CONSERVATION SCIENCE:

The Forensics of Cultural Connections

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The value of scientific examination as an integral part of documenting cultural heritage has been recognised since the preservation of museum collections gained status as a scholarly discipline in the early years of the twentieth century. However, the scientific analysis of archaeological materials and paintings has been reported from as early as the eighteenth century (Caley 1951, Nadolny 2003, Winter 2008). The aim of applying science to the examination of objects of artistic and historic significance is to understand the materials they were made of and the causes of their deterioration. This process of discovery, which is similar to forensic analysis, can be compared to the weaving of a fabric of knowledge based on small pieces of evidence revealed by the artefacts themselves.

Although scientific analysis unquestionably benefits conservators, by guiding their treatment choices and empower curators with knowledge of the artefacts under their care, not all institutions are fortunate enough to have their own conservation science laboratories. In 2015 the Heritage Conservation Centre (HCC) of the National Heritage Board (NHB) in Singapore realised its three-year plan and established a research laboratory dedicated to the analysis and characterisation of materials of cultural significance in the Southeast Asia region.

In the course of analysis that was carried out in the newly established laboratory we were able to trace the artistic workshop techniques, intricate connections between artefacts and places of their origin, and elucidated some aspects of objects' provenance as exemplified by the collections of the National Museum of Singapore, Asian Civilisations Museum and the Indian Heritage Centre.

Conservation science at the HCC, an overview

The Conservation Science (CS) Laboratory is a new entity at the HCC, an organisation within the NHB, a statutory board charged with the management of Singapore's national museums and heritage institutions. Established in 2000, the HCC is the central repository and conservation facility for the management and preservation of the heritage collection of Singapore. In 2013 the foundations were laid for establishing the CS Laboratory which materialised in 2015.

A diverse range of materials are found in Singapore's museum collections, from oil paintings, art and manuscripts on paper, pith, and palm leaves to corroded metal objects and glass beaded decorative textiles, to just mention a few. These diverse artefacts require sophisticated analytical instruments and expertise that enable the interpretation of the analytical data.

To carry out such analyses a set of powerful instruments was utilised at the CS Laboratory at the HCC. A high resolution, field emission scanning electron microscope with energy dispersive X-ray spectroscopy (FE-SEM-EDS) was the first such instrument acquired by the HCC. It examines surfaces, producing micrographs of their topography and detects chemicals which often elucidate the alteration mechanisms of materials.

The Confocal Scanning Laser microscope (CLSM) is another analytical tool. It provides supplemental information to that obtained from FE-SEM-EDS, by precisely measuring the features of surfaces. For example, it measures corrosion of metals, depth of cracks in glass, or indicates how thick a transparent coating is on an oil painting. The resulting data sheds light on the state of preservation, informing conservators as they design an optimal treatment strategy.

The chemical nature of materials and products of their deterioration is characterised by several different instruments. In general, the inorganic elements such as lead in white lead paint or zinc in zinc-white are easily revealed using an EDS detector that works in tandem with FE-SEM.

The Fourier Transform Infrared spectroscope with Attenuated Total Reflectance (FTIR-ATR) provides information about organic chemical compounds which assists in characterising paint bindings and varnishes on paintings among other organic-based components of artworks and artefacts.

Each instrument produces results that complement each other, creating a more complete picture of the artefacts and their place in museum collections.

Tracing cultural traditions and artistic connections through materials analysis

The intricate details revealed in the course of material analysis is illustrated here using three examples of artefacts, each one made of different material: glass, clay and textile fibres, and created in a different geographic location and time.

First, we examined the glass beads from a pair of Peranakan slippers (Figure 1), dated from the early twentieth century, which pointed to trade connections between Singapore and Europe. Next, a clay statue created by Rakhal Das Pal (1834–1911), a prominent Bengalese artist, revealed through an analysis of its clay the artist's techniques of working clay. Finally, a cheongsam made in Singapore in the mid-twentieth century, elucidated manufacture techniques that made use of early polymer fibres and the techniques used in their decoration. The types of analysis involved for each of these three artefacts are elaborated in greater detail later in this article.The findings, however, are preliminary as each artefact is still undergoing laboratory investigation, thus it is a work in progress.

