THE BRITISH MUSEUM

Technical Research Bulletin

VOLUME 6 2012

The Norwich shroud: conservation and investigation of a rare Eighteenth Dynasty shroud

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Summary One of the items in the Egyptian collection at Norwich Castle Museum and Art Gallery is a shroud fragment (1921.37.50), which was acquired in Egypt in February 1897 by Jeremiah Colman, the manufacturer of Colman's Mustard. It was donated to the Museum in a crumpled and fragile state in 1921 and until recently, its full size and the nature and significance of the hieroglyphic texts that cover its surface were not known. In a joint project between Norwich Castle Museum and the British Museum, the textile was unrolled, conserved and examined. The scientific investigations showed the textile to be of linen and to contain the remains of a dermestid beetle. The red and black inks employed were coloured with hematite and a mixture of carbon black and manganese oxides respectively. A small area of paint based on gypsum was also present in one of the spells. In addition, infrared and ultraviolet imaging and image processing were used to increase the legibility of the text, which consisted of spells from the Book of the Dead. The textile proved to be a rare, early Eighteenth Dynasty (*c*.1550 BC) shroud probably from the Theban necropolis. The shroud's owner was a lady called Ipu and further fragments of her shroud were found to exist in the Egyptian Museum, Cairo.

JEREMIAH COLMAN AND THE SHROUD IN NORWICH

In late 1896 Jeremiah Colman, a Liberal member of parliament for the city of Norwich and now best remembered as the manufacturer of Colman's Mustard, travelled to Egypt, see Figure 1. The purpose of his journey was to join his son Alan, who had left England for Egypt a few weeks earlier in November 1896 for health reasons. Alan Colman was accompanied by his sisters and his personal physician, Dr Worthington, while Jeremiah Colman brought with him the rest of his family. In Egypt, the Colmans hired a *dahabeah*, the *Hathor*, and sailed to Luxor, where Alan died five days later. The trip was thus cut short and the family, having made arrangements for Alan Colman's body to be returned to Norwich, headed back down the Nile and out of Egypt.

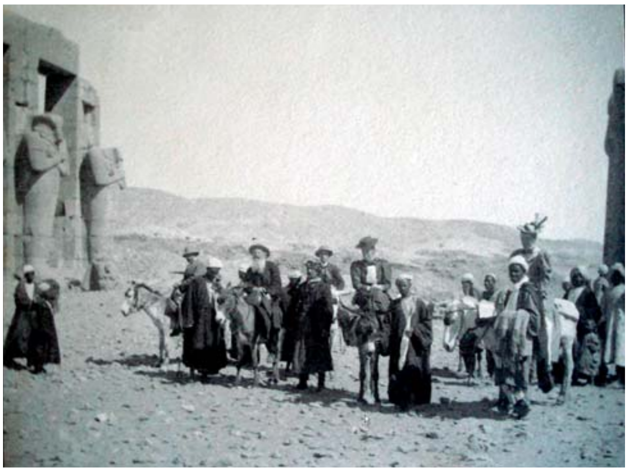

FIGURE 1. Jeremiah Colman with members of his family in Egypt in February 1897. Jeremiah is the bearded figure seated on a donkey to the left. Image: © The Ludham Archive

However, in the few days that Jeremiah Colman spent at Luxor, he acquired a collection of over 250 antiquities, including some exceptional pieces. At the end of the nineteenth century Luxor was awash with dealers eager to cater for such well-to-do travellers and Jeremiah would have been easy prey for some of the more unscrupulous sellers. Nevertheless, he managed to avoid the more disreputable vendors and instead dealt with the likes of Mohammed Mohassib, a prominent and generally well-regarded dealer at that time [1]. Jeremiah was guided in this judicious choice by Alan's physician, Dr Worthington [2; p. 3], who had a fair knowledge of the market in antiquities at Luxor through previous trips to Egypt, on each occasion accompanying invalids in his capacity as a doctor [3; pp. 134–135, 541, 575].

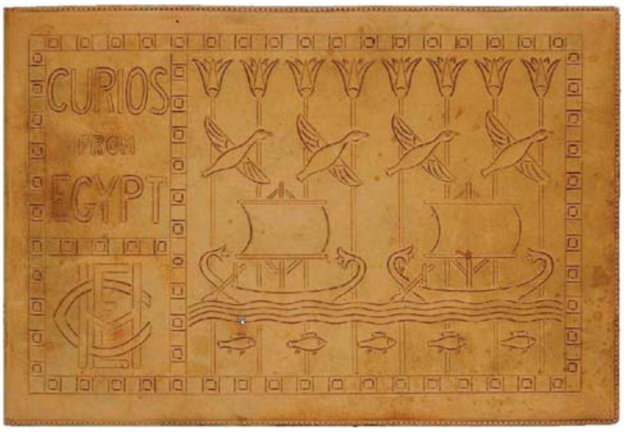

FIGURE 2. The leather-bound Colman Catalogue *Curios from Egypt* commissioned by the Colman family and written by James Edward Quibell. Note the intertwined initials 'HEC', standing for 'Helen and Ethel Colman', the sisters who donated their father's collection to Norwich Castle Museum. Image: © Norwich Castle Museum and Art Gallery

To Jeremiah Colman's credit, his limited knowledge of the collection that he had acquired in Egypt did not lead him to neglect it. After his return to Norwich, he – together with two of his daughters, Ethel and Helen, who had accompanied him to Egypt and who later inherited the shroud and donated it to Norwich Castle in 1921 – decided that the artefacts should be catalogued. The Egyptologist James Edward Quibell was invited to Carrow House, the Colmans' Norwich residence, to view the antiquities and to compile a catalogue, Figure 2.

