A Stitch in Time - The Discovery, Analysis and Conservation of a Melbourne c.1870 Frockcoat

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ABSTRACT

In an Australian context, historical archaeological textiles are rare, and potentially significant finds. In 2015 during an historic archaeological excavation in Melbourne's CBD, archaeologists unearthed a bundle of fabric and thread from an unlined rubbish pit that, when examined by conservators, was found to be pieces of what was once was a frock coat or jacket dating to c1870. This paper will discuss the discovery, conservation treatment and subsequent analysis of this archaeological textile. The discovery of the textile, and the story of its conservation and analysis, provide a rare insight into the manufacture of mid to late nineteenth century clothing and is highly evocative of Melbourne's urban past.

KEYWORDS: *Textile archaeology, scientific analysis, conservation, wool*

INTRODUCTION

In February 2015 archaeologists were called to a site on the corner of Franklin Street and Elizabeth Street in Melbourne's CBD, Australia. The original use of the site was dated from 1850s-1900s, between that period the block was owned by Samuel House & Co. corn and hay dealers from 1857 to 1870, then subsequently by Greenwood and Inman who were corn and produce merchants from 1875 to about 1890. The excavation of 452 Elizabeth Street revealed many objects from an unlined rubbish pit that included a number of ceramic cosmetic containers, complete bottles, a belt fragment, leather shoe soles and structural fixings including nails (Paynter, 2015, pers comm).

A bundle of textiles was also excavated by archaeologists and was identified as being irrelevant and should be discarded. Due to the rarity of textile finds in the archaeological record generally, a conservator visiting the site recovered the bundle of textiles and suggested that it be examined it at the Grimwade Centre for Cultural Materials Conservation at the University of Melbourne.

Initial conservation analysis allowed us to visualise the textile as a whole and lead us to previously hidden clues about the textile's form and style, how it came to be abandoned and why it has survived and come to be in its present state. The future use of the textile will determine the path this research takes; at this stage it is unknown if it is to be displayed, however, it has provided a rare opportunity for research. The analysis of the textile could potentially yield information about its preservation, its past use and its reason for being discarded in the 19th century by its owner, and this information would become a significant contribution for the field of Australian historical archaeology.

THE HISTORY

The Archaeological Context

The context and significance of the textile was taken into consideration prior to any treatment undertaken to ensure the integrity of the textile is maintained. Understanding the context and determining the role of the textile influences the conservation treatment of the textile (Eastop, 1998, 277) and, in order to continue, research was carried out to determine the date the textile was in style. The initial information from the archaeologists regarding the date of the site commenced from the 1850s onwards (Paynter, 2015, pers comm). The property at 452 Elizabeth Street, a block on the corner of Elizabeth and Franklin Street, Melbourne, was subject to archaeological excavation work prior to construction of a new building.

Ochre Imprints archaeologists began work on several trenches where cultural material was found. The bundle of textiles was lifted from Area A, Trench 5 in the southern eastern corner of the site. The following information was provided from the archaeologists:

> '*The unlined pit is likely relating to our earlier phases of occupation of the site (sometime between 1850s-1900). We have structural remains from a number of buildings across the site, likely dating from the mid 1850s. These included in situ wooden posts that related light industrial uses of the site including grain merchants and an associated steam chaff mill.* (See figure 1). *These structures are in an early isometric plan of the city. The rates show that this block was occupied by Samuel House & Co. corn and hay dealers from about 1857 to 1870, then subsequently Greenwood and Inman, corn and produce merchants from 1875 to about 1890.' (Paynter, 2015, pers comm).*

A 600mm thick layer of clay lay over the top of the pit; this was used as site levelling for later buildings in 20th century and is likely to have aided survival of the textile by effectively sealing the burial environment. An iron gatic was placed directly over the top of the pit providing easy rubbish disposal. Soil from within the pit itself was a reddish brown silt clay with a high organic content including rootlets and wood, these were evident on the textile.

A large pocket of trapped water was at the base of the pit and the site was tested for contamination. The tests revealed heavy metals were present, such as lead, chromium and mercury.

