

THE BRITISH MUSEUM

Technical Research Bulletin



Establishing best practice in asbestos removal: the management of unique Medieval floor tile assemblages

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Summary This paper outlines a proactive response by the British Museum to tackle a hazardous substance rather than leave it for a future generation to resolve. A total of 15 tile pavements and panels was removed from the former Medieval tile and pottery room (gallery 43), of which nine had been backed with 'Asbestolux' board, an insulation material that contains between 25 and 40% asbestos. These have been decontaminated, with three pavements and three smaller sections having been remounted for display in the new Medieval gallery. All nine are historically very important and unique artefacts, part of a collection of national and international importance; those chosen for redisplay exemplify different aspects and techniques of tile production and design. The technical challenges of 'remote-control' conservation through the walls of a protective tent are explored, including the training and monitoring of specialist contractors in conservation skills, while ensuring the safety of the staff. It gives a warning to others of the hazards of past practices, and sets out to show the Museum's solution to the problem.

INTRODUCTION

The new Medieval gallery, that opened in spring 2009, presented an opportunity to redisplay some of the Medieval tile pavements as part of an integrated and themed gallery on Medieval Europe, AD 1050–1500. The British Museum holds the best collection of Medieval glazed and decorated earthenware tile pavements in Britain. These reflect the superb artistic innovation of early craftsmen from the twelfth century, and the decorative treatment with their layers of meaning that continued to evolve until the sixteenth century [1]. These pavements provided a practical, hard wearing and agreeable surface on which to walk. The plain glazed mosaic pavements adopted by the monks in northern England and southern Scotland were probably introduced from Cistercian houses in France or Germany where comparable floors were laid [2]. A very different tradition of tile-making was introduced into southern England in the second quarter of the thirteenth century. These circular pavements with inlaid designs were commissioned by Henry III for his chapel at Clarendon Palace, Wiltshire. Initially under royal patronage, the inlaid tiles with decorative motifs established a new fashion that then spread throughout southern England (in, for example, Muchelney Abbey and Salisbury Cathedral) and beyond [3]. Later tiles with inlaid designs were adopted by a few pros-

perous merchants [1; pp. 239–240 and Figure VII (vol. 1), 4, 5] and feature in courtiers' houses as at Acton Court, near Bristol [6; p. 295 and Figure 159] and once discarded these tiles were resistant to decay and so represent an archive of material culture that displays both pagan and Christian iconography, preserved for modern scholarship.

WHAT CAN TILES TELL US ABOUT A BUILDING?

Medieval paving tiles are historical documents that make it possible to engage with the cartoonists behind their designs. The luxury tiles of Chertsey Abbey, with rare figural depictions dating to the second half of the thirteenth century, set out Arthurian legends including that of the popular romance of Tristram and Isolde [7, 8]. Some of the tile borders included representations of evil, embodied as human-headed grotesques. The later wall panel tiles depicting an archbishop, queen and king may have been designed for display in niches in an ecclesiastical setting, while the earlier floor tiles are believed to have been destined for a secular royal setting, either upstream at Windsor Castle or more probably downstream at the Palace of Westminster [9].

In a royal setting these Medieval paving tiles helped to convey power and also communicated educational stories or romances. The pavements are 'signifiers of space' [10], and give an insight into the wealth of decoration in the private apartments of the king and queen at Clarendon Palace, a favoured hunting lodge [11–13]. The inlaid designs may have been copied from pattern books, bestiaries or fine textiles, and the alphabetic tiles also suggest that the inner circle of the court was literate.

