The image revealed: study and conservation of a mid-nineteenth-century Ethiopian church painting

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Summary An Ethiopian mural painting on a cotton support, The Crucifixion of Christ (Af1893,1112.1), was donated to the British Museum in 1893. The preparations for its exhibition brought together a multi-disciplinary team of British museum professionals and community advisors from both the UK and Ethiopia to research, analyse and conserve the painting, which is thought to be unique both in scale and subject matter. Translation of the Ge’ez inscriptions revealed the complex interplay of secular and religious narrative for the first time. Depicting the Crucifixion and scenes from the Passion, the painting also shows key episodes from the life of Bishop Selama, head of the Ethiopian Church until 1867. The scene showing the coronation of Emperor Tewodros II dates the painting to after 1855.

The painting materials and techniques were characterized and showed that a range of imported pigments was employed. It also showed that the apparent absence of a yellow pigment, which suggested that the painting might be unfinished, is caused by the degradation of the yellow pigment orpiment. This allowed the painting to be understood as a finished work, albeit one much altered in appearance and condition. The early inclusion of synthetic ultramarine, a bright blue pigment, in the palette is of note.

The fragile condition of the painting, which resulted from a combination of the materials, technique, construction and previous storage conditions, necessitated treatment. Drawing on both textiles and paintings conservation disciplines, the conservation strategy that was adopted has stabilized the painting. It is now mounted on a solid padded board and is more appropriately displayed, revealing the work in its entirety and allowing greatly improved access to this unique object.

INTRODUCTION

In celebration of the Ethiopian Millennium, the British Museum staged a special exhibition, Church and Emperor: An Ethiopian Crucifixion (3 March 2008–5 May 2008), which featured a remarkable Ethiopian painting of The Crucifixion of Christ (Af1893,1112.1), Figure 1. The painting is thought to be unique both in scale and in subject matter and a rare survival – outside of the originating church context – of a mural painting on cloth. The preparations for the exhibition provided the ideal opportunity to research, analyse and conserve the painting fully and brought together a multi-disciplinary team of curators, conservators and scientists from the British Museum along with community advisors from the UK and Ethiopia. The exhibition and accompanying public programme, including gallery talks, aimed to highlight Ethiopia’s rich artistic heritage and provide an insight into the conservation, materials and technique of the painting. Here, these new findings concerning the painting’s iconography, status and appearance, materials and technique, and condition and conservation are presented. Gathering all the results from this multi-disciplinary study in a single article not only allows the interconnected history, techniques and conservation of the painting to be presented, but also highlights the interdependence of the different disciplines in approaching this object.

THE PAINTING IN CONTEXT

Ethiopia is one of the world’s oldest Christian communities and is renowned for the beauty of its richly painted churches. The ancient tradition of church painting is
a vital expression of faith, inspiring devotion amongst Ethiopian Christians. There are three distinct forms of church painting in Ethiopia: paintings on wood (icons), manuscripts and church mural paintings. Ethiopian artists use narrative paintings to illuminate the subtle meanings of religious texts and to convey often-complex theological ideas. Traditionally, the subject matter of Ethiopian paintings was almost exclusively biblical and it was not until the eighteenth century that more secular themes began to emerge.

The earliest examples of murals are wall paintings in rock-hewn churches, but mural painting on cloth appears to have been known from the seventeenth century and may be a practice linked to changes in church architecture [1; p. 31, 2, 3; p. 44, 4]. From the late sixteenth to early seventeenth century round, thatched churches with a central square sanctuary surrounded by two concentric circular areas (the inner for non-officiating clergy and the outer for choristers and congregation) started to be constructed. Painting directly onto the mud and chaff plaster walls was no longer possible, so cotton cloth supports were employed, which were nailed or pasted onto the church walls and ceilings [2, 5–7]. The cloth paintings, thought to date to around 1820, which adorn every interior surface of the Church of Debra Berhan Selassie in Gondar are examples of this tradition [5; pp. 142–146 and Figure 21]. It seems that murals on cloth were either first painted and then affixed to the walls or the cloth was prepared and painted in situ, Figure 2 [1, 3]. There is also the suggestion that some of the mural paintings on cloth remained loosely stretched to the front of simple wooden frames or ‘strainers’ that were placed against the walls, one next to the other, rather than being transferred to the walls [8; Figure 8]. Patterned cloth curtains were often attached along the top edge by stitching and sometimes cloth strips adorned the spaces between the paintings. For those paintings remaining on wooden strainers, a further rudimentary frame was sometimes attached to the front, around the edge of the image, Figure 3 [5; Figure 31, 8; Figures 10, 12 and 13].

The Crucifixion of Christ is thought to be an example of such a mural painting on cloth. It is thinly painted on a cotton support (see below) and there is evidence of frayed, dirty holes and sewing around the edges, although the original function of the holes and sewing is unclear.

Figure 1. The Crucifixion of Jesus Christ and the Life of Bishop Selama (AF1893.1112.1), painting by an unknown artist, c. AD 1855, from Tigray, northern Ethiopia, after conservation: height 230 cm; width 180 cm
Ethiopian artists were traditionally schooled within the church, often under an apprenticeship to an experienced painter. Very few Ethiopian artists are known by name as paintings were rarely signed, since this was seen as immodest, and very few inscriptions include the name of the artist. Painters were taught the practical aspects of their art alongside spiritual and theological training; the process of painting was seen as spiritual and a way for an artist to glorify God. Artists were expected to learn how to prepare brushes and pigments and the tools of their trade [1, 2]. The traditional recipes for dyes and paints were passed on in conjunction with the knowledge of the symbolic meaning of particular colours. The colours used in ecclesiastical paintings accord to the canons and sacraments of the Ethiopian Church, with perhaps the most important being yellow and blue. During the nineteenth century yellow was used extensively to express the light and salvation of Christ and the intense yellow used gave the impression of concentrated light. Blue is strongly associated with Mary and is the colour worn by Ethiopian Christians to express their faith [3, 9].

Artists learnt the principles of painting by copying existing works and models. The practice established a language of painting, handed down from generation to generation, which was both distinct and instantly accessible. Although artistic conventions were carefully followed, the combination of copying and adaptation encouraged individual artistic expression to flourish. The vibrancy of Ethiopian painting comes in part from its syncretism of new ideas and external influences in a way that heightens the individuality of its established traditions. The assimilation of some foreign models is evidence of Ethiopia’s extensive history of trade and cultural exchange, but it is important to emphasize that artists chose only to assimilate certain elements of other traditions.

