The British Museum

Newsletter
Scientific Research

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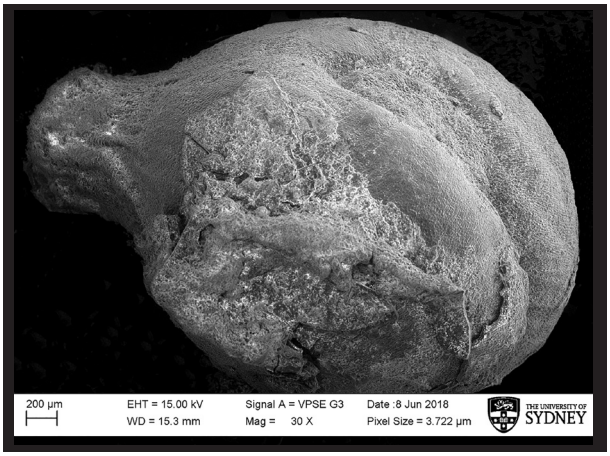
View of Jericho with the archaeological site in the background

Miniature decorated wooden bowl, NM53.36, Tomb B35, Jericho (Nicholson Museum)



Scanning electron microscope image of a grape pip with remnants of grape-skin surviving, Tomb B35, Jericho

A remarkable assemblage of organic funerary offerings from Jericho Tomb B35

Caroline Cartwright, Scientist

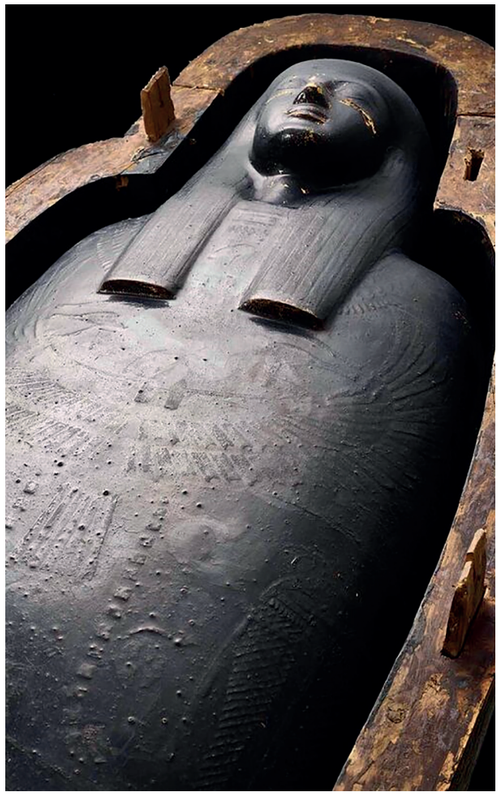
In 1952 whilst excavating 3500 year old tombs at Jericho (Figure 1), Kathleen Kenyon encountered extraordinary (and unexpected) preservation of desiccated wooden furniture and objects along with organic funerary offerings. The British Museum has an important collection of organic Jericho tomb material, which I have already studied and published. Other museums also curate Jericho tomb material, and the Nicholson Museum (University of Sydney) received a significant portion of the Jericho finds in recognition of its financial support. In 2018 I was invited by Dr James Fraser, Senior Curator at the Nicholson Museum to undertake a scanning electron microscope analysis of their wooden objects and botanical funerary offerings from Tomb B35 at Jericho. The Nicholson Museum secured a secondment agreement with the British Museum; also permission for me to use a scanning electron microscope in the Australian Centre for Microscopy & Microanalysis (University of Sydney). So I spent most of June 2018 there, analysing the remarkable array of Tomb B35 material, including wooden table and furniture leg fragments, decorated wooden miniature bowls containing grapes and pomegranate seeds

(Figures 2-3), wooden cups, miniature platters, buttons and combs; and basketry containers with fruits, seeds and grains.

My analyses of Tomb B35 are providing a new understanding of the relationship between the Canaanite inhabitants of Jericho and their surrounding environment. The results enhance the research I have already carried out on organic Jericho tomb offerings in the collections of the British Museum (and other museums in Britain). Tomb B35 in the Nicholson Museum has never been studied, and the offering table was undisturbed, so I have been making exciting new discoveries. Just mentioning one; I found the offering table to be carved from oak wood, presumably sourced from the upland forests high above Jericho. On the table top are plaited rush baskets with plant and animal foodstuffs, placed into the tomb as offerings for the dead.