Quibell was undoubtedly a good choice. He had been living and excavating in Egypt, initially alongside Sir Flinders Petrie, so he was well acquainted with many of the prominent archaeologists in Egypt at the time and had a good working knowledge of current archaeological activity in Egypt. He knew which sites were being excavated, what artefacts were surfacing and which dealers were handling some of the finds. Several of the entries written for the catalogue were clearly informed by this intimate knowledge; for example, of two fish amulets he wrote that "fish of this shape and size were found in March 1897 by M de Morgan" [2; p. 33].

Quibell also had the unique advantage of viewing Colman's collection very soon after it had been acquired and so would have had at his disposal any documentation that might have accompanied the sale of the artefacts. Equally valuable would have been his access to Dr Worthington and the Colman family, some of whom would have been able to provide Quibell with first-hand accounts relating to Jeremiah's extensive Egyptian purchases.

In spite of these advantages, it is disappointing to read Quibell's rather brief catalogue entry for the linen sheet that has recently been conserved and investigated in a joint project between the Norwich Castle Museum and the British Museum. The entry, lacking details such as provenance, date, place of purchase and dealer, reads "Linen sheet: covered with hieroglyphic inscriptions from the 'Book of the Dead'. The mummy in the coffin was often covered with a linen sheet of this kind" [2; p. 17]. There is nothing to suggest that the linen cloth may have been an exceptional piece or that it may have merited closer investigation; this contrasts with his remarks on several other artefacts, such as a scarab that he described as "rare and interesting" [2; p. 63], or two predynastic clay figures that he suggested "ought to be published" [2; p. 15]. Without doubt, Quibell's usually discerning eye had failed to grasp the significance of the shroud.

Having passed into the collections of Norwich Castle Museum from Jeremiah Colman's daughters, the textile remained unstudied for decades and it is only through the discoveries made during the recent joint project to open and study the linen shroud described here that the inadequacy of Quibell's catalogue entry became all too apparent.

CONSERVATION OF THE SHROUD

The shroud before opening

For many years, and on its arrival at the British Museum in January 2011, the shroud existed as a bundle of folded plain weave, beige-coloured linen cloth measuring 28.5 × 16 × 3.5 cm, Figure 3. There were many layers of cloth and the full size of the textile could initially only be estimated as possibly in excess of 1 × 2 m. Hieroglyphic texts were visible on all the exposed surfaces, predominantly in black with a few characters in red, but the underside of the cloth was uppermost, so that the texts were seen penetrating through the fabric making them difficult to read.

No records existed to indicate whether the textile had been opened while in the private collection of the Colman family, but the presence of an anomalous cotton thread of modern appearance, probably from the nineteenth or twentieth century, protruding from inside the bundle, suggested that the shroud had not been folded this way in antiquity.

Prior to the recent conservation treatment, the perceived poor condition of the shroud and its apparent fragility had prevented any thorough investigation of the bundle. The textile was indeed damaged and fragmentary, with frayed threads and tangled, twisted sections of the textile making it difficult to separate and open out the layers without the help of a conservator. However, although there were many splits and tears, sizeable sections of the weave appeared relatively intact.

The textile had a yellow-brown colour typical of aged linen discoloured by cellulose degradation products and had a surface pH of 4, both of which indicated the deteriorated condition of the fibres. Although soft and flexible, the individual fibres had little mechanical strength and examination under the microscope showed that in many areas they were fractured and broken with soft, fibrous ends, resulting in the numerous splits and tears.

FIGURE 3. The Norwich shroud (1921.37.50) in its folded state prior to conservation treatment. Image: © Norwich Castle Museum and Art Gallery and Trustees of the British Museum

Opening the shroud

The initial examination indicated that the opening of the textile without undue damage was feasible.

To facilitate the safe opening of the shroud, a large humidification chamber was constructed from polythene sheeting and plastic drainpipe, inside which the conservation team would work. Such a large humidification tent was required as the aim was to keep the textile at a raised relative humidity (RH) throughout the process of opening. The RH inside the tent was increased to between 65 and 70% and the bundle was placed inside the tent for 24 hours before treatment in order to increase the moisture content of the fibres and make them more flexible prior to the process of opening and reshaping.

Because the shroud had been pleated several times in one direction and folded in half in the other direction before being rolled, the unfolding was carried out in stages, see Figure 4. Close monitoring from all angles was necessary during this process to ensure that loose fragments did not snag on each other. As the size of the textile increased on unwrapping, it became harder to manipulate, so spatulas and hands were used at first to support the textile, followed by slips of Melinex polyester film. Particularly weak areas were supported by sandwiching them top and bottom between sheets of Melinex as they were lifted and turned. A tube of Melinex film was used to unfold the largest part of the textile, and finally to open the shroud.

FIGURE 4. Unfolding the shroud within the humidified enclosure using Melinex film to support the fragile textile. Images: © Norwich Castle Museum and Art Gallery and Trustees of the British Museum

FIGURE 5. The shroud after partial opening, prior to humidification to reduce the creasing and distortion and the realignment of the weave and fibres. Image: © Norwich Castle Museum and Art Gallery and Trustees of the British Museum

After the shroud was opened it was clear that although there were many splits and areas of loss throughout the textile, it was entirely connected together – although only by a single thread in places. It remained, however, distorted with overall creasing, strong pleated folds (particularly at the centre) and sections tightly twisted together in bunches so that much of the inscription was still obscured, see Figure 5. The fibres were generally flexible and pliable enough to withstand the process of opening and flattening, but they were very weak and degraded and it was clear that anything more than minimal handling might cause the threads and weave structure to disintegrate.