Ethiopia’s importance as an international centre of commerce brought many traders and diplomatic missions to the country and communities of foreign artisans flourished at different times. The Ethiopian Church, too, had well-established links with Christian communities around the world, sharing with them an artistic heritage based on Christian scripture [1–4, 10]. Paintings were often given as diplomatic gifts or bestowed on churches by the nobility, as well as being commissioned by individuals and communities [11]. Artists commissioned to paint for churches were often given the pigments needed to produce these works and paid a small subsistence; in some cases they were given land or gifts as payment. The paints and pigments required for the production of ecclesiastical works were also donated to churches, often by regional rulers. For high status commissions, especially those ordered by the emperor or the nobility, traded and imported pigments and paints were preferred [2, 4].

The painting of The Crucifixion of Christ is thought to have been made for Medhane Alam (The Church of the Saviour of the World) in the town of Adwa in northern Ethiopia, Figure 4. The town is situated on the major trade route to the coast and has been a centre for commerce and trade since the fourth century. Cotton was an important commodity of the region and Adwa was well known for its

**Figure 1. An Ethiopian Orthodox religious painting, Yeha, Ethiopia, 2007: Image © Alan D. Coogan**

**Figure 2. A priest with a large canvas painting at the church of the monastery of Nəakuto La’ab, 2007: Image © Alan D. Coogan**

**Figure 4. The Church of Medhane Alam Ethiopia, 2008: Image © J.C.H. King**
finely woven cloth. The town had one of the largest urban populations in Ethiopia during the nineteenth century and was home to many visiting Europeans and a significant community of German missionaries and artisans. Adwa has four churches, the most important being Medhane Alam, a traditional round church founded in 1823. The construction of the church was completed under the patronage of Dejazmach Wube, with the help of a German, Ainchinger, in the 1840s and is renowned for its richly painted interior. The interior of the Church of Medhane Alam has since been repainted and few examples of the original nineteenth-century church paintings survive today [12].

In 1893, James Theodore Bent, a traveller and archaeologist, visited the church and remarked on its elaborate wall paintings and impressive construction. He wrote a detailed account of his travels in Ethiopia and recorded how he first saw the painting of The Crucifixion of Christ: “It was here in the Church of the Saviour of the World that I espied a picture cast on one side, for the colours were somewhat faded, which I faintly hoped to acquire”, Figure 5 [13]. Bent bought the painting from the priest in charge of Medhane Alam and on his return to London, donated it to the British Museum, where it is described in the 1893 Book of Presents as “A painted cloth with the subject of the crucifixion, obtained by the donor in Abyssinia” [14].

The painting follows many established Ethiopian painting conventions including the use of flat colour and simply modelled figures that are outlined in black for added clarity. The modelling is largely restricted to faces and the figure of Christ [3, 10]. The use of simple, flat patterning on Mary's gown succinctly suggests the richness of contemporary embroidered dress. The artist has employed two other important conventions of Ethiopian painting: first, social perspective allows the painter to express the status and complex relationships of the individuals portrayed by the size at which they are painted; second, those considered wrong-doers or in some way evil are always shown in profile, as if not completely whole [5]. The latter convention is clearly demonstrated in the central Crucifixion scene where both Longinus, who pierces Christ's side, and the two crucified thieves are portrayed side on.

ICONOGRAPHY

The painting is dominated by the central image of the Crucifixion of Christ. It is a painting of great religious passion, glorifying Christ’s ultimate sacrifice for mankind and a witness to the fulfilment of biblical prophecy. It shows episodes of the Passion as if they are occurring at the same time, illustrating the words of the Gospel of Saint John. There are 11 smaller, distinct scenes around the edge of the painting with inscriptions in Ge'ez, the ancient ecclesiastical language of the Ethiopian Orthodox Church.

It was Bent's initial description in 1893 that informed previous understanding of the painting's subject matter [13]. His observations seemed to fit with some known Ethiopian painting conventions and, more generally, with Christian iconography, but neither Bent nor subsequent researchers seem to have referred to any translation of the inscriptions. It is these that have proved to be the key to unlocking the stories portrayed. Ge'ez inscriptions were used by the artist to describe the subject and to name individuals, and they add another level of explanation, making use of subtle word play to infer richer meaning. The translation of the inscriptions by one of the authors (HC) has totally changed the understanding of what this painting represents.

It becomes apparent that, of the 11 smaller scenes that surround the central image of the Crucifixion, only three relate directly to the life of Christ. They show three episodes from the Passion, the veil of the temple being rent in two, the flagellation of Christ by Pontius Pilate and Christ being tormented while wearing the crown of thorns. This last scene is known in Ethiopia as the Qwë'ata Resu or ‘striking of His head’ and has a special significance, often appearing on icons. Directly below is the first of eight scenes that record key events in the life of Bishop Selama, an Egyptian monk who was head of the Ethiopian Orthodox Church from 1841 until his death in 1867 [15].
Bishop Selama was considered one of the most powerful and controversial figures in Ethiopia during the nineteenth century. He was just 21 years old when he was consecrated as bishop and head of the Ethiopian Orthodox Church. His appointment caused immense excitement throughout the country at a time of deep division within the church and during a period of great instability and political upheaval. It was hoped that he would unite and strengthen the church, helping to bring stability and peace to the country.

The eight scenes show just 14 years of Bishop Selama's life, from his arrival in Ethiopia in 1841 to the coronation of Emperor Tewodros II in 1855. They detail some of the tribulations Selama suffered because of his support of the doctrine of Tewahedo, the belief in the indivisible nature of Christ. They also shed light on some of the complex political relationships between Bishop Selama and some of the most powerful regional and political rulers of the time.

The first of the eight scenes is perhaps the most critical in terms of dating the painting and understanding the context and timeline of the narrative. The inscription reads "How Bishop Selama anointed the oil of Kingship to enthrone Tewodros at Däräsgä". Emperor Tewodros II was crowned at the Church of Däräsgä Maryam in 1855 after a battle to defeat Dejazmach Wube, his rival for the throne. In preparation for his own, intended, coronation Wube had completed the construction of the church and employed the German artist Eduard Zander, to whom some of the church's paintings are credited [16]. Chronologically, this scene is the last, suggesting that the painting must have been made between 1855 and 1893, perhaps to celebrate the coronation of Emperor Tewodros II and his confirmation of Bishop Selama’s doctrine of Tewahedo as the sole, legitimate doctrine of the Ethiopian Orthodox Church. As well as acting as an important reference for dating, this small scene also sheds light on the power balance of church and state. Using social perspective the artist focuses attention on the three central figures: Bishop Selama (left) who holds a flask of oil, Tewodros (centre) and his new wife Empress Tewebach.

Figure 6. The eye contact between Selama and Tewodros suggests that they are equals and can be seen as a comment on their newly established partnership. Although Bishop Selama needed the emperor's support, Tewodros could not reign without being crowned by the bishop. At the moment of the coronation both church and state appeared to enter a new period of stability and peace.