North Yorkshire pavements: Byland and Rievaulx abbeys

In an ecclesiastical setting these Medieval paving tiles helped create a simple and contemplative environment, to aid meditation, prayers and rituals in the monk's daily life (liturgical function). This type of tiling was popular in Cistercian monasteries in Yorkshire in the thirteenth century, as seen in the plain glazed mosaic pavements at the abbeys of Byland and Rievaulx [14, 15]. These tile mosaics use the combination of different tile shapes with alternating colours to bring out the geometry of the design. The type is thought to have developed in north west Europe in imitation of coloured Italian stone mosaic floors, and the mosaic segments were probably made and laid out by monastic tilers. The architectural stonework inside the monastery church at Byland was rebated to

take the tiles, suggesting that the mosaic pavements were intended as an integral part of the interior design. The pavement seen in Figure 1 was part of a large panel containing a circular pattern, which had been reassembled from loose tiles found at Byland Abbey. This arrangement can still be seen in the north chapel of the south transept at Byland Abbey, although the glaze is now very worn.

In the later Middle Ages initials, rebuses and insignia could convey the individuality and power of a local abbot, as at Hailes Abbey [16; p.11 and Figure 8], or the symbolic meaning of the Passion (as illustrated at Great Malvern Priory), reminding people about their beliefs. The iconographic dating of these tiles helps to document the history of the building and to indicate when refurbishment took place [6; p. 363 and Figure 242]. At the level of the parish, tiles provide an insight into local communities, for example, the detailed designs in relief and counter-relief of the leper hospital pavement found *in situ* at Burton Lazars, the largest leper hospital in the country. It originally formed part of the Order of St Lazarus of Jerusalem and was subjected to Augustinian rule. From the mid-thirteenth century the master of Burton Lazars also became the master of the Order in England. Some of the designs include heraldry that links to dynastic families, but also to a merchant who may have been a patron of the hospital [1; pp. 117–118 and Figure III (vol. 1), 16; p. 26 and Figure 29].



FIGURE 1. Plain mosaic pavement from the site of Byland Abbey, North Yorkshire, reassembled from loose tiles, formerly on display in the Medieval tile and pottery room: 1947,0505.6339–6722