Ritual black liquids applied to 22nd Dynasty Egyptian coffins

Kate Fulcher, Research Assistant funded by the Wellcome Trust.



Coffin of Padihorpakhered (EA29578), 22nd dynasty (c. 900 BC)

Coffin and cartonnage case (containing mummy) of Djedkhonsiufankh (EA6662), 22nd dynasty (c. 900 BC)

Ancient Egyptian burials involved a complex range of rituals, some of which we have evidence for in the material remains preserved on the coffin. One ritual which was sometimes practised involved the application of a black liquid to the wrapped body and/or coffin. Several of the coffins in the collections of the Department of Egypt and Sudan have deposits of this black substance. In some cases the extent of the black liquid is limited, for example Padihorpakhered (EA29578) has only a splash on the face of the outer coffin. In other cases the coverage is almost total; the cartonnage case of Djedkhonsiufankh (EA6662, on display in G63) is completely covered in the black liquid, which has pooled in the bottom of his coffin, cementing him inside.

Analysis of these black substances is being conducted using gas chromatography-mass spectrometry in the laboratories at the Museum, with the aim of identifying the molecular components of the black liquids and thus their constituent materials. Knowledge of the materials present allows their properties to be evaluated, aiding interpretation of their method of application, the locations from which they were sourced and their ideological significance. The analysis so far has enabled the identification of conifer resin, plant oils, animal fats, beeswax and bitumen, which means that this liquid is similar to the “balm” used in mummification.

To some extent, the type of plant resin, and more rarely oil, can be identified using distinctive chemical components or biomarkers, mostly degradation products of the original organic molecules in the resin. Most of these occur across a variety of plants, but some are specific to a plant family or genus. The biomarkers for coniferous resin (dehydroabietic acid and its oxidation products) are frequently seen in the black liquids we are analysing.

Since bitumen is formed from long-dead organisms, the same principle can be applied. The original plants, bacteria, and archaea which formed bitumen over geological time periods vary according to climate and therefore by geographical area and time period. As a result, the biomarkers in the bitumen can be used to identify the source of the bitumen. The bitumen component of mummification balms reported in the literature has been sourced to the Dead Sea, Gebel Zeit in the south of the Gulf of Suez, and Ras Zaafarana in the central Gulf of Suez. Identifying the source of the bitumen establishes evidence for trade routes and contact with other ancient cultures. This scientific study will provide a material perspective on little-known aspects of the complex funerary rituals practised in ancient Egypt.

The project team is Kate Fulcher, Rebecca Stacey, John Taylor, and Margaret Serpico.

Osiris’ New Clothes

Joanne Dyer, Scientist

Visible Light

B (465 nm) LED

R (630 nm) LED

For centuries, foreigners living in ancient Egypt embraced Egyptian customs of life and death while adhering to their own cultural traditions, shaping a new, ‘mixed’ identity. Evidence for this are the artistically rich ‘hybrid’ tombstones found at 6th century BC Saqqara. Typically erected for foreign mercenaries and their families stationed in the nearby city of Memphis, many of them marked the tombs of Carians, people from western Asia Minor who lived in close cultural exchange with Greeks.

An important example of these cross-cultural grave monuments is the stela of Piabrm, a Carian woman (British Museum EA 67235; c. 540-530 BC), which mixes Egyptian, Greek and Carian elements with great syncretic flair and is arguably the most detailed example in this class. Significantly, it also preserves rare traces of paint. However, despite its rich and complex iconography, the low relief and the effects of weathering make this piece difficult to read and its full interpretation holds many mysteries, not least that of the cultural identity of its maker(s).

In this study multispectral imaging techniques were used to re-evaluate this aspect. Astounding details have been revealed with these methods which may contribute important clues to this question of cultural identity. In particular considerable evidence has been uncovered about the ancient textiles and dress represented in this piece, which is completely imperceptible to the naked eye. A key example is the intriguing depiction of Osiris’ tunic. The image under blue illumination (fig, middle) shows a patterned textile, with long panels of alternating zigzag patterns and oval shapes. Under red illumination the presence of Egyptian blue pigment in this pattern is highlighted (fig, right).

