

RESEARCH ARTICLE

Pacific Barkcloth Under the Microscope – Characterisation of Condition, Decoration and Structure

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The creation of barkcloth begins with harvesting the inner bark of certain types of trees followed by soaking and beating with grooved beaters, a process which often leaves undulations on the surface of the bark, also known as the beater mark. The cloth can then be decorated using colorants, applied as particulate pigments, dyes or paints. The resulting material is highly ornate with varying surface textures and colours. The usefulness of stereo and standard light microscopy, ranging from around x10 for low and up to x200 for high-magnification microscopy, and macro photography to examine the subtleties of the surface of the cloth is highlighted in this research, with examples of barkcloth from the Hunterian, University of Glasgow, Glasgow and Royal Botanic Gardens, Kew, London collections. Examples of beater marks, particulate dye material, cracking painted surfaces, as well as the presence of two species used to create one cloth are shown, aspects that are not immediately obvious when examining the cloths with the naked eye. To further enhance the analysis from microscopy XRF and FTIR were used when appropriate. Observing the material in this way can increase appreciation for the aesthetic aspects of barkcloth and can further knowledge of the materials used in production. This can inform condition reports, storage requirements, and potential conservation treatments.

Keywords: Barkcloth; tapa; microscopy; fibres; manufacture; colorants; dyes; degradation; conservation

Introduction

The making of barkcloth is an ancient technology where the inner bark of certain trees has been beaten to make a form of cloth, a technology that can be traced back 1,500 years (Cameron 2006). The manufacture of barkcloth textiles has been carried out by many communities worldwide and until the introduction of woven cloth in the 19th century, was the cloth that was used for clothing, household textiles and ceremonial dress. Barkcloth called tapa (kapa in the Hawaiian Islands) is made from the inner bark of a number of tree species, the most popular being *Broussonetia papyrifera* (BP), commonly called paper mulberry. Other species used include *Artocarpus altilis* (AA) (breadfruit), *Ficus natalensis* (FN) (rubber), *Ficus prolixa* (FP) (banyan) and *Pipturus albidus* (PA) (mamaki). The colour of the inner barks from these tree species varies due to the coloured tannins present; these tannins are naturally occurring polyphenol molecules. **Figure 1** shows paper mulberry inner bark prior to (A) and post (B) beating and,

mamaki inner bark prior to beating (C) and at two consecutive stages of beating (D) and (E).

Levetin and McMahon (2008) describe the preparation of barkcloth as follows: the bark is stripped from the tree in one piece and the outer bark is scraped off. The inner bark of phloem, or bast fibres, is then soaked to soften the fibres and remove impurities. The soaking duration and method of soaking (fresh or saltwater) of the inner bark pre- and post-beating will influence the composition of the final cloth. The soaking in fresh or seawater is a process that is usually termed ‘retting’ and is commonly used in industry to remove the pectin, lignin and hemicellulose from bast fibres (Zhang et al. 2008; Qu et al. 2014). Moncada et al. (2013) stated the finest barkcloth was from Hawaii, which was flexible and very thin, of paper-like quality and very white. It contains fewer impurities, possibly due to a more complex process of preparation involving several cycles of soaking and beating. Additionally, the more the cloth is beaten, the finer it becomes. Sometimes, for the finest cloth, the strips are left to ferment in water before a second beating; this helps to further soften the fibres. Larger pieces of cloth can be made by overlapping strips of tapa and beating or pasting them together (Barker, 2002). There are many publications detailing the production, uses and rituals associated with barkcloth. One recent ‘Tapa: From Tree Bark to Cloth: An Ancient Art of Oceania. From Southeast Asia to Eastern Polynesia’ (Charleux 2017) covers these aspects in detail.

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Figure 1: Paper mulberry inner bark prior (A) and post beating (B) and mamaki inner bark (C) and at two consecutive stages of beating (D) and (E).



Figure 2: Beaters showing the variations in set lines. Hunterian Collection E439-2.

The beaters used in the production of barkcloth are four sided mallets made from native hardwoods. Each side of the beater is carved with parallel running lines that are evenly spaced; the spacing between each carved line becomes closer on each side of the beater, with some beaters having lines spaced approximately 1 millimetre (mm) apart (**Figure 2**). The beating of the bark begins with the side of the beater that has the widest set lines, and as the bark widens and becomes thinner, the maker changes the side of the beater used finishing the beating process with the side of the beater having the finest grooves. Hawaiian barkcloth makers often finished the beating process with beaters carved with geometric designs, while makers in other islands used the straight lines of the beaters to create crosshatching or long parallel lines. These decorative finishing methods leave undulations in the cloth, often called beater marks, and can be used as characteristic indications of the place of origin, specifically for Hawaiian cloth, as ornate geometric designs are unique to these islands (Kooijman 1988). **Figure 3** shows examples of the range of thicknesses and textures that can be achieved with varying amounts of beating: **Figure 3C** is thick like

felt, while **Figure 3D** is gossamer thin. The visual effect of the beater marks can be seen clearly in the parallel lines of **Figure 3A**, while **Figure 3B** shows the characteristic geometric pattern of the Hawaiian barkcloth beater.