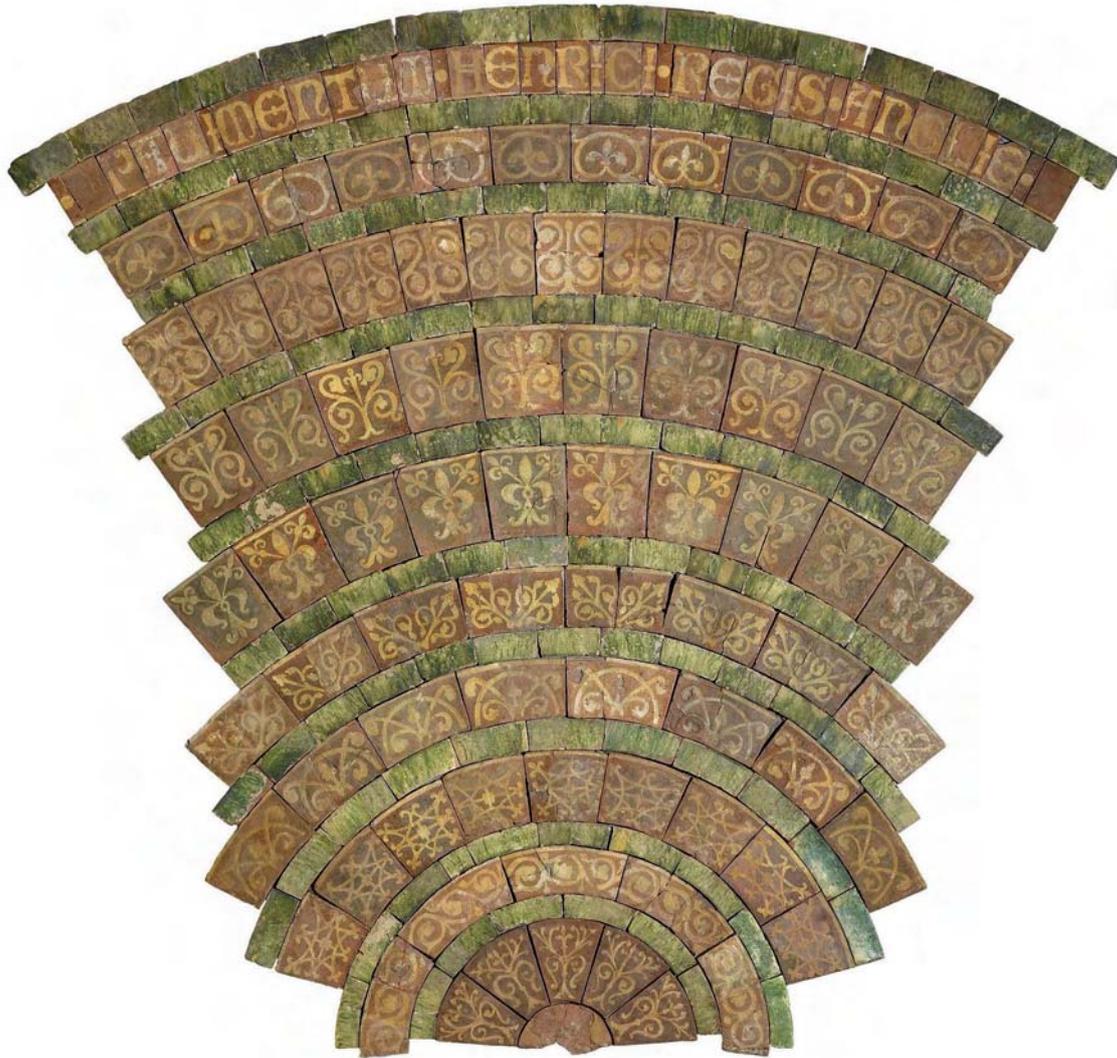


FIGURE 2. Reconstructed circular tiled chapel floor from the king's apartments at Clarendon Palace assembled from tiles recovered during excavations with plaster gap fills. A lost inscription on the outermost band is reconstructed as *Pavimentum Henrici Regis Anglie* (the pavement of Henry, King of England); the innermost band is also missing, and its design has been disputed: 1957,1006.various

The king's and queen's inlaid tiled pavements from Clarendon Palace, Wiltshire

Clarendon Palace was a hunting lodge of the Norman kings and also became a favourite royal residence under Henry II. Henry III (reigned 1216–1272) spent between 3000 and 4000 pounds on the extension and embellishment of its buildings [17]. Labour was much cheaper in the thirteenth century than today, but this palace was still very costly and these Medieval tiles, which are displayed in the newly refurbished Medieval gallery, are to be enjoyed, while they also provide information about the liturgy, theology, art history, history and archaeology of the Middle Ages.

Scattered tiles found in the vicinity of the king's chambers were used to recreate the circular patterns, forming part of the king's private chapel on the upper floor, Figure 2. The inlaid pavement with prancing lions and griffins had been found *in situ* during excavation of the queen's ground floor

private apartments, Figure 3. The tiles for the king's pavement could be traced to a kiln near the palace, which was removed from the site in 1964 and reconstructed in the former Medieval tile and pottery room.

RECENT HISTORY OF THE TILE COLLECTION

For the past 30 years much of the Museum's collection of Medieval tiles could be viewed in the former Medieval tile and pottery room, which was a quarry of information both for students of Medieval ceramics and for the interested public; see [16]. On the upper balcony in this gallery tiles were displayed that showed the many different aspects and techniques of tile design and fabrication associated with individual schools of production between the twelfth and the sixteenth century in Medieval England.