There are no exact parallels for the pattern observed on Osiris’ robe. In fact, it is quite uncommon to find Osiris depicted in a patterned garment at all. As very limited written or iconographic sources survive concerning Carian society and its material culture, this constitutes a crucial knowledge of the visual language and iconography that the Caromemphites used to describe themselves and further evidence of the synergy between their adopted and native cultures.

World History Lab

Antony Simpson, Scientist

In 2015, the departments of Scientific Research and Conservation began a collaboration with a professional videographer to produce exclusive film content for the World History Lab web project. The World History Lab is the online component of the museum’s commitment to the The National Lottery Heritage Fund Activity Plan which aims to provide exclusive behind-the-scenes access to our laboratories and conservation studios at the British Museum. The online resource includes more than 30 short films, presented by staff at the Museum, dedicated to conservation and research. The films include topics such as The Art (And Science) Of A Colourful, Cross-Culturally Dressing Statue to the conservation of a Zulu Rifle Headrest.

The resource includes an extensive Glossary section to explain some of the more technical terms we use in our work, animated virtual tours of the different departments and a section dedicated to collections care. The National Lottery Heritage Fund is hosting the website on behalf of the British Museum until 2023 so we can add more films and blogs as the material becomes available, giving our international audience the opportunity to keep up with the fascinating projects taking place in the World Conservation & Exhibition Centre.

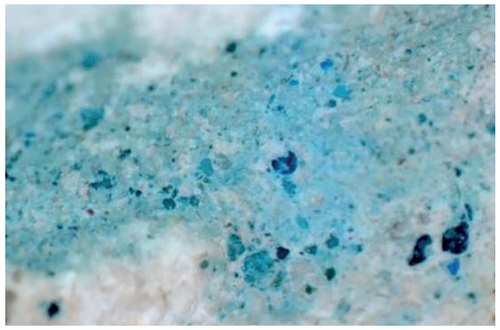
You can find the World History lab here worldhistorylab.britishmuseum.org

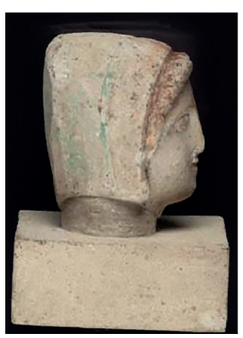
Lasers to conserve polychrome sculptures from Cyprus

Lucia Pereira-Pardo,
Andrew W. Mellon Foundation Fellow

The British Museum's collection of limestone and terracotta statues and figurines from ancient Cyprus is one of the largest and archaeologically most important in the world outside of the island. Dating from the Bronze Age to Roman times, but mainly the Cypro-Archaic to Cypro-Classical periods (750 BC-300 BC), the figures represent animal and human figures, male and female, showing a high level of detail in clothing and jewellery and often preserving part of their colourful painted decoration. Most were excavated in the 19th century at sanctuary sites, where they were deposited as religious offerings, or else were found in tombs accompanying the dead.

Although these statues have been extensively studied from the point of view of style and religious iconography, far less work has been undertaken on technical aspects such as their manufacturing methods or their current condition and conservation problems. An important part of the collection was found to be disfigured by extensive dark staining, as a consequence of a past mould outbreak in the old stores affected by flooding and damp. The storage facilities have since been upgraded and the collection is now undergoing an intensive research and conservation programme, including digitisation to create a comprehensive online catalogue of the island's artefacts. This programme brings together curators, scientists and conservators from across the Museum.





Top: Microphotograph of the remains of blue paint in the headdress of a limestone figurine. Same figurine under visible light (left) and using the visible induced infrared luminescence imaging technique, showing the brightness characteristic of Egyptian blue

Bottom: sculptures found at the 19th century excavations
Bottom: examples of terracotta figurines, some preserving polychromy

Addressing the removal of the staining on the figurines posed various challenges, especially considering the porous and fragile terracotta substrate and the presence of delicate polychromy. Conventional cleaning methods, such as swabbing with solvents or poulticing with gels, were inefficient at cleaning the staining and could not be used safely on the areas preserving paint. Erbium laser cleaning was therefore considered and preliminary tests on the figurines seemed very promising. However, before proceeding to the laser treatment, the pigment remaining on the figurines had to be analysed to determine its sensitivity to the laser. This was also an opportunity to shed light on the range of pigments used; green earth, red and yellow ochre, manganese black and Egyptian blue was revealed by analysis. The laser parameters could then be optimised and the treatment proved to be extremely efficient and safe for the objects, as no physical contact with the surface or use of solvents was required. This was the first use of erbium laser technology on polychrome terracotta and very satisfactory results were achieved, improving our understanding of archaeological aspects of the objects while also pushing forward conservation science.

