated their diversity in geographical origin, and described specific shades and translucencies which largely depend on the impurities associated with the iron oxide colouring component. Thus the siennas are pigments containing yellow to brown hydrated iron oxide, but which are distinguished by their greater transparency from those called ochres. Their various optical properties derive from the proportions of silica and alumina present in the source of the earth. Similarly the umbers are darker brown varieties which contain in addition a content of black manganese dioxide (pyrolusite) as an essential constituent, and perhaps also some carbonized vegetable matter in the poorer grades. Calcination of these earths yielded warmer colours seen as distinct pigments, as in 'burnt sienna', 'burnt umber' and so on.

A great variety of earth pigments were noted in the

Hogarth *Marriage à la Mode* series examined earlier [16], and the range here is as great or greater. True examples of umber were confirmed by the detection of a high level of manganese by spectrographic analysis in several of the darker foliage samples, for example in the deep brown shadow in the cleft of the tree trunk to the right. Elsewhere the foliage greens contain a selection of iron oxide particles of yellow, orange, red and brown, varying in size and crystallinity, and combined with a number of other pigments, particularly Prussian blue, bone black and what appears to be a dark yellow lake.

The translucent rich browns of the foreground and middle distance are also dependent upon earth pigments for their colour, used in a glaze-like technique, perhaps mixed with yellow or brown lake to increase saturation. Umbers and bone black, suggested by the spectrographic detection of manganese and phosphorus respectively in the darks of the foreground, are mixed with yellow lakes and warmer earth colours in the reddest areas. In one case a thin layer of finely crystalline reddish brown earth alone forms the foreground paint, whilst in another a brown glazing pigment is lightly scumbled over with a little yellow and orange-yellow ochre combined with large particles of relatively transparent bone brown. Yellow-brown glazes over fairly pure layers of strongly coloured dark yellow ochre, and thicker strokes of an orange-coloured earth (goethite [39]) make up the mid-tones and highlights on the foliage to the right. The lightest touches of all contain Naples yellow [36, 40].

The most heterogeneous pigment mixtures are to be found for the deepest greens used for the leaves of the tree. These contain Prussian blue, a variety of ochre particles, flecks of transparent yellow-brown (probably a lake), varying small amounts of charcoal black, bone brown, calcite, lead white and even a little vermilion [41]. In one sample transparent birefringent flakes of a rich mid-green, which may well be verdigris, occur, but the colour is unusual and positive identification in samples of this complexity is not practicable. The spectrographic detection of copper in the mixed greens is no guide since they also contain a few particles of blue and green verditer (artificial basic copper carbonates) as 2–5 μ rounded refractive crystallites, but in insufficient quantities to have any real influence on the colour of the paint. Copper pigments of any kind will accelerate the drying of an oil-paint film, and this may explain their presence, especially since blue verditer is also to be found in small quantity in the black paint of the sitter's hat, which comprises mainly the poor-drying pigment, bone black (see below).

The yellow lakes are difficult to identify at present. Their use here is inferred from the release of plentiful dark yellow water-soluble dye when certain of the

Figure 5 Gainsborough, *The Painter's Daughters with a Cat* (unfinished) (No.3812).

samples are treated with aqueous alkali. Probably the most common eighteenth-century recipes for these transparent colours make use either of dyestuffs extracted from the unripe berries of buckthorn (*Rhamnus*) or from the bark of a North American species of oak (*Quercus tinctoria*). The terms 'Dutch pink' and 'brown pink' refer to transparent or semi-transparent yellow and brown lakes prepared on a variety of substrates generally using the dyestuffs from buckthorn, although some confusion of terminology arises. In de Massoul, for example, 'brown pink' is described as both a type of bituminous umber or, in an alternative artificial form, as a buckthorn lake on a calcium carbonate base [42]. The exact identity of such dark translucent pigments as Cologne earth, Cassel earth and Vandyck brown is also unclear in the contemporary literature, but the continuum from umber-like browns to entirely organic peaty or lignitic forms seems likely. Some of these materials have been described recently in more detail by R. White [43].

The figure of Dr Schomberg

It is mentioned above that Dr Schomberg's stockings are painted in pure lead white, although greyish shadows appear in an area not sampled. Analysis by X-ray diffraction showed the presence of basic lead carbonate and only a low concentration of the neutral carbonate with no calcium carbonate incorporated. The name 'Cremona white' quoted by Whitley is unusual and does not seem to occur in the eighteenth-century treatises or colour lists. It is probably a corruption of the commonly used term 'Cremnitz' or 'Cremnitzer white', meaning a pure form of lead white imported from Austria; this in turn is actually a misnomer for 'Krems white', from the name of the town where the pigment was produced. Lead white was sometimes sold in the eighteenth century as a mixture with calcium carbonate, called ceruss or ceruse, the equivalent of the Dutch 'lootwit' which signified a cheap form containing chalk, but the terms were also applied to the pure pigment. Although not sampled Dr Schomberg's wig, cuffs, and collar must all be mainly in lead white. Presumably the flesh also would be principally opaque white tinted with earth colours and perhaps vermilion, with black in the shadows, but the very sound state of the sitter's face and hands disallowed any sample to be taken.