The texture and surface decoration of barkcloth objects can be achieved by the manufacturing process, or by painting, printing, dyeing and rubbing pigments onto the surface of the fibres. The application of light microscopy in the study of barkcloth has focused mainly on using it to try and identify the fibre species used in the production of the cloth (Moskvin, 2017). However, this method has proved inconclusive and the reasons are detailed by Cartwright and King (2012). Using light microscopy at varying degrees of magnification can, however, highlight the delicate textures of barkcloth artefacts and show the fineness of the beater marks and intricacies of the decorative elements that may not be immediately obvious when viewing the objects with the naked eye. Not only can this method of analysis increase the appreciation of the subtleties of the cloth, it can help to increase knowledge of the method of production and inform any necessary conservation processes. The visual differences between the various methods of decoration may sometimes be easily recognisable, for example the difference in appearance between a painted cloth in which the pigment clearly sits on the surface and a cloth which has the pigment rubbed onto the surface. However, decoration achieved during the manufacturing process may be more challenging to decipher. Layers of cloth are often beaten or pasted together, which means that sometimes only the top layer has had the colour applied. This can give the impression that the colour is a surface coat when in fact it is an immersion dyed cloth added as a top layer.

The complexity of the methods of production and decoration across different Pacific cultures results in a widely diverse range of barkcloth artefacts. The focus of this study is to demonstrate how the use of light microscopy at different magnification levels can show in detail the varying textures and surfaces of the cloths. This study aims to provide museum professionals with technical information, images, and an insight into the complexities of barkcloth objects, and the possible challenges when considering the condition, interventive conservation and the handling and storage requirements when working with objects of this nature.



Figure 3: A range of cloths where the amount of beating and beater marks vary to create differing decorative finishes, E380-1; E380-2; E547 and 42888.

The cloths studied in this research come from two UK collections, the Hunterian at the University of Glasgow and the Economic Botany Collection (EBC) Royal Botanic Gardens, Kew. The Hunterian contains cloths collected in both the 18th and 19th centuries and the EBC cloths are from the 19th century. The cloths in these collections all come from the Pacific Islands and their variations in manufacture and decoration are often unique to their island of origin (Larson, 2011).

The findings also include reference to parallel publications on the collections, which report on the colorants identified using high performance liquid chromatography and portable X-ray fluorescence (Flowers et al, 2019) as well as work on the use of spectroscopy to determine variations in cloths made from different species (Smith et al. 2019.)

Research Aims

In this article we propose to use visual observation and optical microscopy to:

- demonstrate that imaging at several magnification levels can give information on the processes used to manufacture and colour cloths

- show detail of cloths that have been manufactured using two species
- show the complexities involved in visual and optical techniques to categorically prove if a cloth which now appears buff/cream in colour was once coloured. Further colorant analysis is usually required
- show a range of examples of coloured cloths where comparison to colorant analysis can be made. Using this as a crib sheet to postulate if certain colorants have been used – this would be useful for museums where the capacity for scientific analysis is limited
- visualise the intricate and highly ornate patterns created by beaters.
- highlight surface micro-cracking of painted surfaces, which can inform conservation and storage decisions

Methods and Materials

Stereomicroscopy was carried out on cloths to examine the fibres and the beaters marks of the cloths in detail. This was done using a Zeiss 2000C stereo-microscope (Stemi SV 11) with a $\times 10$ eyepiece with zoom magnification ranging from $\times 0.65$ to $\times 5.0$. The images shown here were not subjected to any further image processing. Light microscopy

was carried out using an Olympus BX41 microscope and Olympus Stream Start 1.8 image analysis software.

Photography was also used as a way to demonstrate the advantages of photography for capturing and examining surface detail on cloths. This was carried out using a Nikon D3300 camera fitted with a lens for macro-photography.

XRF analysis was carried out using a Niton XL3t GOLDD+ handheld XRF in mining mode (Main range 15s, Low range 15s, High range 10s, Light range 20s). XRF analysis could be carried out anywhere on a cloth but required a uniform area with a minimum diameter of 4 mm.

Fourier Transform Infrared Spectroscopy with attenuated total reflection (FTIR-ATR) was carried out using a Perkin Elmer Spectrum One FTIR Spectrometer with Spectrum software version 5.0.1 and fitted with a Universal ATR Sampling Accessory. The ATR crystal used was a diamond/thallium-bromide (C/KRS-5) with a penetration depth up to 2 μm . 16 accumulations were used at a resolution of 8 cm^{-1} .

HPLC analysis was carried out on the cloths and the methodology and findings are reported in Flowers et al. (2019).

Results and Discussion

Case studies

Cloths undyed and unpainted

The subtleties of the surface of undyed barkcloths can easily be missed or overlooked, especially when dealing with cloths that are uniform in colour. However, the fibrous nature of the raw bark and the method of production with the wooden beaters leave each cloth with a uniquely textured surface.