Apart from the natural colour change through ageing, the textile was remarkably bright and fresh looking, with no significant soiling; only fibres and fibre dust from the textile itself were deposited on the surface. There was no evidence of staining consistent with direct contact with a body. The modern cotton thread seen from the outside of the bundle was found to be lying loosely along the left-hand edge and seems most likely to be present merely by chance, although it may have been used as a means of tying together this fragmentary section.

Treatment and mounting

Further treatment was required to untwist and flatten the shroud to facilitate study of the texts. Over the course of three weeks in the 65% RH environment created inside the humidity chamber the shroud continued to relax. In addition, cold water vapour was applied locally using an ultrasonic humidifier to help open out twisted sections. Working from the centre of the shroud, creases and folds were eased out by hand and held in place using light Perspex or acid-free card weights or fine entomological pins. The textile readily became flat and fully open with the creases only minimally retained by the fabric, partly because of the softness of the fibres.

It is intended that the shroud should be kept fully opened when it is in the stores at the Norwich Castle Museum, to allow for study and to avoid the need to remount the textile for future display. However, its size and fragility meant that some stabilization would be needed and that a support would be required. Accordingly, the shroud was attached to a fabric-covered rigid support board made from Tycore™ by the application of a nylon net overlay, stitched to hold the fragmentary textile securely in place.

The transfer of the large and highly fragmentary shroud onto the prepared support board was a challenge, and was achieved by sandwiching the textile between rigid support boards of matching size, first to turn it over and then to manoeuvre it into its final position. A fine 20-denier nylon net, dyed light beige using synthetic Lanaset direct dyes, was positioned over the shroud, extending over the edges of the support board, then tensioned and pinned in place. Final realignment of individual threads of the shroud could then be carried out using tweezers to reposition them through the holes in the net. The three layers – the cotton covering

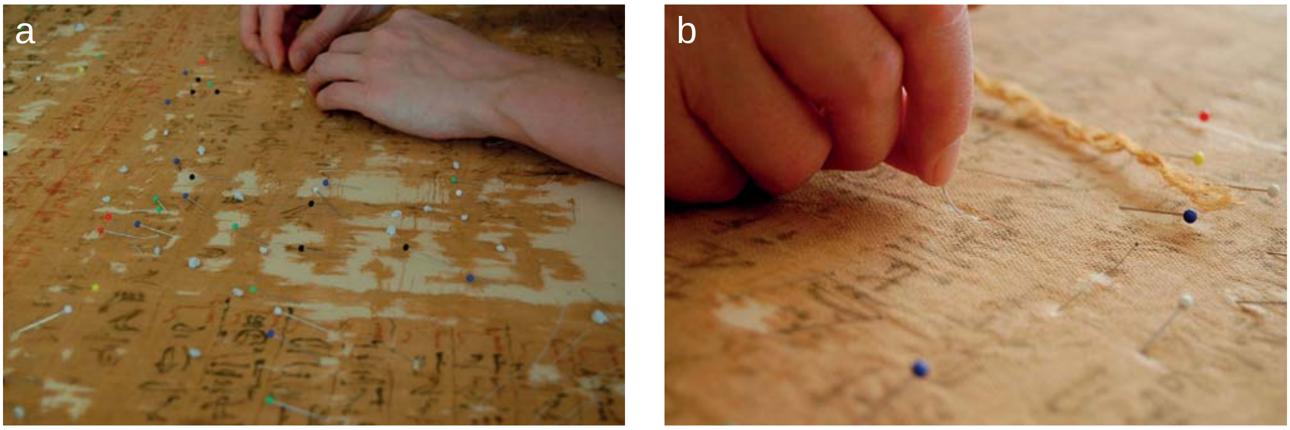

FIGURE 6. Securing the net overlay, showing: (a) the net tensioned and pinned in place over the shroud; and (b) using a curved needle and a 44-denier silk filament thread to attach the net to the mount board, placing the stitches around the fragments wherever possible. Images: © Norwich Castle Museum and Art Gallery and Trustees of the British Museum