The darkest part of the hat is a single thin layer of bone black [44], a little wood charcoal and the smallest quantities of red earth and blue verditer. Judging from their colour and texture, the shoes must be painted with the same mixture.

The appearance of Dr Schomberg's pinkish brown coat is the most intriguing part of the picture, and provided the original incentive to investigate Gainsborough's technique by sampling. Clearly there has been colour change, but establishing its precise origin has required examination of the layer structure and analysis of the materials involved. In addition we have sought to correlate microspectrophotometric transmission curves of the pink surface glaze in thin cross-sections of samples (Plates 11a and 11b, p.57 [45]) with colour measurement on the picture itself. The results are discussed in detail below. It has been possible to show that there has been fading not only of the surface transparent red colour, but also that the present brownish appearance results from the underlayer showing through the partially bleached glaze, rather than from discoloration of the surface paint itself (Plate 10, p.57). The layer structure of the coat is quite straightforward, with a thin translucent brownish 'wash' brushed directly over the light-coloured ground (Plates 11a and 11b, p.57 [46]), and then glazed over fairly lightly in most places with a red lake pigment. Analysis by R. White using high-performance liquid chromatography has shown the red dyestuff to be carminic acid in both faded and relatively unfaded portions of the drapery, with a greater proportion of the colouring material in the deepest coloured areas. The substrate for the lake is hydrated alumina [47], identifying it as a carmine lake of a standard composition for the eighteenth century. The carminic acid would have been derived from imported cochineal, the scale insect *Dactylopius coccus* Costa, found in Mexico and Central America. Numerous recipes for carmine lakes are to be found in the eighteenth-century literature [48]. Carminic acid laked onto alumina produces a beautiful deep crimson pigment when freshly prepared, but was known to be rather fugitive [49]. In oil medium it is entirely transparent.

It can be seen from the thin paint cross-sections in transmitted light that there is loss of colour in both the thicker less faded areas of glaze, as well as those thinly-worked parts in which the red colour is now barely perceptible (Plates 11a and 11b, p.57). It is also clear that in each case the fading is most noticeable in the upper portion of the glaze layer, where exposure to light is the greatest. Thus it seems that there has been fading of the glaze on the coat as a whole, but that where it has been thickly applied, for example near the pocket, the effect is far less obvious than in the thin areas in which the translucent brown underlayer exerts the strongest optical effect. To further disturb the overall colour balance there are highlight strokes of pink where the carmine lake has been used as a tinting pigment mixed with white, and here it has probably been better protected from photochemical change than when applied as a glaze. The coat would originally have been a good deal richer in colour, and less disjointed in the transitions of light and shade than we now see. The yellowish brown underlayer must have been intended to modify the colour of the overlying crimson glaze, but in a way that can only be guessed at. It is regrettable that Gainsborough's technique for *Dr Schomberg*, so sound in many respects, should have included a pigment of lesser stability than the rest of his palette.

Spectrophotometric investigation of the fading of the coat

The distinctive appearance of the coat worn by Dr Schomberg has already been mentioned. Fulcher [50], in his biography of Gainsborough, made one of the earliest references to its colour and appearance, 'His coat and breeches are of velvet, in color something between pink and crimson [....] The picture altogether one of the finest in the world'. Shortly after the portrait was

Figure 6 Detail of the area of the coat shown in Plate 10 (p.57), indicating the points at which reflected colour measurements were made.

acquired by the National Gallery in 1862 the *Catalogue* describes the subject as, 'in a court suit of claret coloured velvet' [51]. This description of the painting appears verbatim in subsequent catalogues until replaced by a brief entry which omitted any description of the coat. The smaller of the two known studies for the portrait was described in the 1917 Christies Sale Catalogue as, 'a small full-length figure in crimson dress' [52]. This sketch, now in a private collection, is similar in colouring to the full-size portrait. Those areas which have faded to a light brown in the final portrait, especially the right sleeve, are, however, a good deal more pink in the study. In both the study and the final painting the top part of the coat is much lighter than the lower portion. It seems possible that the coat in which the sitter was portrayed was itself faded at the shoulder. This has been compounded by a further fading of the fugitive lake pigment employed by Gainsborough. It would appear that the fading is less marked in the study, perhaps because the painting has never been subjected to high light levels. Whilst it is possible that the fading of the coat in No.684 has occurred since the mid-nineteenth century, a description of the use of cochineal by Gainsborough's contemporary Reynolds, suggests that the pigment underwent a quite rapid loss of colour [17]. It may be that the fading was masked for many years by a discoloured varnish.