Top: Steps of the laser treatment on a limestone figurine with red polychromy (before cleaning, after laser and after removing the residues with a damp swab)

Bottom: Image of the terracotta figurines before (top) and after (bottom) laser treatment

Decorated ostrich eggshell; examining an ancient tradition

Caroline Cartwright, Scientist

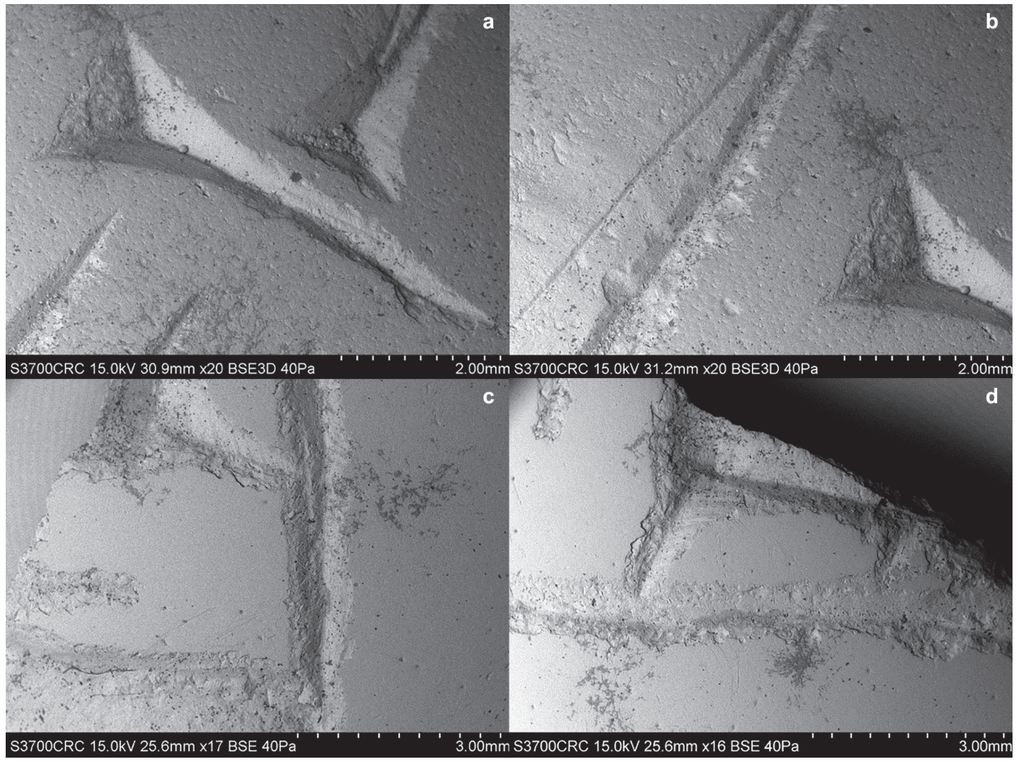
As part of a larger collaborative project, I have been examining examples of ancient decorated ostrich eggshell from the British Museum using a variable pressure scanning electron microscope (SEM). This was done to evaluate a variety of decorative techniques and styles on ostrich eggshell in the ancient Mediterranean and Middle East area. Using the SEM, I was specifically looking for traces of preparation of ostrich eggshell as a raw material through the use of different tools made of stone, organic materials or metal. I also recorded the effects of working techniques used in antiquity, compared with experimental replications on modern ostrich eggshell. This research is contributing to a wider study of the origins and trade routes of decorated ostrich egg vessels in the ancient Mediterranean and Middle East in collaboration with British Museum curators and researchers at the Universities of Bristol and Durham. Prior to this investigation, I participated in a study of 60,000 year old engraved ostrich eggshell from Diepkloof Rock Shelter, South Africa[1]. Whilst these were much more ancient than the fragments I examined from the British Museum collection, this research provided an important comparative framework; particularly regarding the three important factors recognised as significantly influencing the morphology of decorative features:

1. the heterogeneous orientation of the crystalline calcite that makes up 96% of ostrich eggshell structure

2. the three different layers of ostrich eggshell that vary in structure and in thickness, which can be affected by thermal changes

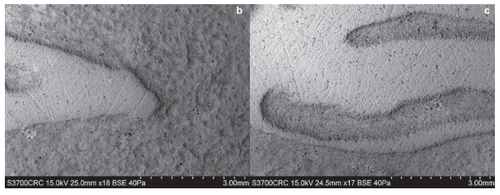
3. the different types and materials of tools used for intentional modification, including incising and engraving.

Figure 1 shows the British Museum decorated ostrich eggshell 1850,0227.5, Vulci (Italy), c. 600-625 BC. Although this particular object was too large to fit in the SEM, some of the highlights of my SEM examination and interpretation of the fragmented decorated ostrich eggshell are summarised here. Figure 2 A-D are SEM images of K8556 ostrich eggshell fragment from Nineveh (Iron Age) showing incised decorative shapes in relief, lines with V- and U-shaped profiles, and buffing or polishing of the areas in higher relief to highlight the decoration. Figure 3 A is a fragment of ostrich eggshell showing the decoration on the inner surface; 1886,0401.1600, 27th Dynasty, Naukratis, Egypt. Figure 3 B-C are SEM images of this Naukratis



fragment showing details of the finely-incised decorative motif, including traces of surface preparation by abrasion or smoothing of the higher relief areas, and pecking of the surrounding areas in lower relief.

In conclusion, I found that superficial incisions generally show a V-shaped profile and do not penetrate the external layer, but deeper incisions with a U-shaped profile penetrate the intermediate (palisade) layer (Figure 2). This reinforces the suggestion that the structure of ostrich eggshell is the principal determinant of decorative morphology, but the type of tool and the way it was used is also crucial. Some of the experimental modification carried out has partially replicated the V- and U-shaped incisions. However, tools of different materials will produce variations in these profiles according to the angle of use, effort expended in creating the incisions, preparatory buffing or abrading of the surface, and post-incision smoothing of the decorated motifs or incised lines. Some of the ancient examples, such as the one in Figure 3 from Naukratis in Egypt (unusually on the inner surface) showed such a sophisticated combination of incising, pecking and smoothing, so far we have been unable to replicate it.



[1]https://www.pnas.org/content/107/14/6180

Chinese dyes in Dunhuang textiles

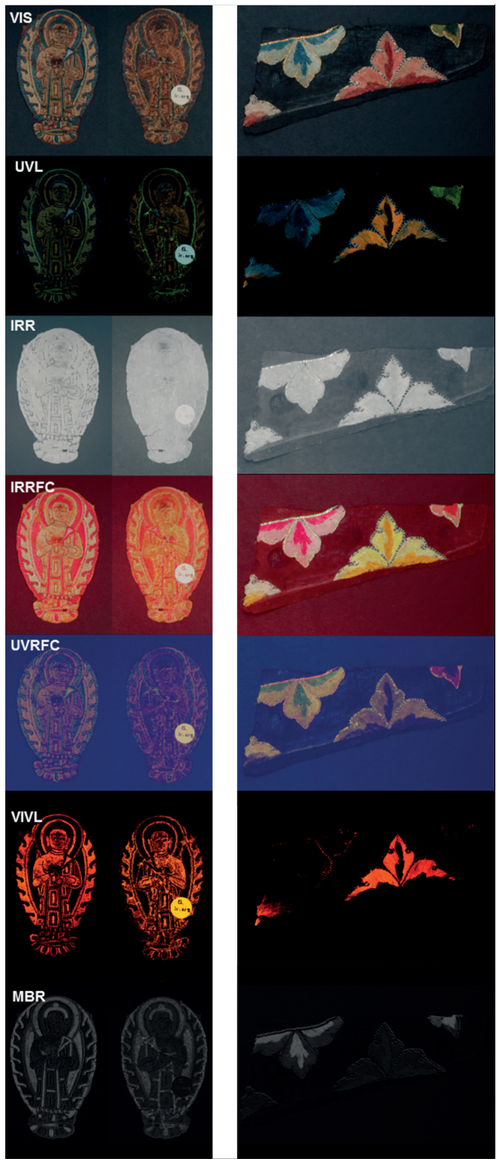
Diego Tamburini, Andrew W. Mellon Foundation Fellow