The area of contamination was located near the grain store and it likely that the textile may have been exposed to heavy metals. A soil assessment was undertaken of 5 boreholes across the site. The soil readings were very acidic and ranged from PH3-5. Grain stores from 1850s-1870s used a form of inorganic mercury, known as mercuric chloride, and chromium, both as anti fungal and anti-bacterial agents to preserve grain stock (Christensen & Kaufmann, 1969, 57). Organic materials are more often than not degraded by microbial activity in the ground, in this case the contamination may have saved the textile. This is an area of the research that will be investigated further.

MELBOURNE'S COLONIAL HISTORY

The city of Melbourne was founded in 1835 when the first European settlers arrived in Port Phillip Bay. The Golden Mile was founded in 1837 by Governor Bourke, this consisted of a grid of roads one by one and a half miles and most of the surviving architecture from this period in the Golden Mile post dates 1855 (Lewis, 1995, 12). The property at 452 Elizabeth Street, where the textile was excavated, was located on the outer edges of the grid in the 19th century, but in present times is now in the heart of the CBD.

The pastoral industry was one of the founding reasons that Melbourne became a settlement in the early part of the 1800s.

Figure 1: The Chaff Mill site in 1870 where the textile was discarded and excavated. Source: Charles Nettleton, 1870 (State Library of Victoria H96 160/1467)

Farm labourers arrived in Melbourne on the first fleet of emigrant ships in 1839 (Lewis, 1995, 15) and the first plots of land were sold and pastoral plots were set up to grow hops and grains. The boom in the agricultural industry was not to last long and the city was plunged into an economic recession in 1840. Change only happened in Melbourne at the discovery of gold in 1850 in regional Victoria reviving the city and attracting immigrants from around the world, more than half a million people arrived to 'make it rich' in the gold rush (Tout-Smith, 2008, 27).

The city flourished and rich Europeans changed the look of the city with European boulevards lined with trees and open parks near Bourke Street, Collins Street and Swanston Street. Historical plans that were drawn in 1866 show how the far end near Elizabeth Street and Franklin Street devoted itself to the industrial side, with mills and factories. The pastoral industry was evident early on in Melbourne where grain merchants, such as Samuel House & Co. and Greenwood and Inman, set up business. An advertisement in *The Age* newspaper in 9th December 1859 describes the business:

> *Samuel House and Company, Steam Mills,*
> *264 Elizabeth Street, hay, corn and flour dealers.*
> *All kinds of grain crushed on the premises. Orders Punctually attended to, and goods delivered to any part of Melbourne or Suburbs*
> (Ochre Imprints, 2015, 4)

An article from the *Launceston Examiner*, and *Commercial and Agricultural Advertiser* newspaper (Burgess, 2009), on Saturday 3rd September 1870 states that Samuel House & Co also owned premises at Queen Street and had called a meeting of creditors.

This suggests that the economic downturn in this industry was indicative of the troubled times in Melbourne's business community. Whilst the company was registered at Queen Street, Samuel House & Co may have located their chaff mill on Franklin Street. The company came to an end in 1870 and Greenwood and Inman took the plot over 5 years later. 'In 1870s and 1880s the frontier aspects of Melbourne had begun to fade' (Flannery, 2002, 24) and by 1890 the city was in a deep depression (Flannery, 2002, 26), the rise and fall of Melbourne coinciding with the reign of Queen Victoria from 1837-1901 (Author Unknown, 2000, 3).

THE CONTEXT NOW

Textiles are quite rare finds in a burial context in Australia, and many are not always recognised by the archaeologist for this reason (Jones *et al*, 2007, 4). In many cases they are not aware of the textile's importance, other professionals such as conservators may shed light, and in this particular case they did just that. Archaeological textiles are also difficult finds because of their organic nature and the decomposition that occurs naturally, however, rubbish pits are common examples of accidental preservation in an anaerobic environment such as this (Brooks *et al*, 16). The textile was found in a damp state, and although unidentified at the time, it was recovered by a conservator and brought to the Grimwade Centre for Conservation in a sealed polyethylene bag to ensure the textile did not dry out until further investigation in the laboratory was carried out (Jones *et al*, 2007, 6). The textile was heavily soiled and unravelled in a sink. *(See figure 2).*

Figure 2: The frock coat unravelled in a sink after being lifted from 462 Elizabeth Street. From left to right, a bundle of threads and sleeves and a small button panel. Proper left front of the coat and Proper right front panel with buttons and metal objects attached. © Photographed McCullagh, 2015

Initial observation indicated that there were various separate panels and, if sewn together, were likely to make up a pattern of a complete coat. There are two large panels that make up the front of the coat, a separate smaller panel that has five buttonholes and a large bundle of material held together by metal that were possible sleeves and collars but in that state were yet to be identified.