In order to investigate the colour changes that may have occurred since painting, a number of areas of the coat were selected for colour measurement. The sampling points chosen are marked on Fig.6, which corresponds to the colour detail shown in Plate 10 (p.57). A reflectance spectrum of the painting surface was recorded at each of the sample points using the Wright–Wassall reflectance spectrophotometer [53].

Measurement point 1 lies within an intense crimson area to the left of the pocket. This colour arises from the application of pure lake pigment; a cross-section taken from close to point 1 contains a relatively thick glaze, only the uppermost portion of which exhibits any signs of fading (Plate 11a, p.57). The reflectance spectrum recorded at point 1 shows similar features to that of a standard sample of a cochineal lake, the major difference between the reflectance spectra being attributable to the presence of the brownish underlayer already described above.

The reflectance spectra recorded at points 1 and 2 have similar maxima (see Fig.7). The higher reflectances at point 2 are due to the lighter colour of this area, which contains a mixture of the same lake with lead white pigment. The colours of the remaining two areas, labelled 3 and 4, are pinkish brown and mid-brown respectively. The reflectance spectra for points 2, 3 and 4 are shown on the same axes in Fig.8.

The reflectance spectrum for the predominantly brown area at point 4 is largely featureless; but this is typical for such a hue. In contrast, the spectrum for point 2 shows a strong reflectance in the red portion of the visible spectrum as well as maxima at shorter wavelengths which are typical of a lake pigment. The reflectance spectrum recorded at point 3 suggests that this area is of an intermediate colour. The CIE (Commission Internationale de l'Éclairage) colour coordinates $L^\star$, $a^\star$ and $b^\star$ were calculated for the three regions whose spectra appear in Fig.8; these data are recorded in Table 1 [54]. It is evident that the colour coordinates for point 3 lie between those for points 2 and 4. Furthermore, the point in colour space represented by the coordinates for area 3 lies close to the vector from point 2 to 4. It seems reasonable to suggest that the colour at point 3 may represent the effect of a partial fading of the pigment present at point 2. A further fading might then produce the colour observed at point 4, which is likely to be due mainly to the brownish underlayer. This conclusion should not be taken to imply that the colour at point 2 represents the original colour of the entire coat; the fact that the pigment has survived here but not elsewhere would argue against such an interpretation.

Table 1 Colour coordinates for points 2, 3 and 4.

	Point 2	*Point 3*	*Point 4*
$L^\star$	33.12	37.34	44.54
$a^\star$	16.29	12.15	6.34
$b^\star$	6.42	14.29	21.23

It has been demonstrated that the fading of certain red lake pigments is accompanied by an increased reflectance in the yellow portion of the spectrum [55]. This trend is certainly apparent from the spectra illustrated in Fig.8. It is possible, however, that this change is due to the colour of the brownish underlayer becoming predominant as the upper layer fades, rather than a coloration in the glaze layer itself.

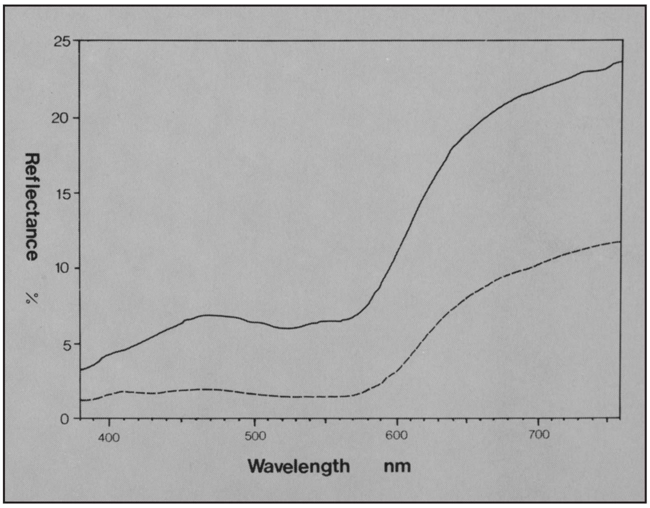


Figure 7 Reflectance spectra of the surface of the painting recorded at point 1 (dashed line) and at point 2 (solid line).

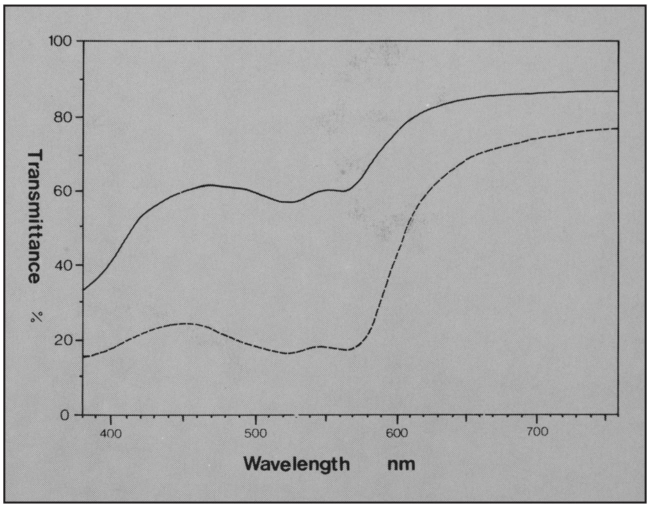


Figure 10 Transmittance spectra of a thin cross-section from an unfaded area of the coat (dashed line) and of a thin cross-section from a faded area (solid line).