FIGURE 3. Part of the ground floor pavement from Queen Eleanor of Provence's chamber, made 1250–1252 and found *in situ* at Clarendon Palace. The original pavement included more tiles in the central panel than are currently held by the British Museum: 1957,1204.various

THE DISCOVERY OF ASBESTOS CONTAMINATION

Several of these unique pavements were destined for redisplay in the new Medieval gallery that opened in March 2009,

but it was discovered that they had been backed in the 1970s, when 'Asbestolux' board had been used as the mounting material. Asbestos insulation board (AIB), commonly known as Asbestolux, was used by the construction industry throughout the UK from the 1950s until the early 1980s. AIBs typically contain between 25 and 40% asbestos fibre, normally brown asbestos (amosite or grunerite) and/or white asbestos (chrysotile). Given the well-publicized dangers of asbestos, and that amosite has been banned in the UK since 1 January 1986, it is not surprising that Asbestolux does not meet current health and safety legislation [18].¹ If the backed tile panels had been left intact, the risk from the Asbestolux board would have been negligible; the risk began only once the tiles were removed from the wall and any mechanical investigative or conservation work was carried out. As the tiles had been adhered to the board using BAL FLEX, a two-part, water-resistant rubber-based wall tile adhesive that needed to be removed mechanically, a strategy was needed to remove and dismantle the asbestos-contaminated Medieval tile pavements; such a strategy was developed and implemented in autumn 2006.

DECONTAMINATION AND CONSERVATION TREATMENT

Preliminary steps

First, conservators searched the web for instances of similar treatments and posted messages on the online conservation forum, *Conservation DistList*, asking for advice from others who had experience of dealing with asbestos associated with museum objects. However, it proved difficult to find conservators with the level of asbestos training required to carry out this work and the necessary licence. Other museums with similar experiences had used licensed asbestos contractors who had worked in close consultation with conservators. The British Museum had experience of using such contractors on building projects, but not to remove asbestos from objects in the collection.

The first stage was to carry out a pilot study in the Medieval tile and pottery room, which had by then been closed, using a licensed asbestos contractor, R & F Insulations Ltd. The aim was to develop a safe method for removing the tile pavements from the walls, followed by a safe method of decontaminating and conserving those tiles mounted on Asbestolux board. The health and safety regulations for working with asbestos required special accommodation arrangements, the need to erect an isolation tent, staff protection, asbestos monitoring, decontamination facilities, and short-term 'asbestos-contained' and secure storage of the panels.

A comprehensive risk assessment was undertaken covering all aspects of the project. The project manager at the British Museum liaised with the health and safety team at the London Borough of Camden (the local authority for

the area), who visited the gallery three weeks before work commenced to ensure all the correct procedures would be followed.

The preparatory stage

To create a working space, some 1200 objects had to be removed from the ground floor and upper floor (balcony) in the gallery and accommodated elsewhere before work on the tile pavements and panels began. All the major tile installations were photographed prior to dismantling, and a risk assessment and conservation assessment were carried out by one of the authors (DL) and a colleague. Once the objects from the lower floor had been removed from their cases, the reconstructed Medieval kiln from Clarendon Palace was dismantled prior to long-term loan to a new gallery at the Victoria and Albert Museum.

The pilot project

Once the room was empty it was necessary to build a hoarding around the gallery door with suitable signage in order to control access, which was restricted to named people who needed to view the work through the viewing panel in the wall of the enclosure that was built subsequently. The need for relevant staff to have a medical report to verify that they had no respiratory problems was considered, but ultimately deemed unnecessary.

To test the methodology a small section of a tile pavement on the upper floor was selected. This comprised inlaid and plain glazed tiles recovered *in situ* from the chancel of Halesowen Abbey in the West Midlands [1; pp. 179–181 and Figure VIb (vol. 1)]. Full asbestos protective measures, including the building of an enclosure tent, were implemented. The section of pavement had been supported on brackets concealed by stud walling, which had to be removed to assess the condition of the Asbestolux board. Many of the tiles had previously been repaired and had areas of restoration. The surfaces of those tiles that looked particularly fragile were faced using Paraloid B-72® (ethyl methacrylate copolymer) and nylon gossamer to protect them during removal, Figure 4.