Table 1 lists the cloths discussed giving their current attribution, size and description. The following four cloths (**Figure 4**), E380-1, E594-1, E596-8 and 42955 show how

the variations in beating and fibre type can create the appearance of stripes and checks.

As previously reported (Smith et al. 2019) on first inspection of E380-1 the darker lines on the cloth may appear to be printed or painted on (**Figure 4(A)** and **(B)**), but analysis by stereomicroscopy shows the presence of two different colours of bark beaten together. Dark fibres can be seen within the lighter coloured fibres of this cloth, as indicated by the perpendicular orientation of the two sets of coloured fibres. These species of differing colours result in a striped appearance when beaten together. Stereomicroscopy (**Figure 4(C)**) shows the light-coloured fibres clearly, they are less dense, but the dark areas appear more clumped. The additional presence of the coloured tannins account for this appearance.

Scharff (1996) reported that misidentification of fibre species may occur if mixed fibres had been used in the cloth manufacture. E591-4 also shows the introduction of dark fibres into the lighter coloured fibres (**Figure 4(D–F)**). Research reported by Smith et al. (2019) on the use of Fourier transform infrared spectroscopy with attenuated total reflection (ATR-FTIR) and principal component analysis (PCA) to differentiate between historic barkcloths in these collections found three distinct groups of historic cloths. These were identified using PCA of the FTIR region between 1200 and 1600 cm^{-1} where molecular vibrations associated with tannins and lignins are dominant. The methodology placed this cloth in a different group to E380-1. Here the use of stereomicroscopy can show the presence of different starting raw materials, which can highlight the necessity of further study for the identification of the species.

Cloths E596-8 (Hawaii) and 42955 (Tahiti) (**Figure 4(G–I)** and **(J–L)**) are creamy white in colour and have the appearance of stripes. This has been created by two different

Table 1: Case studies giving their accession number, current attribution, size and description.

Accession Number	Origin (tentative)	Length (mm)	Width (mm)	Description
Hunterian				
E380-1	Hawaii	200	185	vertical stripes created by fibres
E417-5	Fiji	2200	590	black with red border
E537	Fiji	710	1150	black, brown and cream patterned cloth
E591-4	Polynesia	1220	950	undyed cloth
E592	Tonga	800	500	black and red coloured cloth
E596-8	Tahiti	173	153	uncoloured cloth
E603	Tahiti	1100	670	plain red-brown cloth
E608	Tahiti	530	510	plain cream/yellow
E611-3	Hawaii	2100	1200	mottled grey
Kew EBC				
42885H	Hawaii	560	230	plain dark brown
42890	Hawaii	2500	1860	stripped brown and dark brown
42947B	Hawaii	1550	1340	red stripes on yellow background
42955	Hawaii	252	244	plain cream