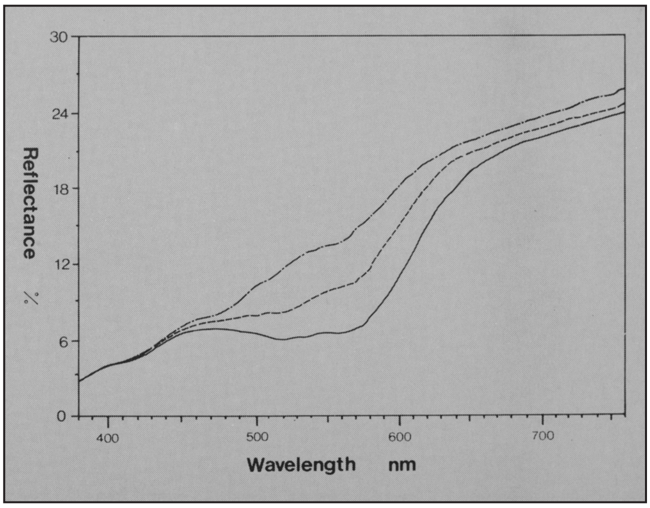


Figure 8 Reflectance spectra of the surface of the painting recorded at point 2 (solid line), point 3 (dashed line) and point 4 (broken line).

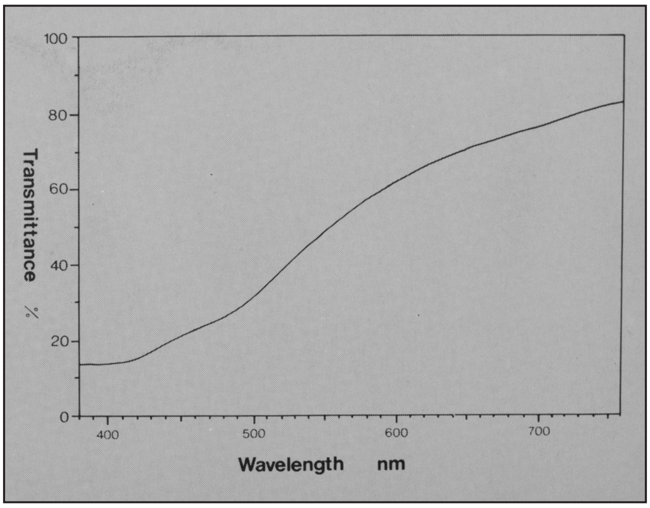


Figure 11 Transmittance spectrum of a thin cross-section of the brown underlayer.

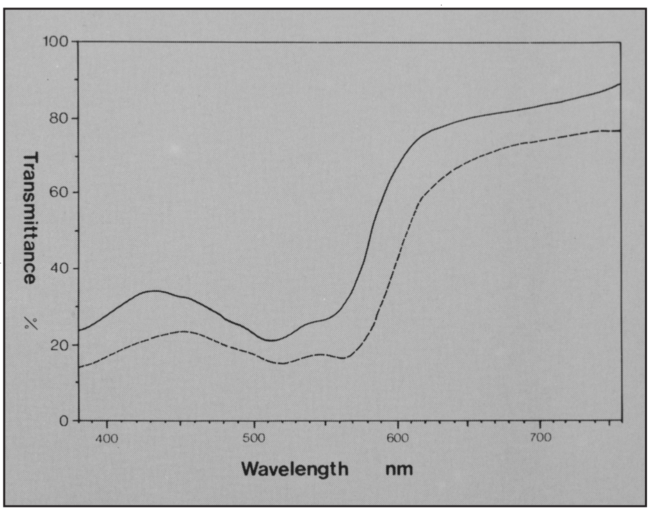


Figure 9 Transmittance spectra of a thin cross-section of the lake pigment from an unfaded section of the coat (dashed line) and of a thin cross-section of a cochineal lake standard (solid line).

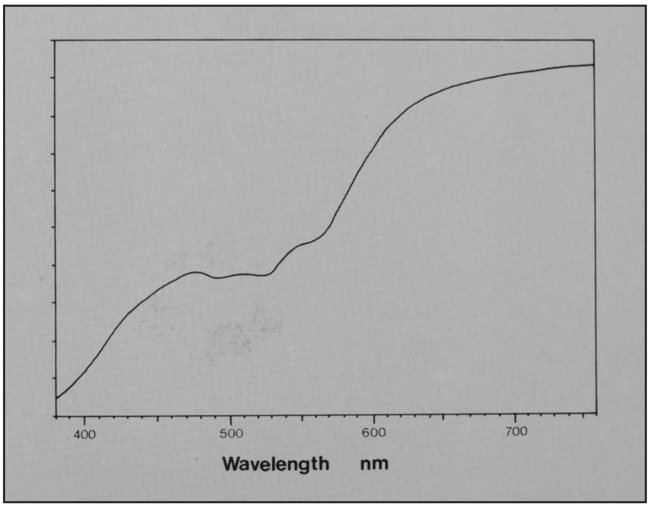


Figure 12 Artefact spectrum created by combining the spectrum shown in Fig. 11 with that in Fig. 10 (solid line).