Wearing disposable overalls and appropriate masks, the Museum's heavy object handling team and museum assistants lifted the pavement off the wall to allow it to be inspected by the specialist contractor to establish its condition. The contractor then wrapped the panel in polythene to contain any fibres during the transfer to the isolation enclosure set up nearby, and laid it face down onto a protective 'foam bed', Figure 5.

Once the pavement had been isolated the metal frame was unscrewed. At first it appeared it would prove relatively straightforward to cut the rubber adhesive from between the tiles and the Asbestolux board. This would leave the Asbestolux board intact, which is a requirement of the Health and Safety Executive (HSE) legislation that prohibits inten-



FIGURE 4. Detail of tile pavement with relief and counter relief-stamped decoration found *in situ* at the leper hospital at Burton Lazars, Leicestershire. These tiles, stamped with a merchant's mark, had friable surfaces, some of which were faced with adhesive and nylon gossamer during the process of dismantling the old display: 1947,0505.4660 various



FIGURE 5. Some of the Museum's heavy object handlers and museum assistants carry the wrapped tile panel into the protective tent; the viewing panel is on the right

tional damage to Asbestolux board, as this would release asbestos fibres. Unfortunately it proved impossible to cut, saw or soften the rubber adhesive. The contractors therefore used flat metal tools which were gently tapped with a hammer to separate the tile and rubber adhesive from the Asbestolux board. The thickness of the adhesive (15 mm) allowed the tiles to be removed without the tool coming into contact with the tiles. Within less than two hours the contractors had removed all 56 tiles from the Asbestolux board, faster than programmed and raising concerns for the conservation and curatorial staff about the handling of the tiles (see below). Once the asbestos had been removed, the tiles were laid out in trays and held in quarantine within the isolation tent.

The Asbestolux board was double bagged and tape-sealed ready for clearance from the working enclosure. The air in

the enclosure was monitored, together with the area immediately outside the enclosure. Once the work was complete a full environmental clean of the enclosure was carried out and smoke tests conducted to confirm that the seals of the tent were effective. An air test then carried out by Cavendish Laboratories Ltd confirmed that the area was clean and the tent could be dismantled.

The main project

For the main phase, it was agreed that more detailed monitoring of the contractors would be required, including a consistent evaluation of the contractor's handling of the tiles and the treatment process. In April 2007, the project manager called a site meeting to introduce the contractors to Museum staff and to conduct a debrief following the pilot project. To address concerns from both sides, the contractors were asked to draw up a Gantt chart of the projected work on three

more tile panels, each of which had been constructed slightly differently. To maintain continuity and build on experience already gained, a member of the R & F Insulations team was appointed to supervise the project. It was decided that British Museum conservators would photograph every stage and every process, that the contractors, conservators and curator would communicate regularly using mobile phones and that there would be a weekly meeting in an uncontaminated area to discuss the work in progress. The redesigned isolation tent included viewing panels to allow Museum staff to monitor each stage of treatment.

Health and safety requirements included wearing asbestos protection suits and air-fed masks, which proved physically exhausting over long periods, Figure 6. After each period working in the isolation tent, the contractors used a mobile decontamination unit elsewhere in the Museum; typically work periods were no longer than 90 minutes. In addition, all tools and equipment were swabbed clean before leaving the isolation tent to prevent cross-contamination.



FIGURE 6. Specialist asbestos contractors, wearing protective clothing and working in the isolation tent, gently prising the Malvern tiles and the dark grey rubber adhesive backing off the Asbestolux board

ASBESTOS ANALYSIS

As a precautionary measure a representative number of tiles held in quarantine were analysed to confirm that no asbestos residues were present. The results were not as anticipated, since asbestos residues were identified adhered to the rubber adhesive. Of the 46 tiles sampled, eight were found to have these 'secondary' asbestos residues, presumed to arise from cross-contamination as the metal tool scraped against the rubber adhesive and the surface layer of the Asbestolux board. Following discussions with Camden's Environmental Health Officer, advice was sought from the Principal Inspector at the London office of the HSE. As a result, the Museum approached KAD Environmental Consultancy Ltd, to provide a detailed, costed proposal and programme for the removal of the remaining fibres in the adhesive residue. It was recommended that scanning electron microscopy (SEM) should be used to determine the quantity of fibres remaining on the tiles, how they were embedded and whether fibres remained within cracks or crevices.