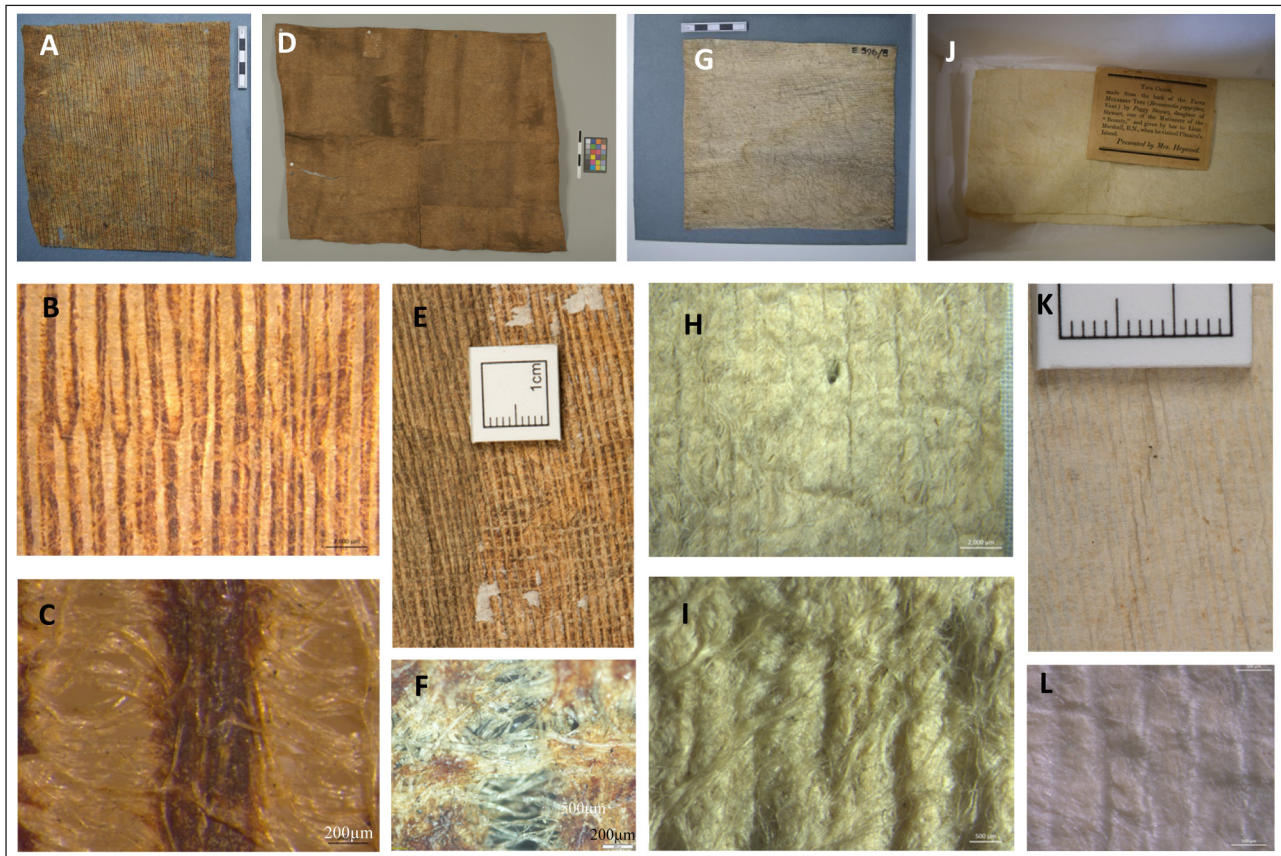


Figure 4: Shows the variations in beating and fibre type can create the appearance of stripes and checks, E380-1 (A–C), E594-1 (D–F), E596-8 (G–I) and 42955 (J–L).

densities of the same fibre as a result of the beating process. These cloths show the clear lines of a beater's mark with ridges slightly less than 1 mm in width. In Hawaii it is reported that the paper mulberry bark was soaked for weeks in either seawater or freshwater depending on the desired colour of tapa required. In Tahiti layers of paper mulberry bark are soaked for several days before the inner bark is peeled free (Barton and Weik, 1994).

Dyed, painted and stencilled cloths

The techniques of decoration vary between different continents, countries and also within island groups. Barton & Weik (1994) stated that barkcloth was coated with coconut oil to impart a gloss to the dyes and in Fiji the fine cloth was soaked in coconut oil and smoked over a fire of green wood, resulting in a rich reddish-brown colour with a dull surface sheen. Hawaiian kapa were rubbed or brushed with oils and resin. To blacken kapa made from mamaki the Hawaiians buried it in taro swamps. This form of mud-dyeing, which is described by Richardson and Richardson (2016), treats a textile with a tannin-rich plant material and then immerses it in mud from a stagnant pond, river or paddy field. The degradation of barkcloth due to mud dyeing is described in articles by Daniels (2005) and Barton and Weik (1994). Here the authors detail how the presence of iron from the mud can catalyse oxidation and hydrolysis pathways and also describes how acid formation from the presence of tannins can also cause the barkcloth fibre to degrade.

The status in society was indicative of the type of barkcloth and the colours worn. The cloths reserved for the use of the highest ranks of society were coloured by soaking them in red and yellow colorants (Adrienne Kaeppler pers. comm. 2018). Kooijman (1988) and Larson (2011) have tabulated these historic accounts of materials used in colorants from the Pacific Island groups. Recent articles by Flowers et al. (2019) and Tamburini et al. (2018) report on analysis on colorants found in three UK collections, Hunterian, University of Glasgow; Economic Botany Collection, Royal Botanic Gardens Kew and the British Museum, London. Here a total of only 5 source materials for colorants were identified in over 100 cloths analysed. As Barton and Weik (1994) stated 'the possibilities for colour and decoration are limited only by the creative imagination of the makers'.

E608 is a cloth (**Figure 5(A&B)**) that appears plain and uncoloured, but HPLC/DAD analysis showed the presence of turmeric (Flowers et al, 2019). Descriptions of the application of turmeric imply that the prepared powder pigment is rubbed into the cloth (Barton and Weik 1994) and Larson (2011) describes the making of yellow powdered pigment. Ten of the cloths analysed by HPLC/DAD from these collections showed only the presence of turmeric and one turmeric with tannin (Flowers et al. 2019). This may mean that the lack of an organic binder results in a 'drier' appearance, which is less obvious as a colourant coating. This aspect combined with the characteristic fading of turmeric reduces contrast and so even under