In order to isolate the contribution to the reflected colour of the individual layers, a number of samples were investigated by microspectrophotometry. The technique has been used in an attempt to differentiate between lake pigments from a variety of insect and plant sources [56]. Modern apparatus has greatly simplified the procedure and reduced the time required to record a spectrum [57].

Transmittance spectra were recorded on thin paint cross-sections from both faded and unfaded areas of the coat. The spectrum of an unfaded fragment of lake pigment is shown in Fig.9. The spectrum is, as expected, quite similar to that of a standard sample of cochineal shown on the same axes. The reflectance spectrum in Fig.7 and the transmittance spectrum in Fig.9 correspond reasonably well. The transmittance spectrum for the unfaded lake is shown again in Fig.10, on the same axes as a similar spectrum for a faded sample. As with the reflectance spectra, there are sufficient similarities between the spectra for it to be evident that the same colorant is present in both particles. The faded sample has a much higher overall transmittance and, more particularly, a somewhat higher transmittance in the yellow region of the spectrum. Unlike the changes noted in the reflectance spectra, this increased yellow transmittance cannot be attributed to an underlying layer, and must arise as a result of the fading process.

The transmittance spectrum of the brownish underlayer is shown in Fig.11. The spectrum is similar to the reflectance spectrum at point 4 (Fig.8) which corresponds to an area where the red lake glaze is particularly faded. In a rather empirical attempt to simulate the appearance of the faded lake pigment on top of the brownish underlayer, the transmittance spectrum shown in Fig.11 was combined with that of the faded lake sample in Fig.10. The artefact that was produced by this method is shown in Fig.12. It is interesting that the resulting curve bears a marked resemblance to the reflectance spectrum of the pinkish brown area measured at point 3 on the picture surface itself, shown in Fig.8.

Conclusion

It is evident that Dr Schomberg's coat is not as originally portrayed by Gainsborough, and we have seen that significant loss of colour in the lake glaze is responsible. Photochemical deterioration of lake pigments is a familiar phenomenon but it is rare to be able to demonstrate such a clear instance in cross-sectional samples (see also pp.58–65). It remains to be explained why in certain parts the red lake has retained its colour rather more successfully than in others. It seems probable that several factors are involved. The best-preserved areas of glaze are the most thickly applied, and simply because more colouring matter is present the effect of fading will be less noticeable than where the glaze is thinner. However, there has been quite extensive fading of the glaze of intermediate thickness and this may be partially explained by the relative reflectivity of the undermodelling layer in different parts of the coat. There seems to be a correlation between the depth of colour of the brownish underpaint and the condition of its overlying glaze — at the points the underlayer is darkest, the glaze has faded less and the fading mainly confined to the upper portion. It is possible that where the underlayer absorbs most light, that is where it is at its most dense, there will have been less photochemical damage to the transparent layer from light reflected back through the surface paint [58].

A third possibility should perhaps be considered. The glazing of the coat seems now rather erratic, not fully following the construction of highlight and shadow to be expected from a logical execution. Darker glazing strokes in the lower part, and highlights of pink where the lake pigment is mixed with white do not blend with the surrounding paint in an entirely satisfactory way. Perhaps Gainsborough took his portrait back to the studio to modify the final touches using a paint less vulnerable to fading. There is no analytical evidence for the use of a glaze other than carmine for the final layers, but the proportion of medium, quantity of diluent originally used, or the specific stability of a particular batch of cochineal lake could all influence the behaviour of the paint film to light over a long period. Might this account for transitions of colour on the surface that Gainsborough could neither have foreseen nor intended?