I recently completed a study of dyes used in a series of Chinese textiles from Dunhuang dated to the 7th-10th century AD. The archaeological complex of Dunhuang (northwestern Gansu province, China) is considered a pearl on the Silk Road and the content of its caves revolutionised Asian studies. The British Museum hosts a significant number of textiles and textile fragments from the site. Although mostly catalogued and studied from the point of view of textile production, weaving techniques and iconography, they have never undergone dye analysis, which was therefore undertaken for the first time. The opportunity arose to analyse the dyes on “Sakyamuni preaching on vulture peak”, which is one of the largest known Chinese silk embroideries from the Tang dynasty period (ca. 8th century AD). The results, published in the journal Archaeological and Anthropological Sciences, revealed most of the dyes used, such as indigo, safflower, cork-tree, madder, sappanwood, gromwell and tannins, but also highlighted the lack of some reference materials, which are fundamental to ensure some identifications.

I therefore collected around thirty sources (mainly plant material) of natural dyes from Asia and I used them to dye silk fabrics. These reference samples were then analysed using fibre optic reflectance spectroscopy (FORS) and high pressure liquid chromatography tandem mass spectrometry (HPLC-MS). They were also imaged using multispectral imaging (MSI). Artificial ageing was performed on the reference samples and the analyses (including colorimetry) were repeated to evaluate the effects of fading. One of the aims of this research was to explore the advantages and limitations of these techniques with application to Asian dyes. All these analyses enabled useful databases to be obtained and the combination of MSI and FORS highlighted the signature behaviour of certain dyes (protoberberine-based dyes, safflower, gromwell, tannins, madder, sappanwood and lac dye), which could be identified non-invasively.

I then used the information obtained on the reference materials to investigate the dyes in thirty Dunhuang textiles from the Museum’s collection. The textiles were selected together with Yu-Ping Luk (Basil Gray Curator: Chinese Paintings, Prints and Central Asian Collection) and Monique Pullan (Head of Organics Conservation) with the aim of providing new insights into the technological skills related to dyestuff production and use in ancient China. First, I analysed the textiles non-invasively using MSI and FORS and these results were used to guide a selective sampling of the areas that needed further investigation. These samples were then analysed by HPLC-MS. The dyes were successfully identified and interesting mixtures of dyes were found. These mixtures could indicate the re-cycling of some of the textiles or may even represent a “dyeing signature” of specific workshops. The benefits of an analytical approach combining non-invasive and invasive analyses were also highlighted. The data produced by this research were published in two articles in the journal *Dyes and Pigments* and will be beneficial to other researchers and conservators investigating textiles from the Silk Road and for the assessment of textiles and their suitability for display.

In December 2018 I organised a symposium - Textiles from the Silk Road in Museum Collections: Scientific Investigations and Conservation Challenges, supported by the Andrew W. Mellon Foundation, where this research was presented. The symposium brought together around 120 attendees, including scientists, conservators and curators working on this topic and provided useful discussions from many different perspectives. This research project has been the core of my Andrew W Mellon fellowship and I am delighted to have had the opportunity to work on such a fascinating and colourful topic.



Visible-reflected (VIS), ultraviolet-luminescence (UVL), infrared-reflected (IRR), infrared-reflected false colour (IRRFC), ultraviolet-reflected false colour (UVRFC), visible-induced visible luminescence (VIVL) and multi-band reflected (MBR) images obtained for the front and back of textile MAS.911 (left) and for the front of textile MAS.915 (right) from the BM’s Dunhuang collection.

Sakyamuni preaching on Vulture Peak, 241 x 159 cm, MAS,0.1129.