The juxtaposition of a religious icon and historical narrative allows, in some scenes, for a duality of meaning, which suggests comparisons between the suffering of Christ and the tribulation of Bishop Selama. It is a very powerful and provocative message for a church painting and one that appears to elevate Selama above his temporal role. It may reflect stories that were circulating in Ethiopia at the time of a great king named Tewodros, a priestly figure, who would restore the glory of Jerusalem and herald a new era of peace [17]. When Bishop Selama anointed Kassa Hailu as Emperor Tewodros II of Ethiopia he appeared to fulfill this prophecy.

Three scenes in particular blur the lines between Christian iconography and secular narrative, but Bent described all three in purely religious terms [13]. In the first (bottom left), Bishop Selama is shown entering Tigray on a mule, greeted by jubilant monks and clergy. Monks hold aloft an umbrella, a signifier of conferred honour and prestige, while Selama is crowned with a halo. The whole scene, as Bent recognized, is reminiscent of Christ’s entrance into Jerusalem. Indeed the position of this scene within the usual composition of the Passion is often reserved for the representation of Palm Sunday.
propaganda could permeate religious painting.心, it is also a testament to the extent to which political deep religious passion, with the Crucifixion of Christ at its artist and commissioner. Although this is a painting of strongly reflects the political and doctrinal beliefs of the describes not only a series of historical events but also betrayal by someone close to him.

As Bent also remarked on the scene (top right), in which Bishop Selama is shown ascending on a rope to Debra Damo monastery. Two priests support him at the base of the cliff, while others at the top of the mountain pull him up. The scene follows traditional iconography associated with Christ’s descent into hell to bring out Adam and Eve, in which Adam is traditionally painted to the left of Eve. The positioning of the monks closely fits this iconography, with only the monk on the left depicted with a moustache, allowing them to be confused with a man and a woman.

The third, and perhaps the most striking, scene (middle right side: Figure 7) shows Bishop Selama celebrating Mass at the Church of Medhane Alam at Adwa and surrounded by 12 figures. He is shown giving Holy Communion to a man to his left, who is painted in profile. The whole scene is closely analogous to the Last Supper, with the outline of Medhane Alam behind suggesting an interior scene. The Gospels explain the Last Supper as the celebration of the first Holy Communion, the foundation of Christian faith. At the Last Supper, Christ identified his betrayer, Judas Iscariot, by giving him a piece of bread and this scene appears to mirror this episode. As he celebrates the holy liturgy, Bishop Selama gives bread to the man in profile, perhaps indicating his own betrayal by someone close to him.

The complex narrative of the smaller scenes thus describes not only a series of historical events but also strongly reflects the political and doctrinal beliefs of the artist and commissioner. Although this is a painting of deep religious passion, with the Crucifixion of Christ at its heart, it is also a testament to the extent to which political propaganda could permeate religious painting.

FIGURE 7. Detail of the scene depicting Bishop Selama celebrating Holy Communion at Medhane Alam, Adwa

MATERIALS AND TECHNIQUE

As Bent mentioned when he first saw the painting, the colours appear muted or faded compared to the traditional palette used by Ethiopian artists [13]. The discoloured, dark brown 'hue' of the cotton further contributes to the painting's overall dull appearance, although there are bands across the surface that are less discoloured (Figure 1), showing brighter, more colourful tones that are most noticeable in the green areas. Certain passages appear unpainted with the preparatory drawing still visible. The apparent absence of the colour yellow from the composition is significant, and was interpreted as further evidence that the painting might be unfinished. However, it has been suggested that paintings would have been removed from churches and replaced with new paintings when they started to fade and so it is possible that, rather than being unfinished, this painting is an example of such practice and is unusual in having survived [5].

The opportunity was taken to study the materials and techniques of the painting, and to compare the findings with what is known from other studies of Ethiopian paintings and manuscripts. Very few church paintings on cloth have been studied and indeed few examples survive. Of the extant examples most are in their original church context and date from the nineteenth or twentieth century. However, the pigments from the seventeenth-century Abba Antonios mural paintings (also on cloth) have been studied [4]. The majority of the studies focus on sixteenth- to eighteenth-century icons and manuscripts [4, 9, 18], although examinations of a few nineteenth- and early twentieth-century works have also been reported [16, 19]. Perhaps the fullest description of the use of dyes and pigments in Ethiopia is given by Tournier, and is based both on interviews conducted in the late 1960s and early 1970s (particularly with the clergy) and the study of documentary sources, including many nineteenth- and early twentieth-century accounts written by travellers or other Europeans working in Ethiopia, who described artists’ practice and materials [2].

Despite the large size of the painting, it is so thinly painted in many areas that there was very limited opportunity to take microsamples for analysis using Raman spectroscopy, Fourier transform infrared (FTIR) microscopy and scanning electron microscopy with energy dispersive X-ray analysis (SEM-EDX); as a result, only four paint samples were taken. The details of all the analytical methods used in the examination of the painting are given in the experimental appendix. The size of the painting precluded its examination in the science laboratories at the British Museum, but with the support of the Eu-ARTECH (Access, Research and Technology for the conservation of the European Cultural Heritage) project it was possible to bring a range of portable, non-invasive analytical instruments (MOLAB) to the painting in the conservation studio. Analysis was undertaken using X-ray fluorescence (XRF), mid-infrared reflectance spectroscopy and fibre optic reflectance spectroscopy (FORS) [20]. These analytical measurements were complemented by studies using infrared, false-colour infrared (FCIR) and ultra-
violet-induced luminescence imaging. The resulting images revealed features of the painting that were either invisible, or difficult to see, under visible illumination. Additionally, the images could be used to identify passages of paint of similar composition to areas analysed, thus allowing the pigments used across the whole painting to be suggested, even when not analysed directly.

The cloth substrate was originally constructed of two pieces of fine plain weave hand-woven cotton (identified by polarized light microscopy [21]), sewn together in the centre with all four selvedges present and running vertically. Rows of regularly spaced holes along the unpainted edges suggest that the cloth was originally attached to another support (perhaps a simple wooden strainer), possibly by sewing. The lack of any turnover edges implies that the cloth was attached to the front of the support, rather than being wrapped around its back. It seems unlikely that the cloth was tightly stretched, as there is little displacement of the cotton threads at the points of attachment. A row of prominent holes and a fragment of surviving thread along the top unpainted edge (following the edge of the red border paint), suggest that a cloth curtain may have been attached to the front of the painting, as discussed above, Figure 8. Several larger frayed holes are also present at various points around the edges.