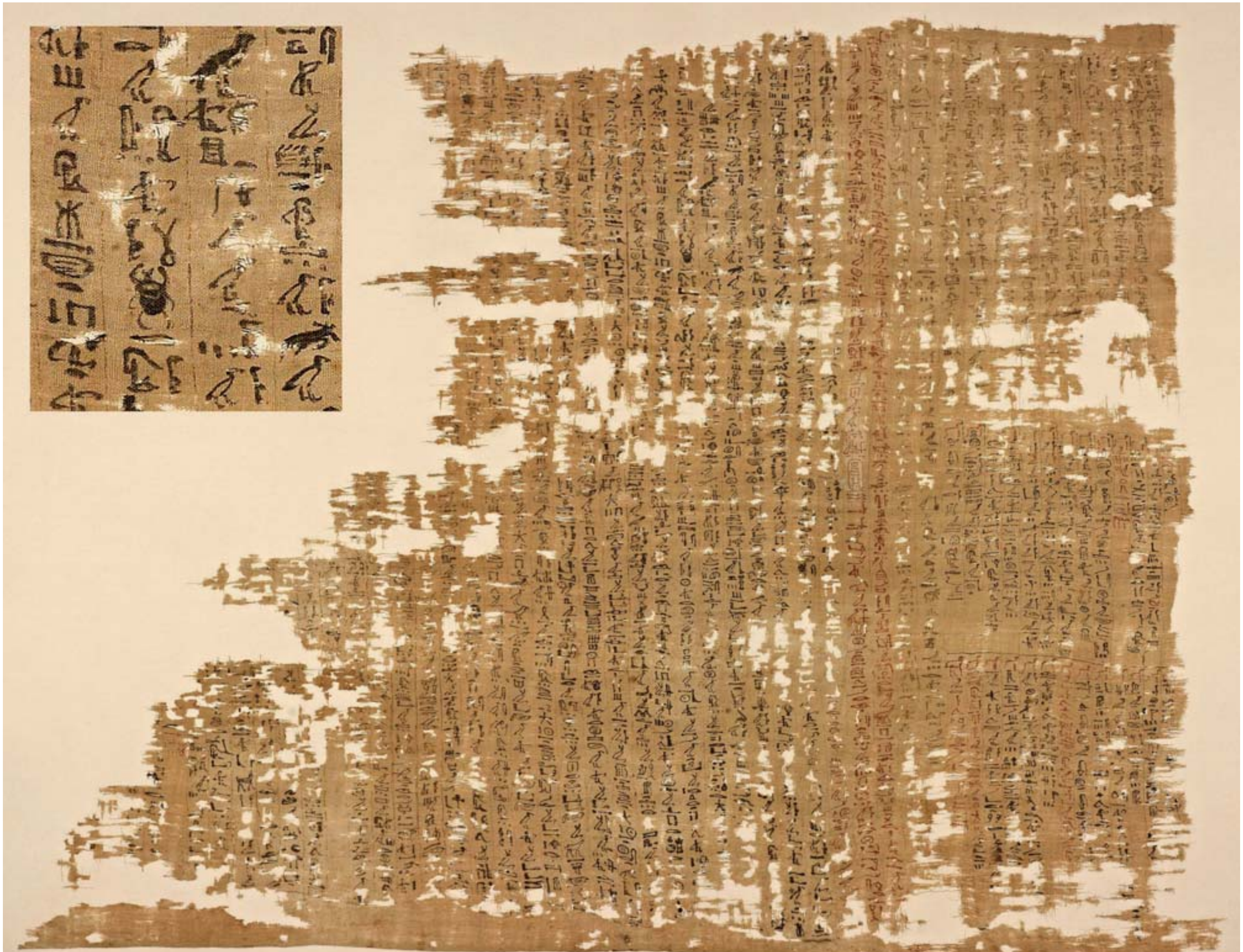

FIGURE 7. The shroud after conservation, secured to a fabric-covered board. The inset illustrates a detail of the text and shows that the nylon net overlay is virtually invisible. Images: © Norwich Castle Museum and Art Gallery and Trustees of the British Museum

on the support board, the shroud and the net overlay – were stitched together using a 44-denier silk filament thread. This slightly thicker silk thread (often 20- or 24-denier is used) was chosen to provide enough strength to hold the shroud on the board in the case of vertical display. Curved needles were used to execute a running stitch, with stitches 3–4 mm in length, anchoring the net and shroud to the support below, see Figure 6.

As it had been possible to flatten the textile so successfully, and because of the numerous holes in the shroud, the

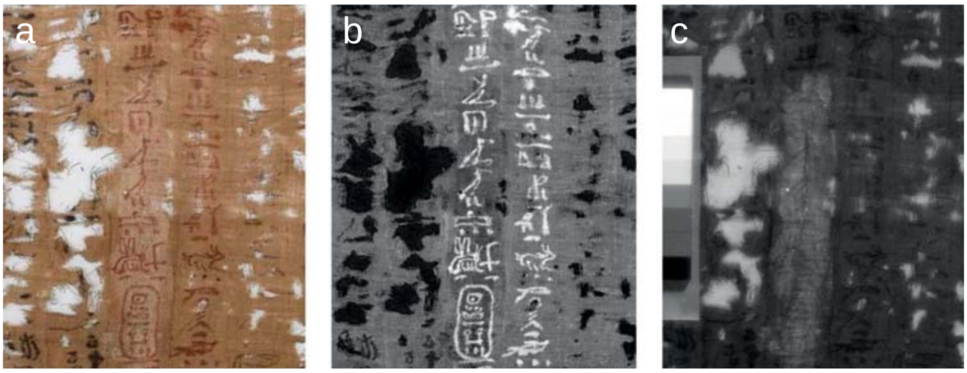

FIGURE 8. The area of the shroud containing the cartouche of Menkaure imaged and visualized using different techniques: (a) in visible light; (b) after image processing to emphasize the red text; and (c) in the UV-reflected image, which highlights the area of white paint. Images: © Norwich Castle Museum and Art Gallery and Trustees of the British Museum

relatively open weave structure and the absence of brittle areas, this mounting system was felt to be the most suitable treatment. It strengthened the shroud, preventing any further damage and at the same time provided a good means of handling, storing and displaying the shroud in future. One of the strongest advantages of this sandwich technique is that stitching worked through the object was kept to a minimum, with most stitching in areas of loss and around the edges. This makes it a potentially less damaging and more easily reversible treatment, as well as less time-consuming to execute. The result is that it is virtually impossible to see the stitching or net overlay when the shroud is viewed from usual gallery distance, yet the fragmentary textile is well supported and the texts are clearly visible, Figure 7. High-quality images of all the texts and the front and back of the textile were made before the application of the net.

The shroud after opening

Once opened, a thorough examination of the shroud could be carried out. Unfolded, the shroud is roughly square, measuring approximately 130 × 160 cm. The textile was woven in a regular plain weave, with an average thread count of 20 warp and 10 weft ends per centimetre; both the warp and weft are S-twist flax thread. The shroud is clearly incomplete, with a finished selvedge on one side only (viewed as the lower edge) and ragged fragmentary edges, where the inscriptions are broken off midway, to the left and top. The left side is most degraded and fragmentary with large sections clearly missing.