A second analysis, designed to test a second decontamination stage, was implemented in August 2007. One of the authors (MM) took 12 representative tiles for testing to the Institute of Occupational Medicine (IOM) in Edinburgh. Here the tiles were each unwrapped and placed in a fume cupboard with an asbestos filter. A sample was taken from

the outer face of the rubber adhesive for SEM examination. A 2 mm thick layer of adhesive was then scraped off and the back cleaned with a HSE-approved vacuum cleaner to remove any fibres, thereby eliminating the possibility of cross-contamination. A further sample of the adhesive was then taken closer to the surface of the tile. The report on the analysis of the 24 samples taken from the 12 tiles confirmed that once the outermost layer of adhesive had been removed the asbestos risk was low.

ADDRESSING THE SECONDARY DECONTAMINATION

The degree of contamination of the adhesive implied that each tile would need to undergo an unexpected second stage of decontamination that had not been foreseen and would therefore have an impact on both the programme and budget. It was not possible for the R & F Insulations team to carry out this next level of decontamination, as it would necessitate working directly on the surface of the tiles.

Initially, it was hoped that, with appropriate precautions for health and safety, British Museum conservators might treat the more than 3000 tiles after they had been individually wrapped and labelled by the contractors within the

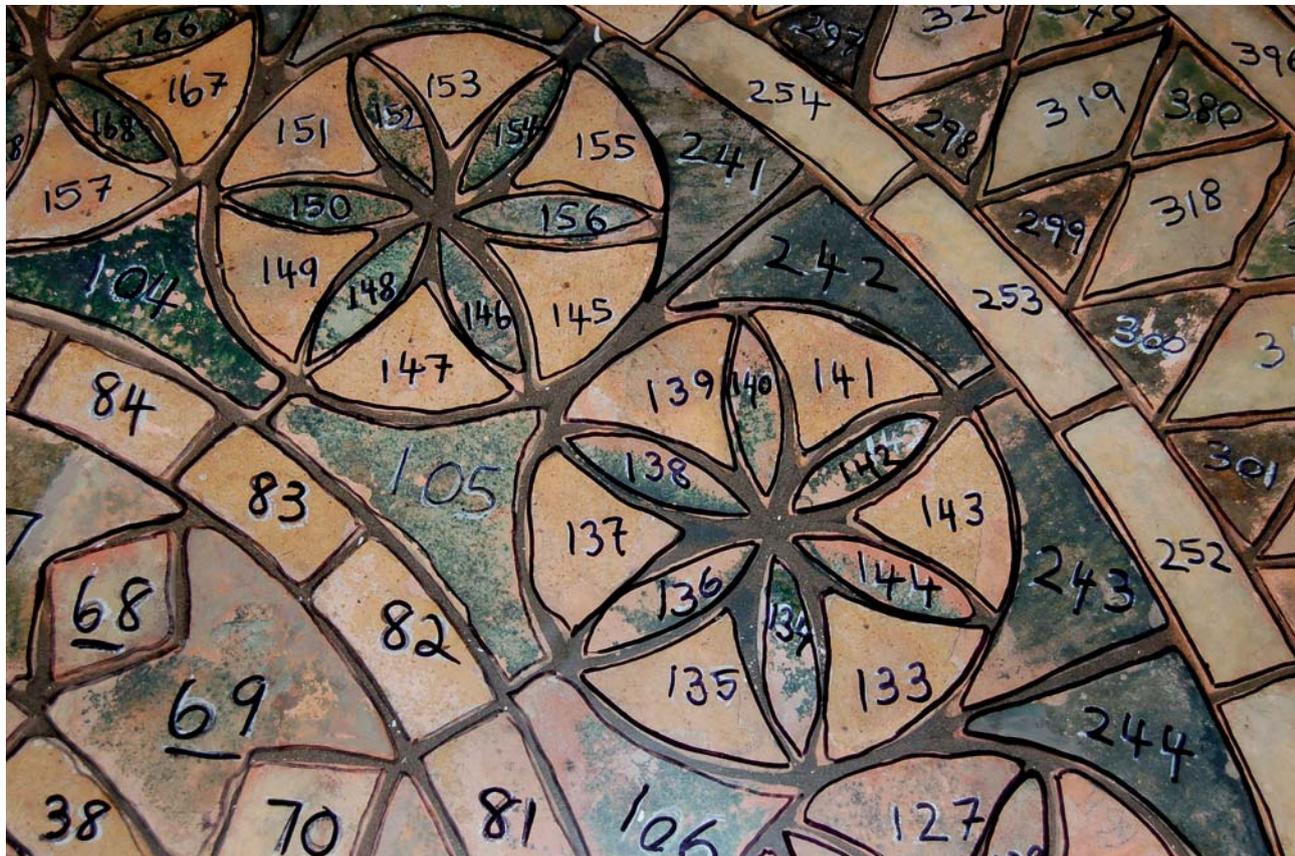


FIGURE 7. The numbering system of the individual plain mosaic pavement from Byland Abbey (detail)

isolation area. This, and the idea of engaging a freelance tile conservator to work at the Museum, proved to be impractical, so a number of specialists were invited to tender for the project, including Heritage Tiles Ltd, who had recently carried out work for the Victoria and Albert Museum.