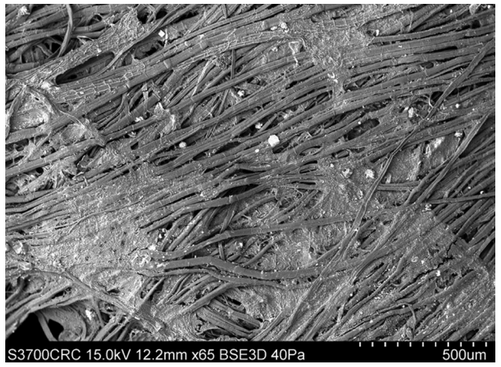
Decorated barkcloth from Pacific Islands…

Diego Tamburini, Andrew W. Mellon Foundation Fellow and Caroline Cartwright, Scientist

Barkcloth or *tapa* is a non-woven cloth made from the inner bark of certain trees and flowering plants and was used throughout the Pacific islands and other areas of the tropics. We recently completed a project on barkcloth that coincided with an exhibition in 2015 called 'Shifting patterns: Pacific barkcloth clothing'. The exhibition showed 77 garments, headdresses, masks and body adornments from the Museum's collection, of which 36 were chosen for analysis. The choice was made in order to have good geographical and chronological coverage. Most of the Pacific islands of Melanesia (Papua New Guinea, Solomon, Vanuatu, Fiji, Wallis and Futuna) and Polynesia (Tonga, Samoa, Niue, Cook, Marquesas, Tahiti, Pitcairn, Hawaii) were considered and the production date of the objects ranges from the late 1700s to the mid-1900s. The analyses focused on the identification of the plant materials and colouring materials (dyes and pigments) used in the barkcloths and the wood used for some beaters and boards, with the aim of producing scientific data that could support or disprove the information present in written records. In addition, the study aimed to highlight patterns and trends in the use of these materials in the various Pacific islands, in order to support archaeological/historical insights about traditions, trade and influences present in these cultures.

Due to the variety of materials under investigation, a multi-analytical approach was chosen for the analyses of the samples. First, optical microscopy (OM) was used to provide preliminary information on the possible co-presence of multiple colourants, as well as the way they were applied on the fibres. Scanning electron microscopy (SEM) was used to identify the barkcloth fibres and woods. Raman and Fourier transform infrared (FTIR) spectroscopies provided information on pigments and some organic materials relatively quickly, using only a few particles of sample. Some selected samples, for which the presence of organic dyes was suspected, were investigated using high pressure liquid chromatography coupled with electron spray ionisation and quadrupole-time-of flight detection (HPLC-ESI-Q-ToF).

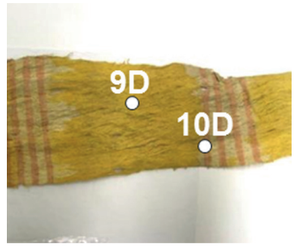
The results revealed that plants used for barkcloth include *Broussonetia papyrifera* (paper mulberry), *Artocarpus altilis* (breadfruit tree), *Ficus* spp. (fig/banyan) including *Ficus prolixa*, *Pipturus albidus* (māmaki) and *Hibiscus tiliaceus* (hau, beach hibiscus). *Syzygium effusum*, *Eugenia*

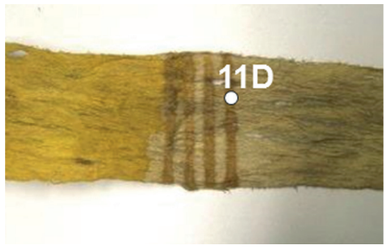


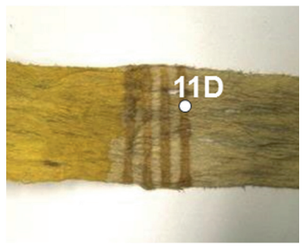
SEM image of *Artocarpus altilis*, breadfruit tree beaten barkcloth