The selected examples demonstrate not only the diversity of analysed materials but also a broad span of scientific questions posed by each material and artefact. Although the analytical methods were similar, the collected data was uniquely relevant to each artefact.

The glass beads from the Peranakan slippers were selected for analysis because of evident deterioration, cracking, spalling and presence of white powdery deposits. The analysis aimed to understand the deterioration processes through surface morphology with FE-SEM and chemical mapping of deterioration products in EDS. Both instruments indicated chemical breakdown of soda-lime glass.

Figure 1. Early 20th century glass beaded Peranakan slippers. Asian Civilisations Museum, 2009-01573. Collection of the Peranakan Museum. Given by mama seet. SPP. Seet Mui Kok wedding. Image courtesy of the National Heritage Board.

Figure 2. Detail of the pink coloured glass bead, micrograph taken with Confocal Laser Scanning Microscope, showing deterioration and cracking of the outer glass layer. Scale 100µm. Collection of the Peranakan Museum. Given by mama seet. SPP. Seet Mui Kok wedding. Image courtesy of the Heritage Conservation Centre, National Heritage Board.

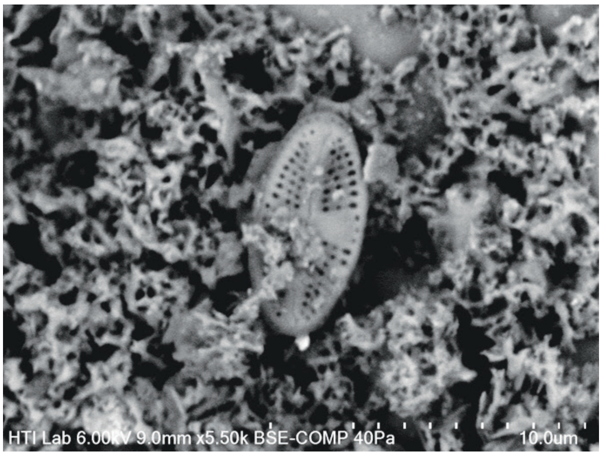

Figure 3. A micrograph of a silicon diatom frustule taken using a Field Emission Electron Scanning Microscope, Hitachi SU5000, Scale 5µm, magnification 5,500x. Image courtesy of Heritage Conservation Centre, National Heritage Board.

Exotic impurities, such as arsenic, found in one of the beads pointed out their link to international trade routes. Arsenic in glass has been associated with Italian manufacturers who have used it as an opacifier as early as the sixteenth century (Sempowski 2000, Sugar 2008).

A revealing find detected during FE-SEM examination showed a well-preserved silicon frustule of a diatom 5 microns in diameter, indicating that the slippers had been exposed to damp soil (Figure 3). Diatoms are microscopic algae living in oceans as well as in fresh waters and in damp soil. Their characteristic biogenic silica frustules are used in diagnostic studies of environmental changes, while their specific chemical makeup may indicate the provenance of an object on which they were located, in the case of "narrow endemics" restricted to a small region of occurrence. However, according to an expert in the field, Dr D Mann, our diatom, most likely Luticola mutica or another closely related species, occurs on soils or in terrestrial mosses in many geographic areas (Crawford & Mann 1990). Therefore, the diatome could not serve as a diagnostic feature, besides pointing out to the wet environment in which the slippers were used or exposed to.

The second example, the Bengalese clay figurine, underwent analysis in conjunction with its preservation for the inaugural exhibition at the newly opened Indian Heritage Centre in Singapore. The figurine is part of a larger group representing various local servants and tradespeople (Figure 4). These clay figurines, made in the late nineteenth century in Krishnanagar, West Bengal by renowned sculptor Rakhal Das Pal, are highly detailed, life-like, and were made to be displayed at the world fairs.

The reddish clay appeared to be original while the yellowish clay suggested filling material. The characterisation of the original and filler materials was the main focus of the analysis, which aimed to guide the conservation decisions. In order to ascertain if the repairs were done by the artist, or at a later stage by a restorer, a correlation between the varying compositions of the original and filler clays had to be established.