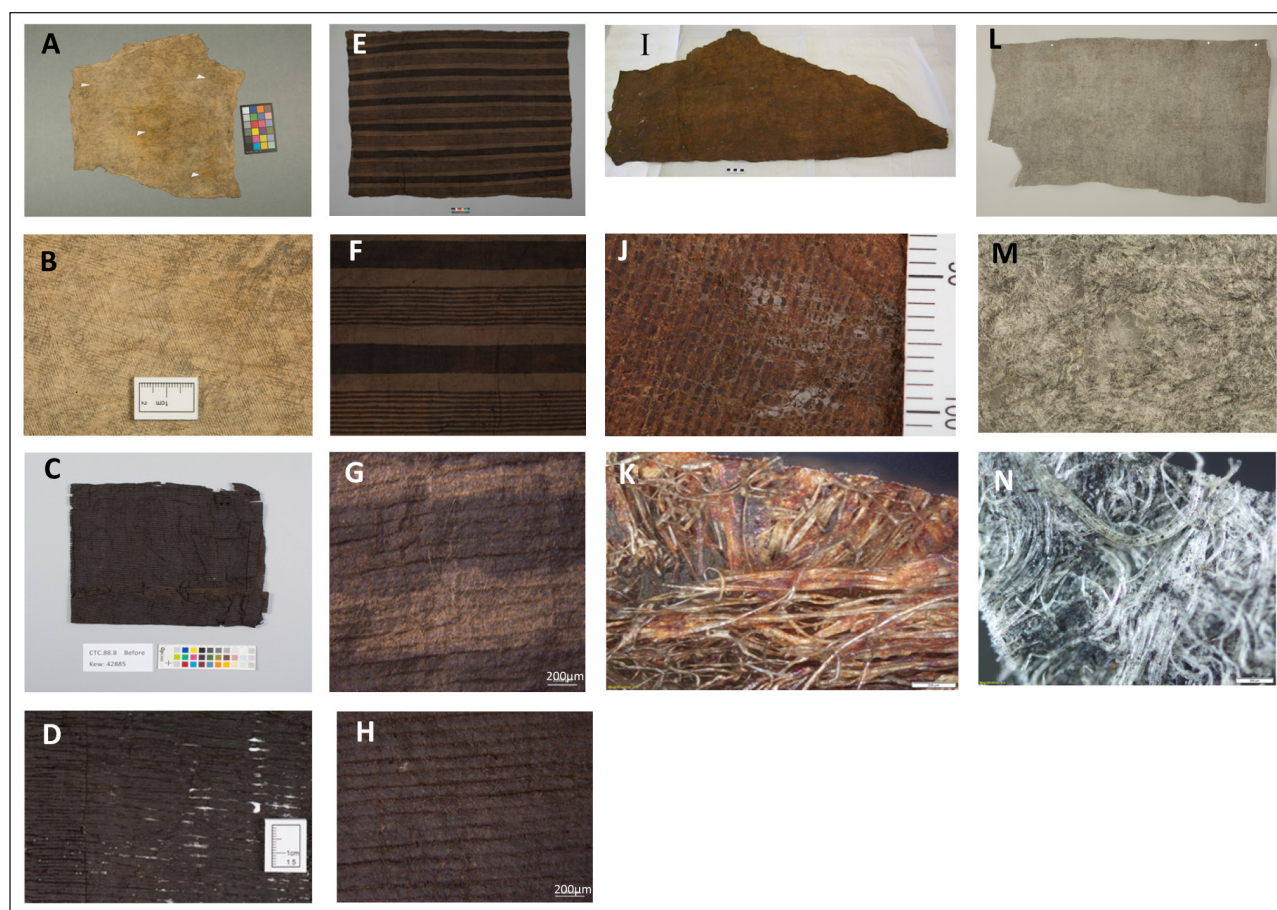


Figure 5: Shows dyed, E608 (A&B), 42885 (C&D), 42890 (E–H), E603 (I–K) and E611-3 (L–N).

magnification it is difficult to observe the particulate associated with this colour. This cloth has faded extensively.

42885 exhibits severe degradation (**Figure 5(C&D)**); the textile is brittle and difficult to handle without causing further damage. The colour has been created by tannins determined by HPLC/DAD analysis (Hugh Flowers, pers. Comm., 2019) but it is not possible to state if these are intrinsic to the bark or have been created through immersion dyeing. Barton and Weik (1994) have stated that to blacken tapa from mamaki (a dark fibre due to the high content of coloured tannins) the material was buried in taro swamps.

42890 is a striped cloth (light and dark brown) that exhibits areas of degradation. The dark stripes have been applied on to the lighter coloured background (**Figure 5(E&H)**). FTIR analysis confirmed the presence of soils indicating that the cloth had been buried/immersed in mud to create the lighter brown. **Figure 6** shows FTIR of the mud samples from the cloth compared to taro swamp mud. The absorbance bands associated with silicates are evident, but it is not possible to distinguish if the mud is taro using this methodology. It has been documented that cloths were often coloured using this mud (Barton & Weik (1994).

E603 shows the use of dye to colour the cloth as the fibres are reasonably well coated and the cloth is brown throughout. However, a more detailed standard microscopy image shows the uneven coverage of the cloth. This

is due to the variations in the fibre thickness and the layering of fibres, which prevented the colourant penetrating every fibre fully (**Figure 5(I–K)**). HPLC/DAD analysis identified the colour was created using tannins (Flowers et al, 2019).