After lengthy communication between all parties it was agreed that the contaminated pavements could be transported to Heritage Tiles in Shropshire for final cleaning. They would also remount three of the larger pavements, while British Museum conservators would remount the smaller sections (see below), leaving the plain mosaic tiled pavement from Rievaulx Abbey to be mounted at some stage in the future.

THE TREATMENT PROCESS

Primary decontamination

Following the pilot study a similar methodology was adopted for primary decontamination of the remaining panels and pavement at the upper gallery level (Malvern, Wessex and Burton Lazars), which were the first to be treated when, in June 2007, it was agreed that R & F Insulations should continue to decontaminate the remaining pavements, Figure 6.

The complete pavement from Canynges House, a merchant's house in Redcliffe Street, Bristol, originally laid between AD 1480 and 1515, required an isolation tent to be built over the whole pavement of 1499 tiles [16; p. 12 and Figure 9]. The contractors erected a large tent in the body of the room to treat this pavement and the smaller section of pavement from Hailes Abbey.

Owing to their complexity (weight, size and position above the stairway), scaffolding was necessary to remove the Byland and Rievaulx pavements from the wall. In December 2007 the heavy objects handling staff brought in lifting gear and placed it at the upper gallery level; the scaffolders next installed platforms and then other Museum staff aided in

the lifting process. Once these large vertical mosaic wall pavements (Byland: 485 tiles, and Rievaulx: 544 tiles) had been removed from the wall and placed horizontal, one of the authors (DL) was able to begin work on the geometric tiles. The surface of each tile was numbered with a removable marker, and the information then transferred to a line drawing of each pavement on plastic film, Figure 7.

R & F Insulations continued to decontaminate the pavements in a sealed enclosure, passing the individually wrapped tiles to conservators for storage in lockable cupboards in the gallery. Once the primary decontamination work was completed, the Museum was provided with certificates of reoccupation.