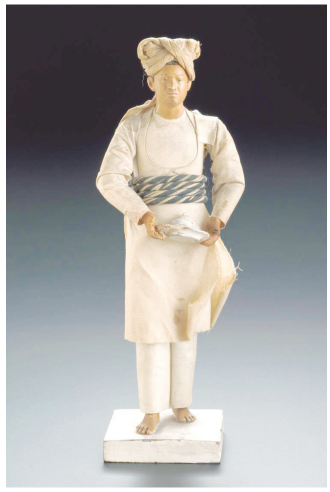

Figure 4. Man holding a plate, West Bengal, Rakhal Das Pal, clay figurine. The Indian Heritage Centre, NHB, 2012-00786. Image courtesy of the Indian Heritage Centre.

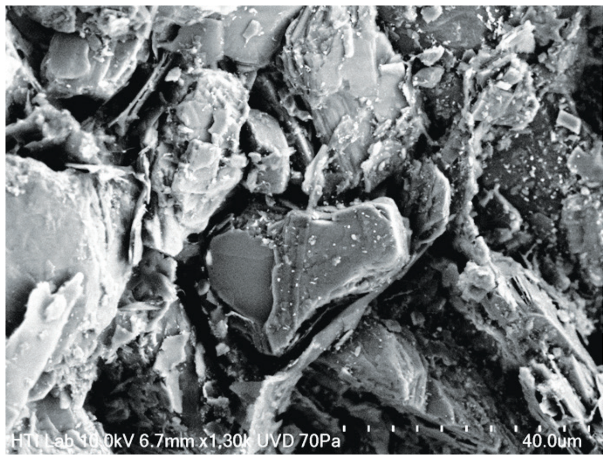

Figure 5. A micrograph obtained using FE-SEM SU 5000 showing the mineral microstructure of well-defined clay particles indicating air-drying technique of clay, magnification 1,300x, scale 20 microns. Image courtesy of Heritage Conservation Centre, National Heritage Board.

Information gained from the surface morphology and microstructure of clay using FE-SEM revealed insights into the clay drying conditions. Typically, if clay is fired, many changes in morphology and the structure of crystalline clay minerals take place, transforming them into a non-crystalline mixture, whereas well-defined particles can be recognised in non-fired clay (Swapan et al., 2005, Castellanos et al., 2012).The latter was observed in the samples of clay from both the original and two filler materials, pointing to a non-firing technique (Figure 5). Furthermore, the presence of vegetal fibre (Figure 6) confirmed the historically known use of straw and grasses in indigenous and local clay production techniques in India.

Cross referencing the analytical findings with bibliographic sources confirmed that the practice of air-drying clay has been known in Krishnanagar, where our figurines were created. The reason for the air-dried approach stems from an Indian cultural belief that the water element is part of a material's composition and the firing process will remove life from within the clay, depleting it of the sacred power of water (Das 2008, Stevenson 2009, Smee 2010).

Figure 7. Cheongsam, National Museum of Singapore, NHB national collection, 2012-00786. Image courtesy of the National Museum of Singapore, National Heritage Board.

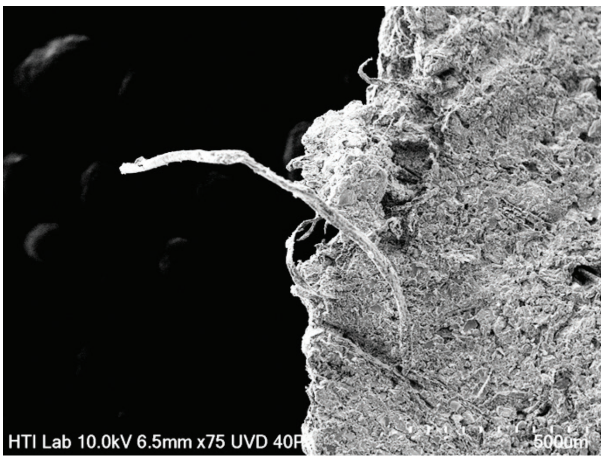

Figure 6. The presence of vegetal fibre in the filler-clay confirmed the traditional use of vegetal material fillers. A micrograph obtained in FE-SEM SU 5000, scale 250 microns. Image courtesy of Heritage Conservation Centre, National Heritage Board.