Light microscopy of **E611-3** revealed that the colour had not penetrated the fibres of the bark, as dye would penetrate the fibres of a textile, but was sitting on the surface of the fibres as dark particulates, which gives this cloth a grey appearance. The stability of the colour should be considered when either cleaning or stabilising the cloth using methods that may involve water or an organic solvent. Research by Macken & Smith (2019) showed the implications of dislodging and moving particulate using solvent vapour treatment on soiled textiles.

The colour of **E537** has been applied to the surface by coating/painting, which has extensive cracking (**Figure 7(A–D)**). The colorants have not been identified on this cloth. However, Larsen (2011) stated that black colorants were produced from soot from burning various nuts such as kukui (*Aleurites moluccana*). The soot is used to create black. This can be mixed with water, oil or bark tannins. It was not possible to sample this cloth for HPLC/DAD analysis so the presence of any additional dye components and the nature of the binder could not be investigated.

Barkcloths are not decorated using traditional paint components. However, cracking could be attributed to

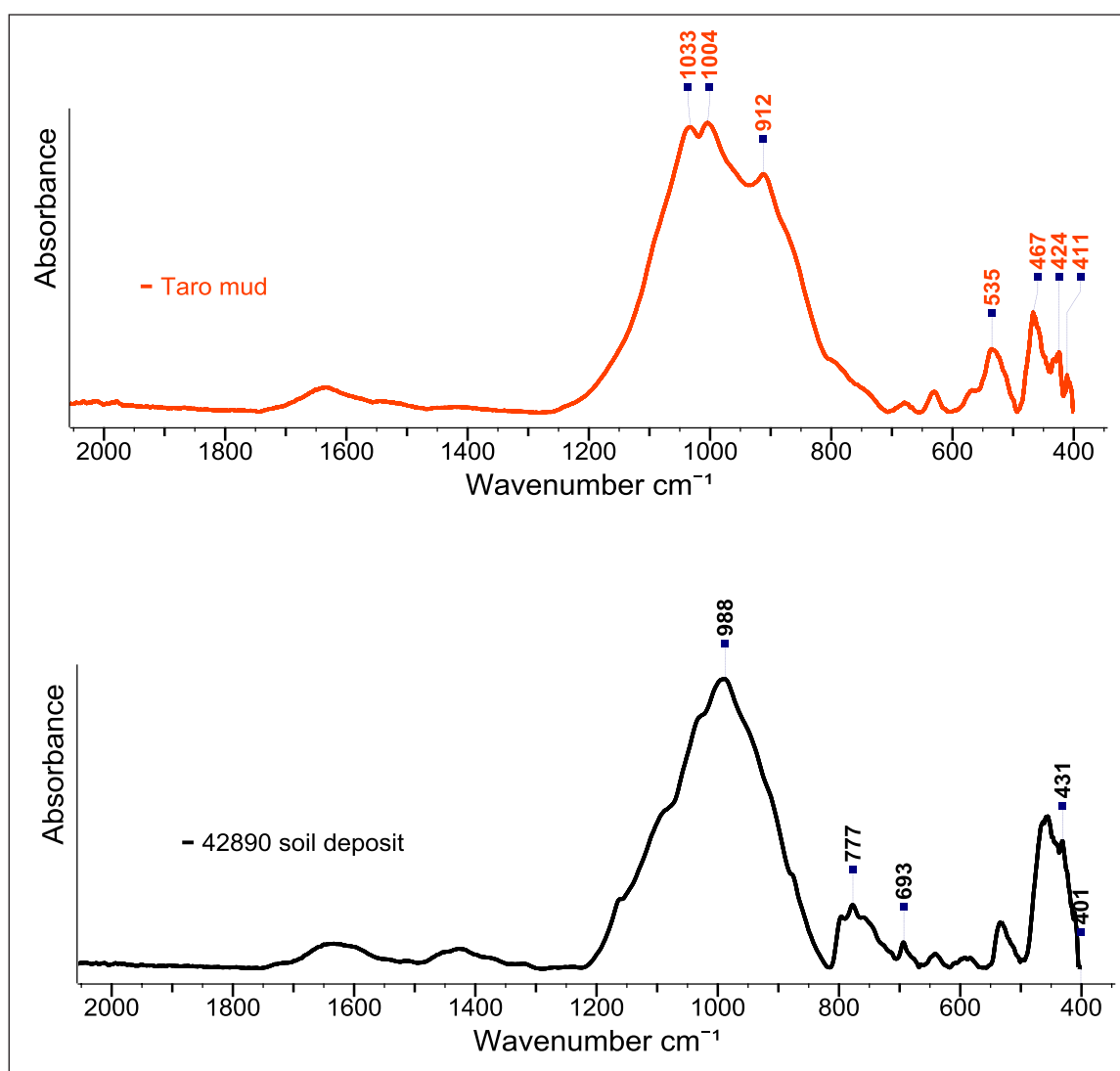


Figure 6: Shows FTIR spectra of the mud samples from the cloth compared to taro swamp mud.