Notes and references

1. National Gallery No.684. See Davies, M., *The British School*, National Gallery Catalogues, 2nd ed. (London 1959), p.36.
2. Whitley, W.T., *Thomas Gainsborough*, Smith, Elder & Co (London 1915), p.81.
3. Whitley, W.T., *op. cit.*, pp.79–80.
4. Lindsay, J., *Thomas Gainsborough. His Life and Art*, Granada (London 1981), p.104.
5. Private collection. See Davies, M., *op. cit.*, p.36.
6. Quoted in Hayes, J., *Thomas Gainsborough*, Exhibition Catalogue, Tate Gallery (London 1980), p.28.
7. Hayes, J., *Gainsborough*, Phaidon (London 1975), pp.23–4.
8. Hayes, J. (1975), *op. cit.*, p.23.
9. Reynolds, J., *Complete Works*, Vol.II, Thomas McLean (London 1824), p.117.
10. Hayes, J. (1980), *op. cit.*, p.25; Lindsay, J., *op. cit.*, p.77; Reynolds, J., *op. cit.*, p.116.
11. See Green, T., 'Thomas Gainsborough' in *Completing the Picture. Materials and Techniques of Twenty-Six Paintings in the Tate Gallery*, S. Hackney (ed.), The Tate Gallery (London 1982), pp.23–5.
12. Quoted in Hayes, J. (1980), *op. cit.*, p.39.
13. Waterhouse, E., *Gainsborough*, Edward Hulton (London 1954), p.19.
14. Woodall, M. (ed.), *The Letters of Thomas Gainsborough*, The Cupid Press (London 1963), p.29.
15. Woodall, M. (1963), *op. cit.*, pp.28–9.
16. Bomford, D. and Roy, A., 'Hogarth's "Marriage à la Mode"', *National Gallery Technical Bulletin*, **6** (1982), pp.59–67.
17. Referring to a portrait by Reynolds, the Rev. W. Mason's MS says: 'His drapery [the sitter] was crimson velvet, copied from a coat he then wore, and apparently not only painted but glazed with lake, which has stood to this hour perfectly well, though the face, which as well as the whole picture, was highly varnished

before he sent it home, very soon faded, and soon after the forehead particularly cracked, almost to peeling off [....]'. See Cotton, W. (ed.), 'Rev. W. Mason's Observations on Sir Joshua's Method of Coloring' in *Sir Joshua Reynolds' Notes and Observations on Pictures* [....], John Russell Smith (London 1859), pp.51–2, and no.1.

18. Bardwell, Thomas, *The Practise of Painting and Perspective Made Easy*, S. Richardson (London 1756).

19. Dossie, Robert, *The Handmaid to the Arts*, Vol.1, J. Nourse (London 1758).

20. De Massoul, M. Constant, *A Treatise on the Art of Painting, and the Composition of Colours* [....], translated from the French (London 1797).

21. Harley, R.D., *Artists' Pigments c.1600–1835*, 2nd ed., Butterworths (London 1970), pp.37–8.

22. Dossie, Robert, *op.cit.*, p.151.

23. Mills, J. and White, R., 'Analyses of Paint Media', *National Gallery Technical Bulletin*, **11** (1987), pp.94–5.

24. See for example, Bardwell, Thomas, *op.cit.*, p.7; Dossie, Robert, *op.cit.*, pp.145–7.

25. Whitley, W.T., *op.cit.*, pp.245–6.

26. See Thomson, G., Mills, J. and Plesters, J., 'The Scientific Department of the National Gallery', *National Gallery Technical Bulletin*, **1** (1977), pp.19–24; Roy, A. 'The Laser Microspectral Analysis of Paint', *National Gallery Technical Bulletin*, **3** (1979), pp.43–50, and various other volumes of this *Bulletin* on the analysis of individual paintings.

27. Bomford, D. and Roy, A., *op.cit.*, p.60.

28. A warm brown and a pink ground can be seen in the two unfinished canvases: 'The Painter's Daughters chasing a Butterfly' (No.1811) and 'The Painter's Daughters with a Cat' (No.3812). However, in 'The Morning Walk' (No.6209) the ground would seem to be off-white as in 'Dr Ralph Schomberg'.

29. Woodall, M., *Thomas Gainsborough. His Life and Work*, Phoenix House (London 1949), p.24.

30. For example, the purple hanging drapery in Rubens's 'Samson and Delilah' (No.6461) and the child's mauve dress in Van Dyck's 'Portrait of a Woman and Child' (No.3011). See Plesters, J., '"Samson and Delilah:" Rubens and the Art and Craft of Painting on Panel', *National Gallery Technical Bulletin*, **7** (1983), p.45 and Plates i–l, p.49. A similar mauve drapery which combines the same components can also be seen to the left of Rubens's 'Minerva protects Pax from Mars' (No.46).

31. Dossie, Robert, *op.cit.*, p.131.

32. De Massoul, M. Constant, *op.cit.*, pp.215–16.

33. See for example, Gifford, M., 'A Technical Investigation of Some Dutch 17th Century Tonal Landscapes', *Preprints of the AIC*, Annual Meeting, Baltimore (1983), pp.42–3.

34. 'Smalt: nearly, as he [Sir Joshua] told me, as dear as ultramarine, and of full as perfect a colour.' Cotton, W. (ed.), *op.cit.*, p.54.

35. Prussian blue was invented by Diesbach in Germany, probably between 1704 and 1710, but the preparation became available in England in the 1720s. See Harley, R., *op.cit.*, pp.71–2.

36. Detected in a sample by X-ray diffraction. The powder pattern was in agreement with that for synthetic bindheimite (lead antimony oxide, $Pb_2Sb_2O_6(O,OH)$), see JCPDS file No.18–687. The yellow pigment was mixed with lead white.