The entire surface is covered by columns of hieroglyphs that run vertically when the selvedge forms the bottom edge. They are written mainly in black ink with certain sections in red ink, including a striking two-and-half columns just off-centre and other smaller sections elsewhere. Within one of the columns of red text there is a section to which white pigment had been applied, although it is difficult to tell if this was underneath or over the red ink. The purpose of the white pigment seemed to be to draw attention to this section as, contained within the area highlighted in this way is a small cartouche – an oval enclosing the hieroglyphs which constitute a royal name, see Figure 8a.

There is a series of seven small circular holes more or less evenly distributed along the selvedge, about 15 cm apart. The shape, regularity and position of these holes may be evidence of a past event, such as hanging or stretching out of the textile. There were no traces of metal oxidation around the holes to indicate the use of metal pins, which can be found when textiles have been hung with nails or drawing pins. The function of these holes is difficult to interpret and they may indeed date from antiquity.

At the upper right edge of the textile fragment the warp threads all end uniformly along the same line, suggesting that they had been deliberately torn or cut here. This straight edge does not extend across the entire cloth, making it unlikely that it is the original edge of the shroud. It was not possible to determine whether this cut or tear had occurred in antiquity or later.

SCIENTIFIC INVESTIGATIONS

Once the shroud had been unfolded it became possible to apply a range of scientific techniques to its study [4]. These included technical imaging, to clarify the written texts and to provide information about materials, and variable pressure scanning electron microscopy (VP-SEM) with energy dispersive X-ray analysis (EDX) and Raman spectroscopy to investigate the nature of the fibres and pigments present.

Imaging

A number of imaging methods were used, selected to provide information on different aspects of the shroud and its inscriptions:

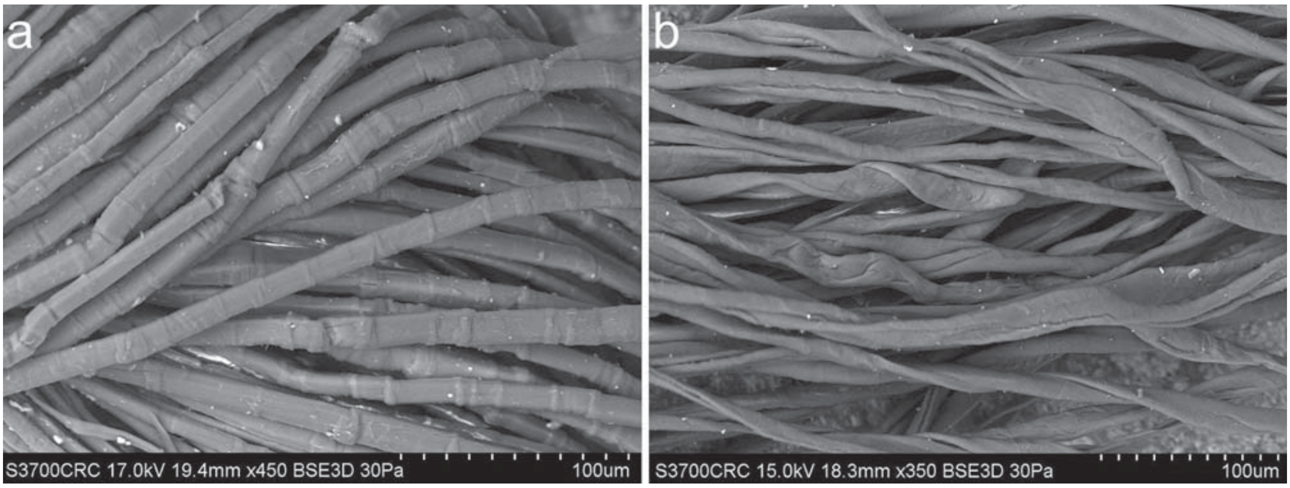

FIGURE 9. VP-SEM micrographs showing: (a) the flax fibres of the shroud, *Linum usitatissimum*, identified by their key characteristic features (dislocations, swellings, cross-markings and longitudinal striations); and (b) the intrusive thread found folded into the shroud, identified as cotton (*Gossypium* sp.) on the basis of key features (smooth, ribbon-like, twisted fibres with longitudinal and spiral striations). Images: © Norwich Castle Museum and Art Gallery and Trustees of the British Museum