There was also a large bundle of spun thread or yarn found with the textile and many threads were attached in various places to the other panels. The threads have a crimped effect that would suggest they have previously been used in either sewing or weaving. The initial hypothesis was that the coat panels had been cut and yet to be sewn together for the wearer.

MELBOURNE AND ITS FASHIONS

From the information given by the archaeologists regarding the time period and the shape of the coat, research into the history and style of costume from early colonial Melbourne began. An assumption was drawn that the coat was possibly a men's coat due to the nature of the site in which it was found. Investigations into fashion started from 1840s onwards in order to categorise the style and period.

The history of Melbourne and the work life style played an important role in men's fashion in the late 1850s onwards. With the gold rush in place, sturdy boots, coats and trousers were standardised, this minimised the class divide where servant and master were seen to wear the same clothes (Joel, 1998, 20 & Fletcher, 1984, 93). Immigrants arriving from Europe were clothed in the latest fashions of the time in frock or dress coats however this was not accepted and dressing down was considered rule (Joel, 1998, 20).

The working class were encouraged by the British government to move to Australia, skills in farming, bricklaying, blacksmiths and joiners were of use to building the new colony (Jarvis, 2010, 81). Practical and plain clothing was encouraged before departing from England for climate reasons and everyday wear; this became standard dress for the working class in Australia.

The short square pea coat and shooting jackets was a favourite working coat for comfort and the lounge coat suited the outdoor lifestyle (Fletcher, 1984, 128). Although the casual look was becoming increasingly evident from the 1850s through to the 1880s, standards were still set by trends in England and descriptions of the colonials were said to own four different types of coat including the morning coat, frock coat, dress coat and overcoat (Fletcher, 1984, 104). The frock coat was a popular choice considered the most dignified however was replaced by the morning coat towards the end of the 19th century (Davies, 1994, 42).

Patterns of frock coats can be found in various books where a standard block pattern (1) can be compared to the archaeological textile.

There are many variations of a frock coat that are similar to the pattern of the archaeological coat however one such pattern in 'Men's Dress 1820-70' of a frock coat with wide sleeves is possibly the closest pattern.

The frock coat from the 1850s onwards was either double-breasted or single breasted and the length was increased from earlier styles. Where the sleeves had previously been tight fitting, these were now replaced with wider, more loosely fitted sleeves, the collar became broader and moved closer to the neck (Köhler, 1963, 407).

The skirt, compared to the morning coat, was much fuller in order to provide walking room (Various, 2011). Comparisons to the drawings and photographs confirm that the textile is likely to be a double-breasted frock coat.

CONSERVATION TREATMENT

Initial Observation

The textile panels were heavily soiled with mud and organic matter such as rootlets. On all panels, excluding the buttonhole panel, metal objects were attached that were causing stress to areas of the textile and distorting the shape. Elements of corrosion were visible and identified by the reddish orange staining, it was highly likely that the metals contained iron and were actively corroding and if not treated immediately would put the textile at risk.

Block patterns are a standard pattern that can be customised to the shape of the person or different elements can be added to enhance the style (Aldrich, 2009, 5).

The textile was unravelled in a sink and exposed to the atmosphere, evaporation took place in a climate-controlled area with temperature of the room at 22.6 °C and 46.5% relative humidity (RH), this was slightly below the recommended RH of 50% (Rodgers, 2004,169).

If water was lost too quickly then cells would collapse and cause shrinkage (Timar-Balaszy & Eastop, 2012, 285) however, the speed of drying was slow over a two week period. The textile was monitored and no severe shrinkage occurred. Wet textiles that are taken from an anaerobic environment and exposed to an aerobic environment can be subjected to micro-organism growth (Gillis & Nosch, 2007) however this has not occurred on the textile.

MATERIAL IDENTIFICATION

Identification of the material was critical in order to determine the correct treatment. Due to its wet nature from the archaeological site, the garment appeared to be either a napped leather or suede or felted wool as no weave could be seen on the surface, both of these are robust materials that are more likely to survive a burial (Rodgers, 2004,164).