In preparation for the application of the paint, a layer of white, kaolin-containing clay was applied to the cotton. In contrast, gypsum, chalk or limestone preparations are mentioned for the other paintings that have been studied [4, 6, 9, 18]. In some areas of The Crucifixion of Christ the clay is very thin but elsewhere (including beneath the red of the Virgin’s robe and the blue garment of the soldier offering the sponge) it appears quite thickly applied. The reason for the variation in thickness of the preparation layer is unclear and does not seem to relate in a simple way to the design (it is not, for example, limited to the figures), or choice of colour. It may have been varied to achieve different visual effects by providing a brighter white underlayer or have been linked to the choice of pigment, medium or method of application of the paint (which would also affect the appearance of the paint). For example, those passages of red paint where the preparation is thin appear a rather dull colour and resemble washes (as in the robe of Mary Magdalene depicted on the far right of the cross) while in areas where the preparation is thicker (such as the robe of the Virgin), the red appears brighter and more thickly applied (although now in poor condition as discussed below). The red pigments are believed to be the same in both areas (see below).

In general, the adhesion of the paint layers on the painting is poor, particularly where the clay preparation is thick. Condition reports prepared in the mid-1980s by UNESCO for the mural paintings on cloth in the Church of Debra Berhan Selassie describe similar adhesion problems for both paint and ground layers [6]. Unfortunately, because the paint of The Crucifixion of Christ is generally very lean and thinly applied, and there have been previous conservation interventions, it was not possible to determine the binder(s) used on the painting with certainty. However, FTIR suggests the use of a proteinaceous binder, probably egg or animal glue, for the paint in several areas from the main scene: the red ‘triangular’ shape in the background between Christ and the right-hand crucified figure; the bright blue of the Virgin’s headress; and the darker blue of the garment of the soldier offering the sponge. The dark blue paint sample contained significantly more binder than the others, which may be linked to the choice of pigment and may also account for the type of detachment observed (see below). The binder used in the clay preparation layer...
could not be determined. The use of an aqueous paint binder is certainly consistent with the matt and underbound appearance of *The Crucifixion of Christ* and its sensitivity to colour change. The different appearance and condition of the green paint (in a sample taken from the sleeves of the figure holding the rope in the top right scene) to the other paints suggest that a different binder may have been used, see Figure 9.

On the basis of microchemical tests, Weihs [9] and James [18] reported the use of protein binders in ground and paint layers of sixteenth- to eighteenth-century icons, and suggested the use of animal glue. Significantly, Weihs also noted that the medium in a group of icons bound the pigments poorly and suggested that high or fluctuating humidity had caused the binder to decompose. He also proposed that paint loss in certain passages could be linked to the use of excessive amounts of binder, or preparation layers that were too absorbent. Nineteenth-century texts quoted by Tournerie also refer to the use of animal hide adhesives in the preparation layers but mention the use of egg yolk, egg white and gum as binding media for the paint layers [2].

The detailed underdrawing seen during visible examination was more clearly revealed by infrared imaging, which also improved the legibility of the inscriptions. The underdrawing was executed using a carbon-based pigment, probably charcoal [2]. In the main, the final composition did not deviate from the underdrawing, but changes in composition are clearly visible in the central image, Figure 10.

Details of the pigments found on the painting and those reported for other Ethiopian works are given in Table 1, and demonstrate that the majority of the pigments used follow the traditions of the previous two centuries. Perhaps the most exciting and significant finding was the detection of arsenic by XRF in almost all of the areas examined, including the majority of the background areas. This suggested that these areas had been originally painted with the bright yellow pigment, orpiment ($\text{As}_2\text{S}_3$). Orpiment is known to convert, when exposed to light or heat, to arsenic oxide ($\text{As}_2\text{O}_3$), a white or colourless compound [22, 23]. It seems likely that a yellow background layer was applied to most of the painting but has subsequently faded, greatly changing the appearance of the painting. Once it was realized that the yellow colour had been lost, it was possible to interpret the painting as a finished work, but one that was greatly altered from its original appearance.

In the chalice in the Communion scene and the yellowish decoration on some of the blue robes a little iron was detected in addition to arsenic, suggesting that an ochre or earth pigment was mixed with the orpiment, perhaps to distinguish these objects from the background colour. There is no evidence for other earth pigments having been used on this painting. A carbon-based black pigment has been used to outline the design and Tournerie cites the use of a black paint prepared by burning hemp seed for this purpose [2]. There is little use of white in the painting, but in the eyes of the figures and a few other areas white clay has been used (and may also have been added to the blue pigments in the dark blue of the garment of the soldier offering the sponge). In the majority of other paintings for which the materials have been investigated, gypsum has been found as the white pigment, see Table 1.

As is typical for other Ethiopian paintings, the red pigment vermilion is used. It seems to have been used mixed with red lead (at least in those brighter red paint passages that were examined by Raman and XRF). FORS suggested that the same pigments are also present in the duller red passages, although possibly in different proportions. However the similarity in the reflectance spectra of the two pigments complicates interpretation. Raman spectroscopy was also used to confirm the presence of red lead as a pinkish-orange pigment in the Abba Antonios murals [4]. Vermilion, orpiment and red lead have been known since antiquity and Weihs suggests that cinnabar (the mineral form of vermilion) and orpiment are both found naturally in Ethiopia while red lead has been found on other African artefacts, perhaps suggesting a tradition of local manufacture [9]. However, Wion [4] and Tournerie [2] argue that certainly from the sixteenth century and probably earlier, all three are likely to have been imported via Ethiopia’s strong international trading
STUDY AND CONSERVATION OF A MID-NINETEENTH-CENTURY ETHIOPIAN CHURCH PAINTING

<table>
<thead>
<tr>
<th>Colour</th>
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<th>Pigment (method of identification)</th>
<th>Literature examplesb</th>
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<tr>
<td>Red</td>
<td>Vermilion and red lead (XRF, Raman)</td>
<td>Vermilion – manuscript (A: Raman), mural painting (B: Raman), icon (C) (D: XRF, SEM), scroll (E: XRF, XRD)</td>
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<td>Organic red (UV)</td>
<td>Organic red (presumed to be madder) – icon (C) (D: XRF)</td>
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<td>Yellow</td>
<td>Orpiment (XRF)</td>
<td>Orpiment – manuscript (A: Raman), mural painting (B: Raman), icon (C) (D: XRF, SEM), scroll (E: XRF, XRD)</td>
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<td>Yellow ochre (XRF)</td>
<td>Organic yellows – scroll (E: XRF, XRD)</td>
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<td>Blue</td>
<td>Smalt (SEM, FORS, IR), synthetic ultramarine (Raman, SEM, FORS, IR) and Prussian blue (XRF, FTIR, SEM, FORS, IR)</td>
<td>Indigo – manuscript (A: Raman), icon (C), (D: XRF), scroll (E: XRF, XRD)</td>
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<td>Green</td>
<td>Copper-based green (XRF, FTIR)</td>
<td>Prussian blue and indigo – icon (D: FTIR)</td>
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<td>Prussian blue and ultramarine – manuscript and scroll (F: XRF, XRD, FORS)</td>
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<td>Prussian blue and ultramarine and indigo – manuscript and scroll (F: XRF, XRD, FORS)</td>
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<td>Carbon black – all examples</td>
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<td>White</td>
<td>White kaolin-containing clay (XRF, Raman, FTIR)</td>
<td>Gypsum – icon (C), (D: XRF, SEM), ground layer, mural painting (A: Raman)</td>
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<td>Lead white – icon (C)</td>
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<td>Brown</td>
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<td>Lead white – icon (D: XRF, SEM)</td>
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<td>Orange</td>
<td>Red lead – mural painting (B: Raman)</td>
<td>Red lead – mural painting (B: Raman)</td>
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<td>Lead chrome – scroll (E: XRF, XRD)</td>
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Notes