similar chemical and physical changes. Most old paintings are marked by a visible network of cracks across the paint surface- the crackle pattern, or craquelure. (Taylor, 2015). There are two main reasons given why cracks appear, ageing cracks and drying cracks. Drying cracks occur due to the physical movement between the paint layers and the support, dry paint is brittle, so any physical changes in the non-brittle cloth are an issue. Ageing can occur due to the support and its preparation, for example barkcloth is hygroscopic, which results in physical changes that put stress on the paint layer. The behaviour and appearance are those of a colourant that has been prepared with a binder and ageing has caused drying of the paint layer resulting in cracking. Conservation of the surface paint layer should be considered, if possible, storage using a roller should be avoided, and the object should be stored flat. The detail of the surface cracking is in contrast to the stereomicroscopy images of **E417-5** where the coating integrity has not cracked.

The colour of **E417-5** was applied to the surface (**Figure 7(E-G)**). These images show the colourant distinctly sitting on the surface of the cloth. This is clear from

the naked eye, but stereomicroscopy shows a definite black stencilled pattern on the black and red areas. This is a useful comparison to cloths that are more difficult to interpret from mere viewing.

E592 shows that colour(s) have been applied to the surface of the cloth (**Figure 7(H-J)**). Part is coloured using a matt brown/orange colour and a section of this has been coated with a black glossy paint. XRF analysis found elevated iron levels indicating the use of ochre, which is reported to be used on barkcloth (Larsen, 2013).

Turmeric has been used to create the yellow colour of **42947(B)** and the red stripes were created by applying noni (*Morinda citrifolia*) (Flowers et al. 2019). The cloth was stored folded and the area exposed showed fading of both the turmeric and the noni.

High performance liquid chromatography (HPLC) analysis to extract partially beaten bark of mamaki, banyan, breadfruit and paper mulberry containing inherent tannins demonstrated that even using mild acidic extraction techniques (Flowers et al. 2019) these were extracted (Flowers pers comm 2019). This finding should be borne in mind when analysing cloths.



Figure 7: Shows painted and stencilled cloths, E5379 (A–D), E417-5 (E–G), E592 (H–J) and 42947B (K–O).

Relevance to conservation

There are many factors that can influence the condition of an object. This includes the method of production and the use of the object by both the people or community who created the object, the use and storage of the object after it was acquired from the source community, and the way in which the object is used, stored and displayed after accession into the museum environment. The exact methods of historic use, storage and display may not always be known to a conservator or museum professional, however, as shown in the case studies above, the use of microscopy and macro-photography can aid in understanding the materials and process of production of the object, as well as looking for areas of weakness, abrasion, colour changes, accretions, and brittleness (Florian et al. 1990). An important step in heritage conservation is the identification and documentation of the different elements in the artefact.

Structural damage

The beater marks created during the manufacture of the cloth can range in size and visibility, however, they are often particularly noticeable on cloths that have been beaten very thinly, as seen on such cloths as **Figure 5(J)** and **(D)**. These types of thin areas are notable because of the care required when handling and storing the objects due to the vulnerability of the very fine fibres of the bark material. In these examples the use of macro-photography to examine the objects in more detail shows that the thinness of these areas is noticeably different between the two examples.

Also, the fineness of the cloth, **Figure 5(J)**, has been created from the act of beating of the bark during manufacture. This is thought to be the case as there are fine fibres still attached over the areas of very thin material, and although the cloth is fragile and vulnerable to damage, it can be moved and handled without loss of the fibres. The thin areas seen in **Figure 5(D)** are a result of degradation of the material. The areas of loss (which can be seen as the white background showing through the cloth) run predominantly along the thin grooves created by the beater, and there are no fine fibres in these areas, like the ones that can be seen in **Figure 5(J)**. Small pieces of fibres detach easily from the cloth, despite being stored in a custom-made box, and there is a fine layer of black 'dust' created by the powdering of the dark fibres under the cloth.

The conservator's ability to distinguish between thin areas caused by manufacture and degradation is crucial when considering a support treatment or consolidation, as fineness created during making or manufacture is inherent to the intent of the maker.

Decorative surfaces

Very fine beater marks and areas of decoration, created through construction or by the addition of pigment to the surface, may be altered during a humidification process. Humidification techniques usually involve the slow addition of moisture to the object, either through a semi-permeable membrane or by raising the relative humidity around the object, followed by reshaping the object generally using light weights or by easing out creases

using light finger pressure. Humidification techniques can successfully remove large creases from barkcloth which have been caused by re-folding and storage after accession into the museum environment. However, caution must be employed as the microscopy image of the beater marks (as seen in the images of E596-8 and 42955) show the fineness of the undulations which could possibly be flattened or altered if over weighted during a humidification process. Cloths created by layering techniques could delaminate with excessive amounts of moisture introduced, especially if the method of layering is unknown, for example, if a paste has been used to adhere the layers of barkcloth together. Coloured and pigmented barkcloth should be tested for colourfastness before the addition of moisture. This is a standard precaution taken by conservators before applying any liquid or moisture to a coloured surface, however the particulate nature of the pigment seen in the microscopy images of cloth E611-3, and research into the colorants used during the production and for the decoration of barkcloth indicate that the adherence of the pigments to the bark fibres cannot be assumed to be stable, and pigments only coat the surface of the fibres (Flowers et al. 2019). Previous research has shown the ability of organic solvent vapour to move particulates of dirt (Macken and Smith 2018) and a hypothesis could be made that a similar result could occur with the addition of water vapour to colorants that maybe water soluble.