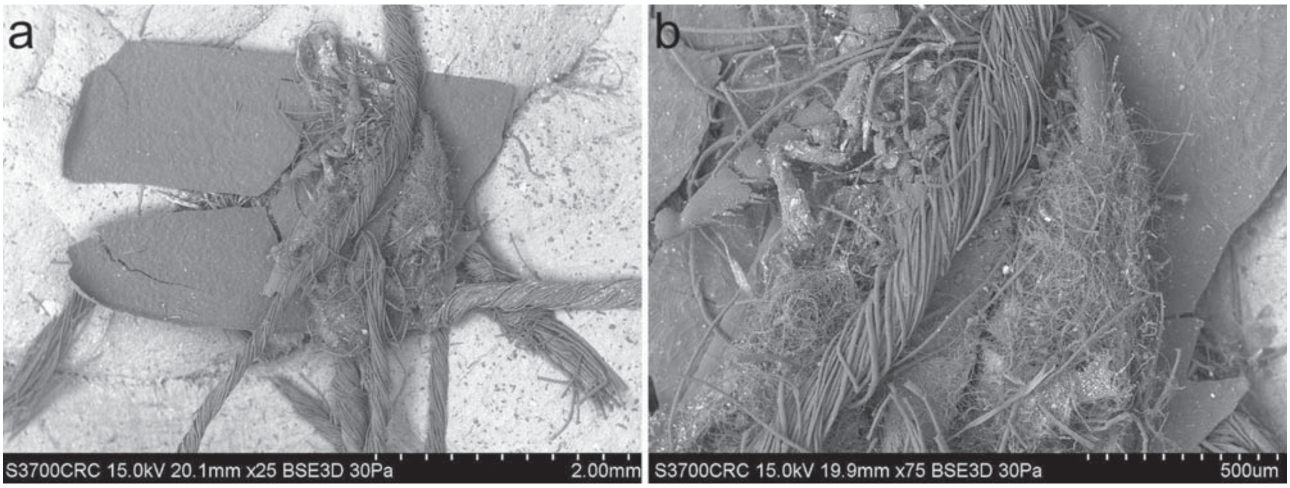

FIGURE 10. VP-SEM micrographs showing: (a) the fragmented remains of a dermestid beetle (*Dermestes frischii*) found in the fibres of the shroud; and (b) an area of the shroud fibres that the beetle has partially consumed and reworked into a 'nest' (one of the legs of the beetle can also be seen in the upper left of the image). Images: © Norwich Castle Museum and Art Gallery and Trustees of the British Museum

- *Infrared reflectography (IRR)*: IRR is most frequently used in museum contexts to reveal hidden features or preliminary drawings beneath painted surfaces [5]. However since carbon-based materials are particularly opaque to infrared radiation and carbon is by far the most common black pigment in ancient Egyptian art, it was anticipated that IRR investigation (as described in the experimental appendix) would clarify the black inscription on the shroud. No hidden text was revealed by this technique, but the contrast between the black ink used for the majority of the hieroglyphs and the linen substrate was enhanced, making the text more readable. This is because the ink absorbs infrared radiation nearly as strongly as it absorbs visible light, while the linen (even in the areas where it is stained and discoloured) absorbs infrared radiation less strongly than in the visible region.
- *Image processing*: Although the black text showed strongly in the IR reflectogram, there was poor differentiation between the red text and the background. Clearer images of the red text were produced by image processing using the method described in the experimental appendix, which greatly improved readability, as seen in Figure 8b.
- *Ultraviolet (UV)-induced luminescence imaging*: UV-induced luminescence imaging was used to investigate the distribution of luminescent materials on the shroud. Luminescent compounds typically include many modern conservation materials and a number of organic substances used in antiquity [6]. Strong luminescence from the underlying modern board on which the shroud was supported during imaging made the image difficult to interpret, but detailed examination revealed no evidence of any luminescence from the shroud itself. This suggests that not only were no luminescent pigments used in the original text, but that the shroud is – as expected – unlikely to have been subject to any modern conservation treatments since it came into the collections of Norwich Castle Museum.

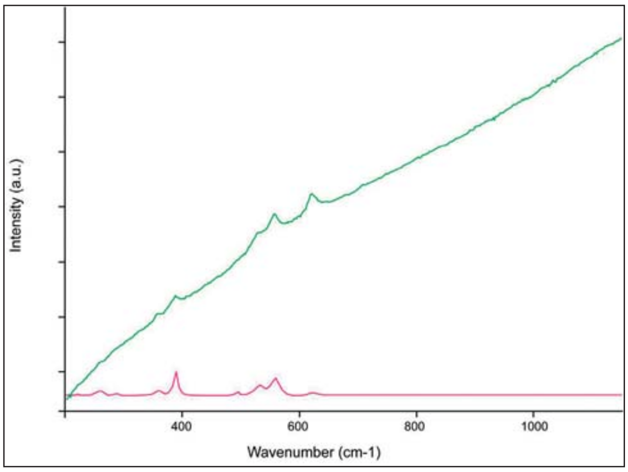

FIGURE 11. Raman spectrum from a sample of black ink (green trace) with a reference spectrum for manganite (pink trace). Exciting wavelength 532 nm, power 0.25 mW

- *UV-reflected imaging*: UV-reflected imaging generally provides information about materials present in the upper layers of an object [7]. For this reason UV-reflected images were collected of the area of white paint around the cartouche, Figure 8c. The resultant image clarified the distribution of the white pigment, showing it to be crudely applied, probably using a wide brush and over the red ink of the text.

Fibre and insect identification

A number of tiny fibre samples were taken from different areas of the shroud. These included the shroud fabric itself, a small area that was found during conservation to contain the remains of a beetle and the apparently intrusive thread described above. VP-SEM examination of the fibres of the shroud showed that it was linen, consisting solely of flax fibres (*Linum usitatissimum*), Figure 9a. The intrusive thread was identified in the VP-SEM as modern cotton, *Gossypium sp*, Figure 9b.

The fragmented remains of a skin beetle found amongst the fibres of the shroud (Figure 10a) were identified as a scavenger species, *Dermestes frischii*, which can feed off many different types of hosts including skin, fibres, dried human, animal and vegetable matter, wood and stored products. This dermestid beetle had partially consumed and reworked some of the flax fibres into a 'nest', Figure 10b. It was not possible to determine the date of this insect, which could have entered the shroud fabric at any time since its production.

Pigment identification

Tiny samples of the two inks used to produce the texts and of the white pigment on and around the cartouche were collected and investigated using SEM-EDX and Raman spectroscopy, described in detail in the experimental appendix.

SEM-EDX examination of the red ink showed it to be iron-based and Raman spectroscopy of the same material proved the colourant present to be hematite (Fe_2O_3). Hematite, in the form of either iron oxide or red ochre, is by far the most common red pigment found in Dynastic Egypt [8]. Here quartz and other minerals were also present, suggesting red ochre as the most likely source.