b Literature references: A – seventeenth-century manuscript painted on parchment [4]; B – seventeenth-century manuscript on parchment [4]; C – sixteenth- to eighteenth-century icons [9]; D – seventeenth- to eighteenth-century icons [18]; E – eighteenth- to late nineteenth- or early twentieth-century parchment talismanic scrolls [19]; F – manuscripts and talismanic scroll on parchment [16].

In these cases the green is described as amorphous and does not yield a Raman spectrum. The green in the British Museum painting gave a comparable result when analysed by Raman, so it is possible that a copper-based green similar to verdigris may have been used in these objects, but this could not be confirmed without the use of XRF or another elemental analytical technique.

Links to Europe, Asia and the Middle East, where they would have been synthetically produced. The microscopic appearance of the vermilion from The Crucifixion of Christ, with large particles of fractured appearance, suggests that it was produced by the dry process, since the use of ground cinnabar seems very improbable. Although much vermilion was produced by the wet process by the nineteenth century, since the use of ground cinnabar seems very improbable. Although much vermilion was produced by the wet process by the nineteenth century, producers of dry process vermilion in the nineteenth century included China and Germany [24]. Sources cited by Tournerie, and Marx’s study of blue pigments, point to the well-developed market between Ethiopia and Europe, Cairo and Alexandria during the nineteenth century, which is discussed further below [16].

The use of a mixture that had originally contained red lead, vermilion and orpiment was detected in the Virgin’s halo. Mixtures of red lead and orpiment are known to be incompatible as the paint darkens due to the formation of black lead sulphide [23, 25]; it is likely that the Virgin’s halo was originally an orange-red colour, rather than the brown colour seen today. Vermilion is also known to darken, but elsewhere on the painting – where it is mixed only with red lead – it retains its red colour, suggesting that the darkening of the vermilion has not occurred to a great extent [26].

In the majority of other paintings examined a mixed green of orpiment and indigo has been used, although a range of green pigments has also been reported, see Table 1. Indigo does not appear to have been used at all on The Crucifixion of Christ and here the green pigment is copper-based. FTIR microscopy suggests the use of a verdigris-type pigment, which has degraded to a brownish colour over much of the painting, Figures 9 and 11. Compared to other paint passages, the green paint film appears more richly bound and coherent, and the pigment particles less distinct, which might suggest that a different binding medium has been used. There is some indication of the formation of copper-fatty acids soaps in areas where the green colour has been preserved, hinting at the use of an egg yolk or oil medium for the green. Girard, traveling in the 1860s and cited by Tournerie, mentions the use of verdigris, along with vermilion, lead white, ivory black, Prussian blue, cobalt blue, green, yellow and “a certain blue composed of lead white and powdered glass” [2]. It should
However be noted that these terms probably describe the colour of the pigments, rather than providing certain identifications.

Rather than indigo, three other blue pigments have been identified on the painting, used in various combinations to give a range of different blue tones – Prussian blue, smalt (a cobalt-containing potassium glass) and synthetic ultramarine. In the bright blue sample from the Virgin’s headdress, Raman, FTIR and SEM analyses indicated the presence of synthetic ultramarine, while SEM and XRF suggested the additional presence of a small amount of an iron-containing pigment, probably Prussian blue. In the dark blue from the garment of the soldier offering the sponge Raman, FTIR and SEM indicated the presence of Prussian blue and smalt, but no ultramarine was detected. Using XRF and FORS it was possible to survey a wider range of blue paint passages but unfortunately it was not possible to confirm the presence or absence of smalt in the areas examined. It is therefore not clear if the use of smalt is limited to the soldier’s garment or is more widespread. However, XRF and FORS suggest that all the blues contain a mixture of ultramarine and Prussian blue (even in the bright blue of the Virgin’s headdress). The proportion of these pigments varies, so that the darker blues are richer in Prussian blue and the brighter blues are richer in ultramarine.

In the second half of the nineteenth century there is a noticeable change in Ethiopian painting to the use of a brilliant, intense blue, very different to the indigo blues that dominated previously. This has been linked to the use of synthetic ultramarine, first produced industrially in France in 1830 [27], and which Marx has suggested was in use as a painting pigment by 1855, employed by German artists and missionaries working in Ethiopia and Jerusalem [16]. Depending on the precise dating of the painting, the identification of ultramarine in *The Crucifixion of Christ* may be the earliest confirmed use of synthetic ultramarine on an Ethiopian painting, although Marx identified a painting of 1852, possibly painted by Zander, in the Church of Däräse Maryam, which visual examination suggests also employs synthetic ultramarine. Zander was closely connected to both the regional ruler of Tigray, Dejazmach Wube, and Emperor Tewodros. He was commissioned by Wube to assist in the completion of the Church of Däräse Maryam along with the German botanist Wilhelm Schimper. Wube also commissioned the completion and redecoration of the Church of Medhane Alam at Adwa, again employing German artisans. The strong connection between these individuals and the use of German artistic practices suggests that Zander may have been directly involved with the painting of *The Crucifixion of Christ* and with the choice of pigments employed.

The use of Prussian blue and smalt has been reported previously in mural paintings on cloth, manuscripts and icons. It is believed that smalt was first introduced to Ethiopia by the Portuguese Jesuits and imported from Italy or Portugal [4, 9]. Although by the nineteenth century smalt had largely fallen out of use by European artists for easel painting following the invention of Prussian blue in the early eighteenth century and cobalt blue and synthetic ultramarine in the early nineteenth century, it continued to be used by artists during the second and third quarters of the nineteenth century and it was produced for use in laundry blue well into the twentieth century (Reckitts Ltd continued production until 1952) [28]. During the nineteenth century, smalt appears to have been used as an artists’ pigment in Germany much later than in France, particularly around Dresden and Munich, where its use may have been linked to local production associated with the ceramics industry [29; pp. 56–58].