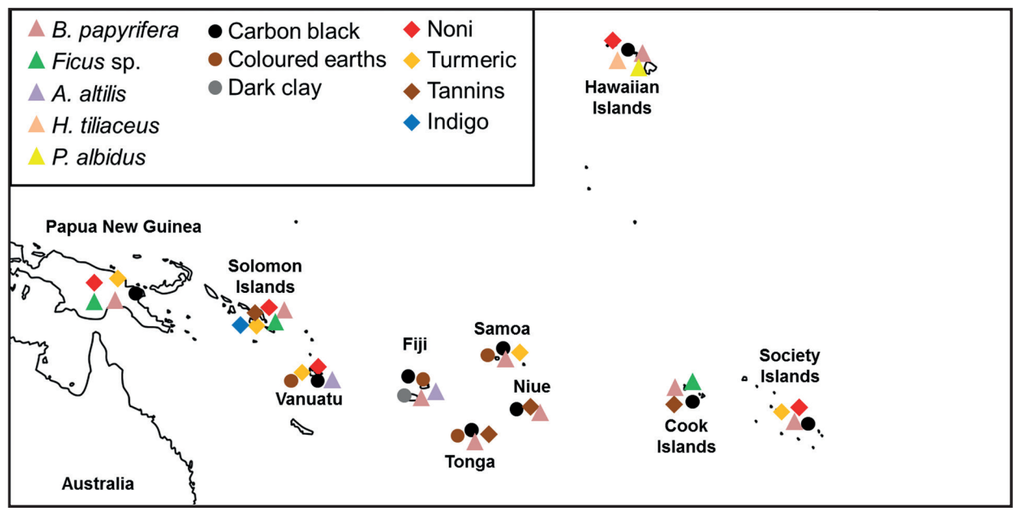
reinwardtiana, *Acacia koaia* and *Styphelia tameiameiae* were identified as the woods used to produce the barkcloth beaters and beating boards. Reddish-brown earths, dark clays and carbon-based blacks from vegetable precursors were the most common pigments; noni (*Morinda citrifolia*), turmeric (*Curcuma longa*), indigo and tannins were the main dyes. The results of FTIR and HPLC-ESI-Q-ToF analyses provided preliminary information on the painting materials, suggesting the predominant use of binding media from vegetable sources (most likely gums and plant exudates, possibly containing oils and resins). Proteins were also identified on a number of objects, but further investigations are needed to clarify the use of binding media. Most of these results were expected to some extent for these objects, but so far scientific confirmations have been rare.

This research was published in the journal *Archaeological and Anthropological Sciences* (D. Tamburini et al. 2018 "Scientific characterisation of the dyes, pigments, fibres and wood used in the production of barkcloth from Pacific islands" *Archaeological and Anthropological Sciences*; https://doi.org/10.1007/s12520-018-0745-0) and will be useful to other scientists and conservators who work with similar objects. There is a high potential for future research, especially in terms of expanding the database of scientific data on barkcloth objects from these geographical areas and various production dates, and setting these results within a more precise cultural and historical framework for each island.









Sampling position and samples taken from a yellow perineal barkcloth band

Geographical visualisation of the analytical results of the barkcloth dyes, pigments and fibres

Analysis on excavation

Andrew Meek, Scientist

Scientists at the British Museum research laboratory occasionally take pieces of analytical equipment from the laboratory to excavation sites in other countries. In late October 2018 I was invited to travel to Shutb in the Asyut region of Egypt to carry out compositional analysis of glass objects excavated during recent excavations. The aim was to discover more about the objects and what they could tell us about the trading networks operating in the Asyut region in the first millennium CE.

The assemblage of around 250 fragments found during the 2016 and 2018 excavation seasons was studied during a four day period in collaboration with Daniela Rosenow from the German Archaeological Institute. Daniela carried out a typological study and was able to identify that the majority of the excavated material dates to the Roman and Late Antique periods and includes bowls, plates, lamps, flasks/bottles, goblets, cups and beakers. Two pieces showed incised and/or cut decoration while one fragment was made of mosaic glass. The existence of several glass wasters provides clear evidence that glass was formed into objects at Shutb.

I used the department's portable X-ray fluorescence equipment at the excavation site to compositionally characterise a total of 96 fragments. This type of analysis is performed on the surface of objects and is entirely non-destructive. Preliminary results suggest that the majority of objects are made of glass produced in Egypt. Some of the known Egyptian primary raw glass groups found in Shutb can be dated within a relatively close period of time. This study provides additional information about the position of Shutb within the wider Roman and Late Antique trade networks.

To find out more about the project visit: www.britishmuseum.org/research/research_projects/all_current_projects/asyut_urban_development.aspx

Examples of the glass fragments excavated at Shutb
Photo by Matjaz Kacicnik

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