The third artefact that underwent material analysis was a cheongsam. This dress which originally belonged to Mdm Wu Chuen Chuen (1915–2004), the owner of Stamford Café, a popular Western food eatery at Bras Basah Road from the late 1940s to the 1960s. It was selected because of severe deterioration of a decorative layer. The analysis aimed to establish the mechanism and causes of this deterioration to assist a conservator in designing an optimal stabilisation technique which eventually would facilitate display of the dress.

The term cheongsam refers to a tightly fitted dress with an asymmetrical diagonal neckline closure that was popular in the mid-twentieth century in Singapore (Lee and Chung, 2012). The use of new synthetic materials, such as polymer fibres, was on the rise, yet their longevity and interaction with other materials were not well known at that time. The textile fibre was determined to be of acetate based as indicated by FTIR spectra; the adhesive appeared to be nitrocellulose, which is known to degrade over time (Shashoua, 1992). The severely degraded decoration prevented any safe movement of the dress without causing shedding of the paint applied on the surface; the bond between the textile and the decoration had failed.

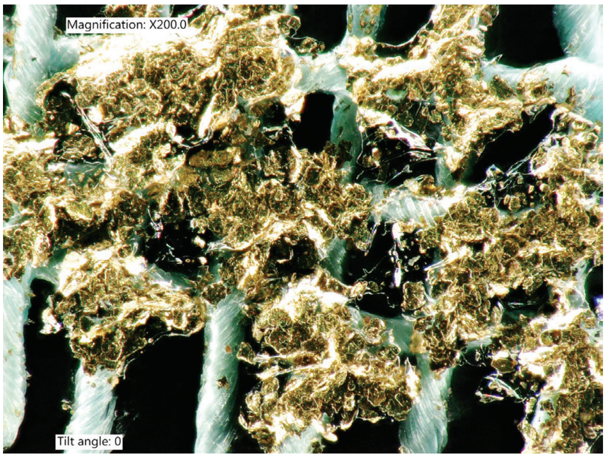

Figure 8. SEM micrograph showing poor adhesion between the fibre and decoration. The pattern of the fibres indicates an extrusion method characteristic of synthetic polymers. Image courtesy of the National Museum of Singapore, National Heritage Board.

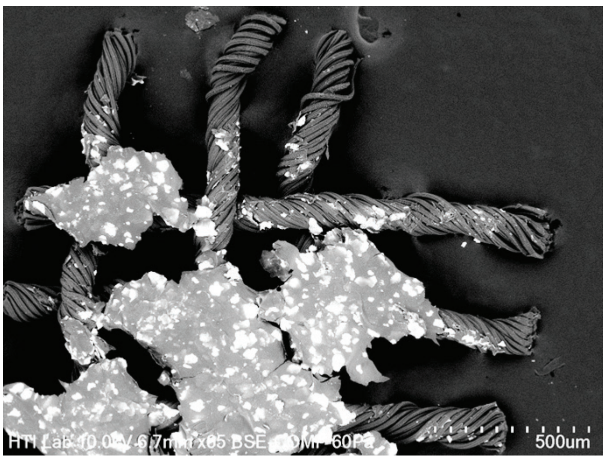

Figure 9. Digital micrograph acquired in a 3D Laser Scanning Microscope showing a cluster of metallic paint flakes suspended in adhesive. Image courtesy of the National Museum of Singapore, National Heritage Board.

In the course of analysis in FE-SEM-EDS the surface morphology of the fibres showed extrusion patterns such as elongated ridges which are typical for manufactured synthetic fibres. The paint was a mix of brass metallic particles suspended in a material that served as an adhesive. The confocal laser scanning microscopy traced the interface of paint flakes with the fibres, confirming their loose positioning on the surface of the fibres' matrix.

The analytical results assisted the conservator in designing a treatment that stabilised the decoration of the dress. Detailed reports of the analytical and conservation processes are on file at the Heritage Conservation Centre.

Closing remarks

The case studies presented here highlight the range of materials that are currently undergoing analysis at the Conservation Science Laboratory at HCC. They offer a sample of the broad scope of research projects that will be undertaken in the near future, for the benefit not only of the NHB-HCC's staff of conservators and curators but also to demonstrate the laboratory's potential for serving the Southeast Asia region as a resource centre. The scientific data produced in the course of examination forms part of the permanent records of the National Heritage Board.

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