SEM examination of samples from areas of black ink produced backscattered images that showed bright white grains lying on top of the threads, together with some smaller and darker particles. The brightness of backscattered images is related to the atomic weight of the material under examination. These images therefore demonstrated the presence in the pigmented areas of elements heavier than those of the shroud fibres, an unexpected result as most Egyptian black inks are carbon-based [8]. SEM-EDX analysis of the bright particles indicated the presence of manganese, together with a mixed suite of elements (calcium, silicon, aluminium, potassium, iron and magnesium) that are commonly associated with soil or sand.

Raman examination of the same areas suggested the presence of two black materials. The first gave spectra that matched reference material for amorphous carbon, suggesting the use of either soot (carbon black) or crushed charcoal (the absence of phosphate indicates that the carbon is not derived from burning bone or ivory to give 'bone black'). The second produced spectra (Figure 11) that were a close match to published reference spectra for manganite ($MnO(OH)$ [9]), a mineral that is known to occur in Egypt [10]. The black ink would therefore seem to be a mixture of amorphous carbon and a manganese-based compound. These findings are somewhat unexpected. Amorphous carbon is without doubt the most common black pigment in Egyptian art [8] and its presence in the black ink on the shroud is unsurprising. The discovery of the additional presence of a manganese-based material is far more unusual. Spurrell reported the use of manganese blacks in a Middle Kingdom site at Beni Hasan [11], but this has not been confirmed by modern analytical techniques. Middleton found manganese-based compounds used as black pigment in a series of painted reliefs from the late Twelfth Dynasty tomb of Djehutyhotep at El-Bersheh [12], but there seem to be no reports of the use of the material in a New Kingdom context. However shrouds such as this are rare and this lack of data may reflect the infrequent analysis of such items.

Raman analysis of the white pigment found in the cartouche showed it to be gypsum ($CaSO_4 \cdot 2H_2O$). This material is known to have been in common use as a white pigment in Dynastic Egypt [8]. While the sample that could be taken from the shroud was too limited to give an accurate range of particle sizes, the white pigment was noticeably more coarsely ground than either the black or red. For that reason, and because of the manner of its application to the textile, it seems more appropriate to term this material a paint rather than an ink.

SEM imaging and optical microscopy showed all three pigments used to have been applied directly onto the unprepared textile surface, but it was not possible to remove enough of any of the coloured materials to allow analytical study of the binding media.

THE INSCRIPTIONS ON THE SHROUD

The entire front surface of the shroud is occupied by inscriptions in vertical columns defined by narrow lines of black ink; these columns vary in width from about 2.5 to 3.5 cm. The columns on the left and in the centre of the shroud occupy the full height of the textile, but at the right side the field is subdivided by horizontal lines to form three blocks of shorter columns, positioned one above the other.

The inscriptions within the columns are written in a cursive hieroglyphic script. Most of the texts are in black ink but, as mentioned above, for two-and-a-half columns located roughly in the centre of the textile red ink was employed. It was also used for selected words and phrases in other places and, at the far right, for a hieroglyphic group reading 'recitation', which is repeated at the heads of all the columns of the middle and lower registers. The style of handwriting is uniform throughout, suggesting that only one scribe worked on the shroud.

The texts consist of extracts from the large collection that the ancient Egyptians called 'Spells for Coming Forth by Day', which is today known as the 'Book of the Dead'. This body of magical recitations, designed to aid the dead person in attaining eternal life, developed from the Coffin Texts of the Middle Kingdom and first came into use in the early part of the Second Intermediate Period (*c.*1700 BC). The earliest examples of the Book of the Dead have been identified on wooden coffins of royal persons buried at Thebes – Queen Mentuhotep and Prince Herunefer [13, 14]. In the late Seventeenth and early Eighteenth Dynasty (late sixteenth century and early to middle fifteenth century BC) passages from the Book of the Dead were written on linen mummy shrouds, sometimes accompanied by illustrations (vignettes). The practice of writing the texts on linen fell out of use in the reign of Amenhotep II (*c.*1425–1400 BC), by which time it had become customary to inscribe the spells on rolls of papyrus [15].

The palaeography of the inscriptions and the wording of the Book of the Dead spells on the Norwich shroud are consistent with a dating to the early decades of the Eighteenth Dynasty (*c.*1550–1500 BC). The texts on the shroud are to be read from left to right; this is contrary to the usual right–left orientation of Egyptian handwritten texts but it is characteristic of Book of the Dead manuscripts, in which not only is the direction of reading reversed but the hieroglyphic signs themselves are also oriented so as to face the end rather than the beginning of the text ('retrograde' script). These peculiarities perhaps served to emphasize the special, sacred character of the texts, but the use of retrograde writing may also be a result of scribal copying from papyri in hieratic script, in which the signs always face right [16].

The ragged left edge of the shroud preserves only small parts of Book of the Dead spells 39 and 65, which are followed by spells 116 and 91 (the identification of these incomplete texts has been confirmed by comparison with the other fragments of the shroud mentioned below). To the right of these come spells 64 and 30B. The final (right-hand) section of the cloth, subdivided into three registers, contains, at the top, spell 100 and the first part of spell 149, while the middle and lower sections contain spell 136B. The modern numbering of the spells derives from a relatively late redaction of the Book of the Dead; in early examples such as the Norwich shroud the spells do not appear in a fixed sequence.

The spells follow one another without any clear marks of separation. Spell 64, however, ends with a conspicuous rubric in red ink, extending over parts of three columns and containing a prominently written royal cartouche, Figure 8a. This rubric is a standard formula, describing the mythical discovery of the spell, which allegedly occurred during the reign of King Menkaure (Mycerinus), the builder of the Third Pyramid at Giza. Since there is no contemporary evidence for the existence of Book of the Dead spells at so early a date (*c.*2525 BC) the account is generally understood to be a later tradition, invented to lend authority to this important text by associating it with one of the great rulers of Egypt's distant past.