37. Harley, R., *op.cit.*, pp.91–2. De Massoul, M. Constant, *op.cit.*, p.200, for example mentions *crocus martis* as a precipitated iron oxide yellow, and Mars yellow on p.147.

38. Dossie, Robert, *op.cit.*, p.93.

39. Shown by X-ray diffraction analysis. Powder pattern in agreement with goethite (iron oxide hydroxide, α–FeO(OH)); see JCPDS file No.29–713.

40. True Naples yellow (lead antimony oxide) was also found by spectrographic analysis for the child's yellow dress in 'The Painter's Daughters chasing a Butterfly' (No.1811).

41. In two samples from the unfinished background landscape of 'The Painter's Daughters with a Cat' (No.3812), similarly complicated mixtures of pigment were found. These contained charcoal, bone brown, Prussian blue, red and yellow earth pigment, a brown lake, and a trace of white. In one sample an underpaint comprising green earth and yellow ochre seemed to have been used.

Green earth has been detected by EDX analysis in several paintings by Gainsborough including: 'The Reverend John Chafy Playing the Violin Cello', Tate Gallery, London, no.TO3895 (sky and foliage paint); 'Portrait of Lady Howe', Kenwood House, Iveagh Bequest (landscape and as a glaze for deep green foliage); and 'Portrait of Abel Moysey', Gainsborough's House, Sudbury, Suffolk (in foliage paint).

42. De Massoul, M. Constant, *op.cit.*, pp.152–4.

43. White, R., 'Brown and Black Organic Glazes, Pigments and Paints', *National Gallery Technical Bulletin*, **10** (1986), p.65.

44. Inferred from the presence of calcium phosphate, detected in a small sample by X-ray diffraction with the Gandolfi camera.

45. Thin paint cross-sections were prepared from ordinary polyester-embedded samples affixed to microscope slides with cyanoacrylate adhesive, by grinding and polishing to a thickness of about 20–30 μ.

46. No analysis could be made on this thin brown underlayer, although a very few scattered pigment particles of black, reddish brown and yellow are microscopically evident. It seems likely that the main colouring component is a transparent yellow-brown, perhaps a lake.

47. Aluminium detected in a sample by laser microspectral analysis.

48. See for example, De Massoul, M. Constant, *op.cit.*, pp.192–3, 209; Dossie, Robert, *op.cit.*, p.60; Anon., *A Compendium of Colours and Other Materials used in the Arts* [....] (London 1797), p.60.

49. Dossie, Robert, *op.cit.*, p.56; De Massoul, M. Constant, *op.cit.*, p.25.

50. Quoted in Fulcher, G.W., *Life of Thomas Gainsborough, R.A.*, Longman, Brown, Green and Longmans (London 1856), p.198.

51. Wornum, R.N., *Descriptive and Historical Catalogue of the Pictures in the National Gallery. The British School*, HMSO (London 1865), p.40.

52. Christies Sale Catalogue, 15 June 1917, no.78.

53. Bullock, L.J., 'Reflectance Spectrophotometry for

the Measurement of Colour Change', *National Gallery Technical Bulletin*, **2** (1978), pp.49–55.

54. Commission Internationale de l'Éclairage, 'Recommendations on Uniform Color Spaces, Color-Difference Equations, Psychometric Color Terms', *Supplement No.2 to Colorimetry (E–1.3.1) 1971,* CIE Publication No.15, Bureau Centrale de la CIE (Paris 1978).

55. JOHNSTON-FELLER, R. M., 'Reflections on the Phenomenon of Fading', *Journal of Coatings Technology*, **58**, 736 (1986), pp.33–50.

56. KIRBY, J., 'A Spectrophotometric Method for the Identification of Lake Pigment Dyestuffs', *National Gallery Technical Bulletin*, **1** (1977), pp.49–56.

57. All the transmittance spectra reproduced in this article were recorded on a Zeiss UMSP50 microspectrophotometer. We are very grateful to the UK division of Carl Zeiss (Oberkochen) Ltd for allowing us the use of this instrument, and to Alan Daglish for his help.

58. A similar factor has been suggested to have been of importance in the deterioration of 'copper resinate' green glazes in Veronese's 'Allegory of Love, III' (No.1325). See PLESTERS, J., ROY, A. and BOMFORD, D., 'Interpretation of the Magnified Image of Paint Surfaces and Samples in Terms of Condition and Appearance of the Picture', in N. S. Brommelle and Garry Thomson (eds.), *Science and Technology in the Service of Conservation*, Preprints of the Washington Congress, IIC (London 1982), pp.169–70.

Plate 11 Gainsborough, *Dr Ralph Schomberg* (No.684). Photomicrographs of thin cross-sections (*a*, *b*) photographed in transmitted light under the microscope at 600 ×, and a cross-section (*c*) photographed in reflected light at 220 ×. Actual magnifications on the printed page shown opposite.

(a) Red glaze on Dr Schomberg's coat from a relatively unfaded area.