Secondary decontamination

In February 2008 all the contaminated tiles were collected from the Museum for delivery to the studios of Heritage Tiles, Table 1. The treatment of the tiles to remove all the backing adhesive took place over a period of six months. Before collecting the treated tiles, the Museum required assurance that the cleaning process had been effective, so a sample of 60 tiles from the Canynges, Hailes and Burton Lazars pavements was analysed by Bradley Environmental Consultants in September 2008. Fortunately, on this occasion, no asbestos fibres were detected and the tiles were returned to the Museum for redisplay or storage.

DISCUSSION AND CONCLUSIONS

The proactive response by the Museum to tackle a hazardous substance rather than simply wrap these tile panels and leave the issue for a future generation to resolve, owes much to support for the project at a senior level in the Museum. All nine tile pavements previously mounted on Asbestolux have been decontaminated, with three having been remounted by outside specialists for display in the

TABLE 1. Summary of the pavements treated and redisplayed, including details of numbers of tiles, dimensions and mass

Pavement	Number of tiles	Dimensions excluding existing frame (mm)	Tile number and type (average mass)	Estimated total mass (kg)
Byland Abbey (mosaic)	485 (redisplayed)	1910 (height: h) × 1275 (width: w) × 40 (thickness: t)	485 × small (300 g)	150
Burton Lazars hospital	112 (20 redisplayed)	1510 (h) × 800 (w) × 20–23(t)	112 × medium (600 g)	70
Canynges, merchant's house, Bristol	1499	5860 (h) × 4090 (w) × 27–30(t)	1499 × large (1200 g)	1800
Hailes Abbey rebus	80 (16 redisplayed)	607 (h) × 610 (w) × 26–30(t)	16 × large (1200 g)	20
Halesowen Abbey	56	570 (h) × 1340 (w) × 30(t)	56 × medium (600 g)	30
King's, Clarendon Palace, Wiltshire	244 (redisplayed)	2250 (h) × 2110 (w) × 29(t)	81 × large (1200 g) 163 × medium (600 g)	200
Malvern Priory	37 (5 redisplayed)	1093 (h) × 163 (w) × 33(t)	5 × large (1200 g)	6
Queen's, Clarendon Palace, Wiltshire	196 (redisplayed)	2640 (h) × 1040 (w) × 24(t)	70 × large (1200 g) 126 × medium (600 g)	160
Rievaulx Abbey (mosaic)	544	1200 (h) × 1600 (w) × 33–37(t)	544 × small (300 g)	160

new Medieval gallery. The choice of which pavements to redisplay was difficult as all nine are historically significant. The three chosen illustrate different aspects and techniques of tile production and design and will be displayed as part of an integrated and themed gallery, while smaller sections have been remounted in-house (Hailes, Malvern and Burton Lazars).

This contribution has outlined the technical challenges of 'remote-control' conservation through the walls of a protective tent; training the specialist contractors in conservation skills and monitoring their work fell largely to one of the authors (DL). This marathon task of enabling the public to view these magnificent Medieval pavements again "while ensuring the safety of the staff, gives a warning to others of the hazards of past practices and sets out to show the Museum's solution to the problem" [19]. The procedure undertaken by the Museum is one that could be recommended to others.

ACKNOWLEDGEMENTS

The authors are enormously grateful for the support and advice received from their colleagues at the British Museum: Rainer Geschke, Sue Greetham, Zoe Hancock, Marilyn Hockey, David Saunders, Chris Terrey, Ken Uprichard and Jonathan Williams. The photographs in Figures 1–3 were taken by John Williams and those in Figures 4–7 by Denise Ling.

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NOTE

1. Current UK regulations bring together the three previous sets of regulations, which covered the prohibition of asbestos, the control of asbestos at work and asbestos licensing. These regulations prohibit the import, supply and use of all forms of asbestos. They continue the ban introduced for blue and brown asbestos in 1985 and for white asbestos in 1999 and also continue to ban the second-hand use of asbestos products such as asbestos cement sheets and asbestos boards and tiles, including panels that have been covered with paint or textured plaster containing asbestos.