Marx has argued that a readily available source of synthetic ultramarine in Ethiopia in the nineteenth century would have been laundry blue, and that the occurrence of Prussian blue and synthetic ultramarine mixtures on paintings is further evidence for its use. Laundry blue does not describe a specific formulation and the various commercial preparations include a range of blue pigments such asPrussian blue, synthetic ultramarine, indigo and smalt as well as other additives. The early widespread availability of this material across the globe, and use of laundry blue as a colourant in ethnographic objects is well documented [16, 30, 31]. The presence of synthetic ultramarine, apparently used (at least in some passages) in combination
with Prussian blue on *The Crucifixion of Christ* (Table 1), may indicate that laundry blue was used as the pigment source. It is also possible that the smalt detected on the painting (particularly if always accompanied by Prussian blue) could represent the use of another laundry blue with a different formulation. However, references to the use of glass-based pigments such as smalt in Ethiopia appear in nineteenth- and twentieth-century accounts [2]. Without further sampling it is not possible to determine which blue pigment combinations are present, or to determine whether the range of blues observed derive from (various) laundry blue preparations, mixtures of pure pigments or combinations of the two. However if pure pigments were being used, the number of different blue pigments present and their use in mixtures would seem slightly wasteful.

The total loss of the yellow colour from the painting due to the fading of orpiment suggests that the painting has been exposed to high levels of light in the past. It is possible that organic colourants or glazes may have been used on the painting, but evidence of these highly fugitive colourants is likely to have been lost during such light exposure. Luminescence imaging was used to look for the remains of organic colourants or varnishes (although the matt appearance of the paint suggested a varnish was unlikely). In the luminescence images evidence can be seen for what appears to be an organic red pigment used to outline features such as fingernails and to model the faces and necks of some figures (as described by Chojnacki, see Figure 12) [3, 10]. Weihs suggests that madder lake was used as a red pigment, having been introduced by Portuguese Jesuits [9, 10]; its use has been identified in a seventeenth-century icon [18].

Interviews reported by Tournerie and Marx reveal a rural church painting tradition in which a diverse palette of colours could be obtained from locally derived organic plant materials and mineral pigments, including earth pigments [2, 32]. The modern rural church painting tradition probably builds on earlier practice, and certainly talismanic scrolls from the Musée du Quai Branly contain a large number of (unidentified) organic colourants as well as earth pigments [19]. For *The Crucifixion of Christ*, and many other works that have been examined, while the white, black and earth pigments were probably produced locally, the majority of other pigments were imported. Documentary evidence also refers to the use of imported paints, where possible, at all periods [2]. Thus for high status commissions, there seems to have been deliberate use of more expensive, imported pigments and “... a popular tradition regarding the use of pigments and their origin which is different from the royal and aristocratic tradition” [4]. If laundry blue has been used on the painting this would certainly have been an imported product, even if not a high quality artist’s material, and may simply have been used for convenience or for its colour.
Loss of colour and other colour changes have drastically altered the appearance of the painting, and much of the original richness has been lost. Although lacking some of the subtleties of the painted surface, in an attempt to recreate a sense of the original appearance, a digital reconstruction was attempted and is shown in Figure 13.

CONSERVATION

Condition

Although the painting has been in the British Museum’s collection for 115 years it had never been on public display, very little was known about its condition and no previous treatment records existed. The painting was encased in a heavy glazed wooden frame with a hardboard backboard, so that the full extent of the fragile nature of the painting was only revealed on removal from the frame. Despite previous conservation the painting was in urgent need of treatment. The whole painting was excessively dusty; the cloth support was sagging and loose on its strainer and was discoloured, with evidence of staining and stiffness around old damages. In addition the cloth was very brittle with many vertical tears evident and light could be seen through its structure, emphasizing the thin and fragile condition, Figures 9 and 11. The paint was also in poor condition with loss, active flaking and wear.

The painting had undergone conservation treatment twice in the past. Presumably around the time the painting entered the collection in the late nineteenth century, it was stretched onto a wooden strainer, using the unpainted edges, which were wrapped around the strainer bars creating turnover edges and secured to the strainer with metal canvas tacks. The painting was then fitted into a glazed black-painted frame.

Judging by the materials and technique used [33–35], tear mending and a full lining treatment was undertaken to support the cloth substrate at some point in the 1960s or 1970s. Coloured nylon net patches were attached to the reverse of the tears with polyvinyl acetate (PVA) adhesive, which was identified by FTIR [21] (see Figure 9), and two further large pieces of net were attached with the same adhesive to cover the whole of the reverse, overlapping horizontally just below the centre. The net extended beyond the edges of the original cloth and in places was folded over, and adhered to, the front of the original unpainted edges, presumably to support weaker areas. The painting had been reattached to its nineteenth-century strainer in a different position (perhaps to align the vertical of the cross), creating alterations to the turnover edges and making new tack holes, Figure 8. The painting had then been replaced in its nineteenth-century frame and a hardboard backboard attached.

It was apparent that the painting had deteriorated significantly over the decades since this treatment, not only due to the inherent fragility of the painting and deterioration of the original materials, but also as a result of the impact of
previous treatments and the prevailing environmental conditions in the area in which the painting had been stored. The cotton fibres were weak, acidic and discoloured suggesting advanced degradation of the cellulose. It appeared that the fibres had deteriorated considerably since the application of the nylon net. This lining was no longer supporting the painting and its adhesion was uneven, creating undulations and creases in the cloth substrate, Figure 14. The unpainted edges were fragmented, showing losses, tack damage and weakened turnover edges; the tear repairs were stained and the surrounding cloth was stiff and brittle, Figure 9. There were numerous stains, tidemarks and recent vertical tears across the surface. The thicker paint passages were flaking from the surface, the more thinly applied colours (mainly reds) were being carried away on shedding cotton fibres and the bright blue passages were powdering from the surface, Figure 14. The green paint appeared well bound, but discoloured, and the cloth beneath was extremely weak.

It was very apparent that while some areas of the cellulosic support had become very fragile and yellowish-brown in colour, bands that coincided with the position of the strainer bars (which are particularly noticeable in the luminescence images) were lighter in colour, Figure 1. Pure cellulose undergoes a slow process of chemical breakdown over time due to reactions with light, oxygen and moisture, leading to discoloration and loss of strength [36]. These reactions are acid-catalyzed and the extent of degradation and discoloration of the cotton support suggests that the painting has been exposed to an acidic environment in the past, accelerating the natural degradation processes. Wood, and particularly engineered woods, are known to off-gas high levels of acetic and formic acids [37; pp. 95–105; pp. 161–176 and Appendix 1], and the positioning of the less discoloured bands suggests that the hardboard backboard applied in the 1960s or 1970s was the likely source of acidic compounds [38]. It seems probable that a microclimate developed between the glass and the hardboard backing, perhaps compounded by the quite high light and temperature levels in the painting’s previous position on a stairwell wall. The lighter coloured bands presumably represent areas where the cotton was protected from these acidic emissions to some extent by the strainer bars. The oxidative degradation of cellulose is also catalyzed by transition metal ions such as iron and copper; the particular fragility of the cotton in the areas where the discoloured green paint is present results from the copper-based green pigment used in these areas, Figures 9 and 11 [39–41].