THE OWNER OF THE SHROUD AND RELATED FRAGMENTS

At several places within the surviving texts the name of the original owner is legible: 'Ipu, daughter of the Lady of the House Mutresti'. Both names are characteristic of the late Seventeenth and early Eighteenth Dynasty, and an Ipu with a mother of the same name is known from three fragments of an inscribed linen mummy shroud now in the Cairo Museum, Inventory JE 96807 [17; Textband pp. 13–18, Tafel 5; Tafelband Tafeln 11–14]. These fragments bear spells from the Book of the Dead written in a similar hand and style to those of the Norwich fragment. Although the Cairo pieces are themselves damaged and incomplete, the spells inscribed on them can be identified as, from left to right, numbers 124, 83, 84, 85, 82, 77, 86, 99B, 119, 7, 102, 38A, 27, 14, 39, 65, 116, 91, 64 and 30B. The last six of these spells are of particular interest in determining the connection between the Cairo and Norwich pieces, since where the torn edge of the Cairo pieces contains only the beginnings of columns the corresponding edge of the Norwich piece supplies the missing words, leaving no doubt that they are parts of a single textile. The combined dimensions of the adjoining pieces in Cairo are 274 × 138 cm, which is compatible with the measurements of the Norwich fragment, and two of the Cairo pieces include a selvedge that evidently represents the original upper border of the fabric.

The linen itself has been stabilized and brought to exhibition standards in a format that is more easily accessible for display or study and also suitable for future long-term storage. The shroud has, indeed, yielded far more than Quibell's catalogue entry might ever have suggested.

EXPERIMENTAL APPENDIX

Imaging

UV-reflected images were taken using a Canon 40D camera body modified by removing the inbuilt blocking filter in order to exploit the full sensitivity of the CMOS sensor (*c*.300–1000 nm). The lens was a Canon EF 50mm f/1.8II. Illumination was provided by two sets of four Philips PL-S 9W fluorescent lamps positioned symmetrically at *c*.45° to the focal axis of the camera. The lamps were fitted with Schott DUG11 interference filters that block visible and infrared (IR) radiation and transmit principally in the range 280–400 nm. A second Schott DUG11 filter placed in front of the lens allowed UV radiation to reach the sensor while blocking all stray IR and visible radiation.

To record UV-induced visible luminescence images the camera and illumination source were the same as those used for UV-reflected imaging. Schott KV418 and IDAS-UIBAR filters were placed in front of the lens. This combination blocks all UV and IR radiation, allowing only light in the visible range (400–700 nm) to enter the camera.

Infrared reflectography (IRR) was carried out using an OSIRIS infrared camera based on an InGaAs sensor that is sensitive to radiation in the range *c*.800–1700 nm [5]. The shroud was illuminated with two standard tungsten photographic lamps positioned at *c*.45° to the focal axis of the camera.

Uncalibrated visible images made with a Canon 40D camera were image processed to enhance the red text using the image processing package VIPS/nip [24]. The raw (RGB) images were converted into the CIE L*a*b* colour space (where L* is a metric for lightness, a* represents a red–green opponent scale and b* a yellow–blue opponent scale). The a* channel was extracted and negative (green) values were 'clipped' to zero. The resulting monochrome image was scaled to produce an image that represents the 'redness' of the object, so that regions that were painted with red pigment appeared light and the remaining areas appeared darker.

Scanning electron microscopy with energy dispersive X-ray analysis (SEM-EDX)

Scanning electron microscopy (SEM) was carried out using a Hitachi S-3700N Variable Pressure SEM. Samples were mounted, uncoated, on adhesive carbon pads. The fibres and beetle remains were identified in backscattered mode with an accelerating voltage of 15 kV and a chamber pressure of 30 Pa. The partitioned segment mode was set at BSE3D to accentuate diagnostic features. Reference collection specimens were used for comparison.

Pigments were analysed using an accelerating voltage of 20 kV and a chamber pressure of 30 Pa. Areas for analysis were selected from images acquired in backscattered mode. The EDX compositional data were obtained using an Oxford Instruments INCA EDX microanalysis system with an INCAx-act Silicon Drift Detector.

Raman spectroscopy

Pigmented areas on small fibre samples were analysed using a Dilor Infinity Raman spectrometer with green (532 nm) and near infrared (785 nm) lasers at a maximum power of 4 mW at the surface with a spot size of a few microns. Spectra were collected for total times between 2 and 20 minutes.

ACKNOWLEDGEMENTS

The support of the British Museum's 'Partnership UK' programme, and in particular of Maria Bojanowska, is gratefully acknowledged, without which the project would not have been possible. The project team would also like to thank Robin Mallett for confirming the skin beetle as *Dermestes frischii*.

PROJECT TEAM

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British Museum: Janet Ambers, Caroline Cartwright, Emma Passmore, Melina Plottu, Monique Pullan, Nicole Rode, David Saunders and John Taylor.

MATERIALS AND SUPPLIERS

- Nylon net: Dukeries Textiles and Fancy Goods Ltd., 15a Melbourne Road, West Bridgford, Nottingham, Nottinghamshire NG2 5DJ, UK.
- Cotton calico: Wolfin Textiles Ltd., Unit 4, Phoenix Works, Cornwall Road, Pinner HA5 4UH, UK.
- Tycore board: Preservation Equipment Ltd., Vinces Road, Diss, Norfolk IP22 4HQ, UK.

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