Painted barkcloth can display cracking, often caused by folding, rolling, handling, environmental conditions or by the use of the object (Hill 2001). The largest of these types of cracks are often noticeable to a conservator during initial analysis; however magnified analysis of painted surfaces of objects has shown numerous micro-cracks, which may not be immediately noticeable to the naked eye. The micro-cracking imaged in **Figure 7(A)** and **(B)** of E537 presents issues to those museum professionals who may be handling or involved in the storage of painted barkcloth objects.

Storage

Damage to paint layers that are dry, brittle and inflexible can be exacerbated by excessive handling, movement, and by storage methods in which the cloth is folded or rolled tightly around a roller with a small diameter. When dealing with objects with delicate paint layers, the barkcloth should ideally be stored flat, however this can prove difficult due to the large size of some artefacts. In these cases, the objects should be rolled around a roller with a wide diameter (ideally with the painted surface facing out) or concertinaed using pillows to support the folds.

The use of microscopy to analyse barkcloth artefacts can show the fine detail of the textured surface and methods of decoration. The collection of microscopy images presented in this research aims to highlight the usefulness of the technique for a range of museum professionals in the study of the production and condition, as well as to inform the decision-making processes regarding potential conservation treatments and storage solutions.

Conclusions

Barkcloth varies in coarseness, density and colour, and the techniques and styles are comprehensively categorised by island, which vary between different continents, countries and within island groups (Larsen, 2011). The cloth itself and the various decorative processes applied to the cloth create a range of surfaces and the use of stereomicroscopy and standard light microscopy can show detail of the fibre, the degree of beating, its homogeneity and heterogeneity and the presence of particulate that can make up the colour.

Those studying barkcloth artefacts for both historical and conservation purposes can greatly benefit from analysing the material further using microscopy and macro-photography. As seen in the images provided in this research, the use of microscopy shows the patterns and fineness of the beater marks created in production. When viewing coloured cloths with the naked eye it can be very difficult to determine if any variations in shade are the result of decorative finishes, or if two species have been used that are very different in colour, however using microscopy can clearly show the texture, density and directional orientation of the fibres of the bark. The difference in appearance of overall colour and surface decoration may be easily distinguished with simple visual examination; however, a closer look at coloured cloths can reveal potential issues that can impact both interventive and preventive conservation treatments. The dyeing or application of a colour over the entire surface of a cloth can be achieved by immersing the cloth in a dye liquor or by rubbing a dye or pigment into the surface (Barton and Weik 1994). These two techniques produce a surface appearance that may be initially similar; however, using microscopy can show characteristic differences in the results of the two techniques, which may influence the need for, or the amount of, moisture used in humidification or structural support techniques. Storage solutions such as concertinaed folding or flat storage may need to be considered given the possibility of micro-cracking of painted surfaces.

The use of microscopy and macro-photography can advance the identification and documentation of barkcloth objects. This can lead towards better documentation accuracy and has the possibility to inform those professionals studying the materials, the methods of production, and current condition of barkcloth, allowing for a greater understanding of the history and future requirements of such artefacts.

Acknowledgements

Margaret Smith and Aisling Macken were funded by AHRC (grant number AH/M00886X/1: Situating Pacific Barkcloth in Time and Place) www.tapa.ac.uk. The authors wish to thank Misa Tamura, the project conservation researcher, for her help in sampling and contributing her knowledge on the materials of barkcloth and Jennifer Brunton for helping with the microscopy imaging. The help and accommodating attitude to access the collections of Mark Nesbitt, Economic Botany Collection, Royal Botanic Gardens Kew and Malcom Chapman, Hunterian University of Glasgow is acknowledged as without their support this work would not have been possible.

Competing Interests

The authors have no competing interests to declare.

Author Contributions

MS conceived the idea for the study. The experimental work was carried out by both authors and the text was written jointly.

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How to cite this article: Smith, MJ and Macken, A. 2020. Pacific Barkcloth Under the Microscope – Characterisation of Condition, Decoration and Structure. *Journal of Conservation and Museum Studies*, 18(1): 2, pp.1–10. DOI: <http://doi.org/10.5334/jcms.193>

Submitted: 13 December 2019 **Accepted:** 03 August 2020 **Published:** 06 October 2020

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