Treatment

Conservation was necessary to reduce the rate of future deterioration and make the painting available for vertical display. The extreme fragility of the painting dictated the level of conservation intervention and the degree to which visual changes and damage were considered acceptable. Because the methods that it was necessary to use restricted the potential for reversibility or re-treatment [42], it became more important to consider the longevity of the chosen treatment and regard this as the most realistic approach to ‘minimal intervention’ [43; pp. 9–14, 44; p. 22].

The appearance of the painting prompted the question of whether it was a tensioned painting or a painted cloth (untensioned), as described in the Book of Presents in 1893. The previous treatments suggested that this question had arisen before. However the physical evidence of rows of uniform holes and frayed holes around the edge of the painting suggests that it was originally attached under slight tension to a secondary support and may well have been nailed to the church wall. This understanding of both how the painting would originally have been displayed and how it had been treated and displayed since its donation to the Museum meant that collaboration between paintings and textile conservation disciplines was essential. The resulting treatment addressed the extreme fragility of the painting and to some extent reflected its perceived original context.

A wide-ranging conservation treatment was undertaken, the full details of which are available through the Collection Database on the British Museum website. Here, a summary of three of the stages – tear mending, lining and mounting for display – are discussed.

The painting was removed from its strainer, the paint was consolidated with acrylic-based resins and dispersions and the old nylon net lining and patches were removed. At this stage of treatment the full extent of the fragility of the cotton fibres was appreciated. It was clear that the painting could no longer support itself and was in danger of fragmenting further. The choice of materials and techniques was severely restricted by the painting’s predisposition to staining and colour change and the role of the cloth in the visual interpretation of the image. The obvious degree of acid hydrolysis and oxidative degradation of the cloth suggested deacidification treatment would be advantageous; however the risk to the painting during treatment was considered too great [45, 46]. Instead, in an attempt to limit the possibilities of further increases in acidity through ageing of the conservation materials, the choice was made to use predominantly synthetic materials for the treatment; the reduced response of synthetic materials to changes in environmental conditions was also beneficial in helping to retard further physical deterioration.

The fragility of the cotton substrate around the tears and weak areas meant that tear mending techniques employed by paintings conservators, such as butt joins and thread-by-thread repairs, could not be considered [47, 48]. Conversely, patching was an appropriate method that is often used in textiles conservation to reinforce areas of severe degradation and support tears and areas of loss [49; p. 34, 50; p. 349]. In addition, the minimal tension required by the painting (see below) meant that there would be little risk of the shape of the patch transferring to the surface of the substrate [47]. A fine semi-transparent sheet of Japanese Kasenshi polyester paper was chosen for
the patching material. This was coated with Beva® 371 gel, an adhesive that is commonly used for both textiles and paintings conservation [51, 52]. The potential for heat-reactivating the dry adhesive reduced the risk of staining. Concerns for the reversibility of Beva 371 and the potential limitations of using adhesive nap bonds on fibres with reduced tensile strength were recognized [50; p. 347, 52; p. 6, 53], and Brooks et al. do not recommend adhesive techniques for use on fragile archaeological textiles for this reason [33; p. 9]. However it was considered that the non-penetrating nap bond, bond strength, solubility and stable ageing properties of this adhesive offered the least obtrusive approach and the best opportunity for future re-treatment [50, 54, 55]. Studies of the strength of nap bond and peel strength in relation to adhesive coat weight, application method and heat-activation temperature of Beva 371 [44; pp. 28–29, 50, pp. 343–346, 56; p. 133], and the variable effects of these criteria on strength of adhesion, flexibility of the treated textile and ease of reversal were taken into account when developing the treatment. Accordingly, spray applications were tested until the desired adhesive strength for the patching material and the subsequent lining was achieved [56, 57]. Spraying directly onto the lining and patching fabrics rather than using a pre-purchased adhesive film enabled a finer film to be applied that gave maximum flexibility and required a shorter heat reactivation time, which was desirable for such degraded fibres [58].

The Kasenshi paper was prepared with a spray application of several thin coats of Beva 371 gel, which was diluted 1:3 in white spirits. Working on the reverse of the painting, the worst tears were realigned and bridged with small strips of Kasenshi paper adhered to the cotton cloth with heat. Larger patches were used to support severely degraded areas and losses, Figure 11.

The decision to mount the painting on a solid support, similar to those often used to support textiles, afforded the opportunity to consider a lightweight lining with minimal tension, using a finer material than generally used for canvas paintings. The painting was not subject to the usual behaviour of canvas paintings, as summarized by Phenix [44], as the degree of tension required was far less than for a painting with a thicker, stiffer paint layer. A textile conservation approach was more applicable and the aim of the lining was, therefore, to reinforce and support the degraded cotton fibres, not to relieve stress [44; p. 23]. It was difficult to select a suitable synthetic lining from the comparatively thick, heavy or stiff materials used by paintings conservators. A woven material with a certain degree of strength and rigidity was required to support the painting and prevent too much movement of the weak fibres. The colour and look of the material was important, as it would be visible at the edges of the new solid support and through the losses of the fragmented unpainted edges. A level of transparency was also desirable so as not to cover the ‘strikethrough’ of the image on the reverse, Figure 11. These criteria presented the “inevitable dilemma of form needing to be balanced against function” [44; p. 30].

To this end polyester crepeline (Stabiltex®) was chosen that, while it has apparently not been used on paintings, has a recognized history of use in textiles conservation [57, 59, 60]. Although fine and delicate to handle, once sprayed with Beva 371 gel the weave was locked in position providing a relatively rigid and strong structure. Two 200 cm-long strips (100 cm wide was the maximum available) were stretched onto wooden strainers, secured with double-sided tape and sprayed with several coats of the same preparation of Beva 371 gel used for the patching material. The Stabiltex was then heat-sealed to the back of the painting, with the warp direction of the Stabiltex running from the top to bottom of the painting and overlapping the fragile central seam. This was the most appropriate orientation for the Stabiltex in this case. However as recent research has shown that synthetic fibre woven materials, similar to natural fibre woven materials, display a greater level of crimp in the warp direction than the weft in the majority of cases, a degree of creep in the vertical direction could be expected [61]. The application of the adhesive will, however, minimize this by locking the weave in position. The new lining extended beyond the original painting and provided new tacking margins with which to attach the painting to the new solid support.