1. Carmine (cochineal) lake glaze.
2. Thin, brown *imprimatura.*
3. Lead white and chalk ground.

(b) Red glaze on Dr Schomberg's coat from a severely faded area.

1. Faded carmine (cochineal) lake glaze.
2. Thin, brown *imprimatura.*
3. Lead white and chalk ground.

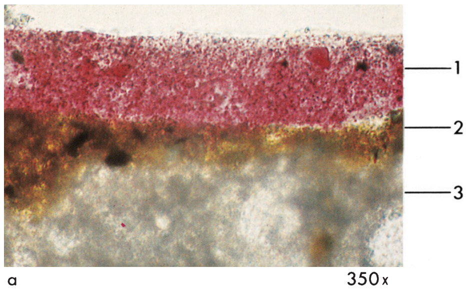
(c) Thick greyish blue sky to right of Dr Schomberg's shoulder.

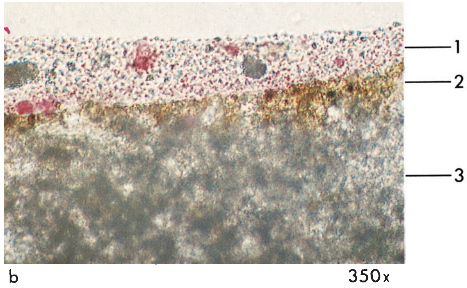
1. Multilayered paint of the sky containing wood charcoal mixed with lead white.
2. Lead white and chalk ground.

Plate 12 False colour enhancement of the image produced by near superposition of a 'live' image with that stored earlier. This corresponds to the monochrome image in Fig.14.

Plate 13 Detail from Jan van Huijsum *Flowers in a Terracotta Vase* (No.796). This detail corresponds to the area used to demonstrate the colour difference detection procedure. To simulate the fading of yellow glazes over blue underpaint, a blue wash was applied to the area of the stem labelled A. To simulate fading of a blue pigment, a white wash was applied to the iris petal labelled B.

Plate 14 False colour map of changes detected by the image processing system through the blue filter set. The areas of difference are superimposed upon the original image. These can be seen to correspond with the deliberate changes indicated on Plate 13.





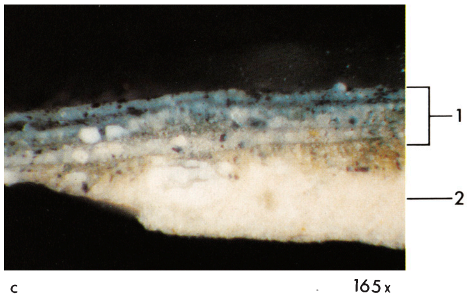
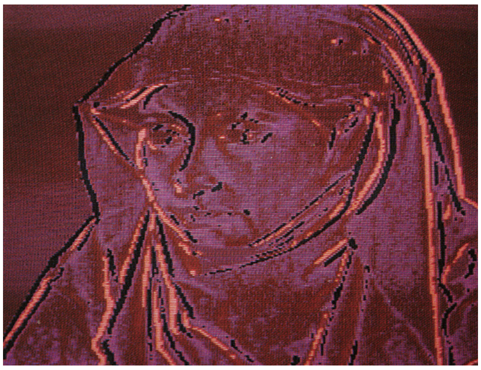
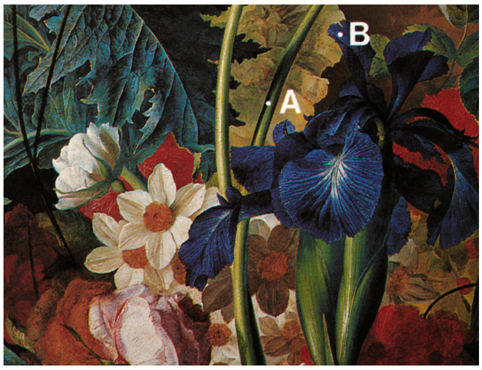


Plate 11 (Above)
Gainsborough (No.684), paint cross-sections.
Full caption on facing page.

Plate 10 (Above)
Gainsborough,
Dr Ralph Schomberg
(No.684),
detail of coat, after cleaning and restoration.





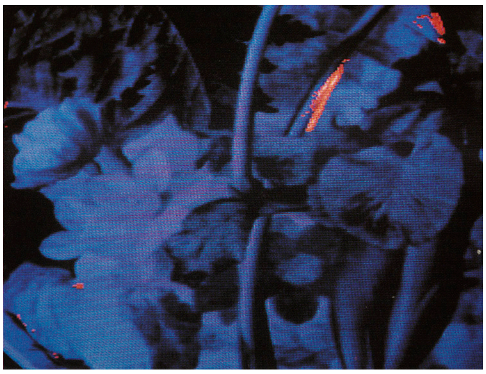


Plate 12 (Above, left) Image processing.

Plate 13 (Above) Image processing.

Plate 14 (Left) Image processing.

Full captions on facing page.