The use of the original unpainted edges of the cloth in the previous treatments wasreadressed. From a paintings conservation perspective it seemed appropriate to hide the unpainted edges from view. However, the likely original mounting method for the painting in the church meant that the unpainted edges might have been visible, albeit gathered or creased at the edges of the painting, and therefore not necessarily considered distracting to the image. The fragile and fragmentary condition of the edges also meant they could not be reused in the current treatment. As a result, the initial intention to attach the painting to the new support in a way that would hide or mask the unpainted edges was abandoned in favour of flattening and including them in the final interpretation, Figure 14.

A padded solid board similar to those routinely used in the textiles conservation studio at the British Museum, and described by Cruickshank et al. [58; pp. 12–13 and Figure 8], was constructed. The support fabric of cotton calico usually employed to cover the Cellite® panel was replaced with the synthetic woven material Lascaux® P110, which was available in suitably broad widths and in a sympathetic colour. As mentioned above, like many other materials woven from synthetic fibres, the weft direction of Lascaux P110 is firmer than the warp direction, so it was positioned with the weft running vertically. The Lascaux fabric was, however, not ideal as it was found to be more stretchable in the warp direction than many other synthetic fabrics [61]. A layer of medium weight Vilene® covered by a layer of thin cotton domette was used beneath the Lascaux P110 to provide slight padding, with a vertical channel left in the centre of the Vilene to accommodate the thickness of the original central seam. The painting was attached by wrapping the Stabiltex tacking margins around the edge of the board under slight tension, and heat-sealing to the reverse
Detailed study has confirmed *The Crucifixion of Christ* to be one of the very few surviving examples of Ethiopian church mural paintings on cloth known outside of the original church context. The translation of the Ge’ez text has allowed the subject matter to be understood and has offered the opportunity to begin to appreciate the subtle and complex language of Ethiopian Church painting. As Bent remarked, there are clearly influences from other painting traditions and this work shares an artistic heritage with both the Eastern and Western Church [13]. It is, however, uniquely Ethiopian and must be seen in the light of a continuous innovative and dynamic 1500-year-old tradition that is firmly rooted in Ethiopia. Unique both in scale and subject matter, the painting is a valuable historical document of a complex period in Ethiopian history.

The painting technique and the materials used are typical of Ethiopian painting practice and demonstrate the tendency to import pigments for high status works and the rapidity with which new materials became available during this period. Indigo is not used on the painting as a blue pigment or a component of green paint. Instead, a copper-based green and three other blue pigments (synthetic ultramarine, small and Prussian blue) are used. The presence of synthetic ultramarine in this work is possibly the earliest example of its use in Ethiopian church painting. The use of mixtures of the various blue pigments may suggest not only the use of pure pigments, but possibly also the use of laundry blues as a source of blue pigment. The discovery of the use of orpiment indicates that the painting is a finished work, but its deterioration, and that of other pigments and the cotton support, has drastically altered the appearance of the painting. With the knowledge of the pigments gained during this study it is possible to obtain a sense of the original appearance through digital reconstructions.

Understanding how the painting might originally have been displayed and determining the varying approaches to its past treatment and museum display were important in developing a conservation strategy and informing whether the painting should be approached as a tensioned painting or a painted cloth. The treatment that was adopted produced a successful marriage of paintings and textiles conservation techniques. Although the treatment has stabilized the flaking paint and increased the overall strength of the painting, the cotton substrate remains in a fragile state, and in poorer condition than many similarly constructed paintings centuries older.

CONCLUSIONS

EXPERIMENTAL APPENDIX

An Olympus BH-2 microscope was used for bright field and polarized light microscopy. FTIR spectra were acquired using a Nicolet Avatar 360 FTIR spectrometer and a Nicolet 6700 Series FTIR spectrometer with a Continuum infrared microscope (at the British Museum) or a Nicolet 5700 Series FTIR spectrometer with a NicPlan infrared microscope (at the National Gallery, London). The samples were placed between the windows of a Spectra-Tech micro-compression diamond cell. Spectra were acquired over a range of 4000–400 cm⁻¹ (or 4000–650 cm⁻¹ using the FTIR microscopes) using between 32 and 128 scans at a resolution of 4 cm⁻¹.

Raman spectroscopic analysis was conducted using a Dilor (Jobin Yvon LabRam) Infinity spectrometer (dispersion system) with green (532 nm) and near-infrared (785 nm) lasers. Spectra produced were identified by comparison with reference spectra in a British Museum in-house database.

For SEM-EDX, used to determine pigment particle morphology and elemental composition, paint fragments were mounted on an adhesive carbon stub and examined directly without further sample preparation (rather than being embedded and prepared as polished cross-sections). Samples were examined at 20 kV using a JEOL JSM 840 SEM equipped with an Oxford Instruments ISIS EDX analyser with a silicon-lithium detector (liquid nitrogen cooled). Imaging was carried out using a Centaurus scintillator backscattered electron detector. Some samples were additionally examined at 20 kV with a working distance of 12 mm using a Hitachi S4800 SEM equipped with an Oxford Instruments INCA EDX analyser with an X-act analytical Silicon Drift Detector. Imaging was carried out using a five-segment solid-state backscattered electron detector or a scintillator secondary electron detector.

The equipment and method used for false-colour infrared and infrared reflectance imaging were as described by Verri [62].

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MATERIALS AND SUPPLIERS

- Cella® 620 (glass fibre, epoxy laminate on aluminium honeycomb): www.technicalresinbonders.co.uk
- Kasenshi® Japanese polyester paper No. 12. Weight: 12g m⁻², 1080 mm x 100 m: Yoshida Co., Ltd, Japan. Email: wagamiya@topaz.ocn.ne.jp
- Stabilite® (now Tetex®) polyester crepeline: Plastok® Associates Ltd, www.plastok.co.uk

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STUDY AND CONSERVATION OF A MID-NINETEENTH-CENTURY ETHIOPIAN CHURCH PAINTING


NOTES

1. There are very few examples of varnishes reported for seventeenth- to nineteenth-century Ethiopian paintings, although Weis suggests that from the seventeenth century onwards aloe-containing vegetable lacquers were used as varnishes (and refers to two varnished sixteenth-century Italianate Ethiopian icons) [9]. Tournerie mentions the use of a range of organic materials as varnishes, including animal skin glue, egg yolk, wax and boiled Aloe spp. [12].


3. These risks included over-wetting, optical changes to the cloth and pigments, not delivering enough solution to the surface to decadify the substrate effectively and leave an alkaline reservoir [45, 46].

4. The term ‘lining’ is used here in its context as a paintings conservation term, meaning to attach a second supporting layer to the reverse of the original textile substrate. The equivalent term in textile conservation is ‘adhesive support’, a lining having a different meaning.