By process of elimination, the material was identified by using digital microscope and FTIR. Identification of the material using the smaller button panel was preferable as there was less surface dirt on the underside of the panel and there were areas that were unaffected from visible corrosion staining. A digital microscope revealed what appeared to be napped surface where fibres or hairs appear to follow in the same direction.

A comparison was needed and a suede shoe under the microscope revealed very little similarities. Suede has visible hair follicles that are characteristic of skins and therefore, it was possible that the material was not a skin.

Removal of surface mud on the textile panels was necessary to reveal other characteristics and details for identification. This was achieved by a dry mechanical clean using bamboo sticks to dislodge the mud from the surface. A warp and weft were revealed along the edge of the large front panel.

This determined that the garment was woven and concluded that the textile is not a skin but could be a protein or cellulose composition, most likely wool or cotton. The weave of the material is a plain or tabby weave and very tightly and evenly woven. The areas that revealed the weave were on the front hem edges of the coat, the top layer of pile had been worn away indicating that the coat had been worn and used. Buttons were already attached to the large panel and some areas indicated stitch holes, but no threads, present indicating that the coat had been previously stitched together and then taken apart.

Fourier transform infrared spectroscopy (FTIR) is a technique used for fibre identification that is non-invasive and easily characterises cellulose and protein fibres that would determine if the coat is wool or cotton (Stuart, 2007, 131; Greaves & Saville 1995, 47). FTIR was performed on the small buttonhole panel on the inside of a folded seam on a clean surface uninhibited from dirt and visible corrosion. Two readings were taken from the buttonhole panel in different areas of the folded seam. A further two readings were taken from a separate loose bundle of threads that was found with the garment.

The scans show that the separate threads and the panel are the same material. Peaks at 1650 and 1500 show that the material is protein based and is either wool or silk. These fibres are built up of amino acids that link together to form a protein and mainly made up of keratin (Greaves & Saville, 1995, 2; Timar-Balazsy & Eastop, 2012, 23).

Due to the heavy nature of the material is more likely the material is wool. Protein based fibres subjected to an anaerobic burial are proven to survive more so than plant based material and will generally rot more rapidly due to microbial action (Annis, 2012, 194). This may indicate a reason why the textile has survived such a burial.

TREATMENT PROPOSAL

The intended outcome was to stabilise the panel from further degradation and to remove as much soil and as many metal compounds as possible in order to maintain for future preservation. It is unlikely that the textile will be displayed and it is likely to be used as a potential research project for the archaeologists at Ochre Imprints at a later date.

The initial treatment involved a dry clean to remove the surface soil and objects. The textile had already dried out in the sink and the soil was encrusted onto the surface and therefore should not be brushed or vacuumed as this would potentially break the fibres. The textile was not rewetted once dried, as this would cause the fibres to become brittle (Gillis & Nosch, 2007, 14).

THE ISSUES WITH WASHING ARCHAEOLOGICAL WOOL

The textile, although a sturdy object, was not wet washed in an immersion bath for numerous reasons. Saturating wool with water allows the fibre to soak up to 200% of its dry weight making the wool extremely vulnerable, this would make already degraded wool fibres susceptible to mechanical damage when washed (Timar-Balazsy & Eastop, 2012, 51).

This causes disproportionate changes to the dimensions of the wool fibres and can rupture the original hydrogen bonds. Humidification also affects the links between bonds and can cause shrinkage on drying (Timar-Balazsy & Eastop, 2012, 51). The issue with the possible metal compounds such as iron, mercury and chromium impregnating into the protein polymers was also a concern. Testing for metals using p-XRF had not yet taken place and therefore until the full content of the textile was tested, washing was not an option being considered.

There was a possibility that that washing could potentially remove metal compounds that had sustained the life of the textile and wet washing may remove the metal ions that had attached themselves to polymer chains making the textile structurally unstable if removed (Timar-Balazy & Eastop, 2012, 224).

Wool can be prone to bacterial attack in a burial situation and then after when exposed to an aerobic environment, however it is known that certain metal salts such as iron corrosion that were visually identified in this particular textile, can deter biodegradation (Hearle *et al.,* 1998, 379). Isolated areas that have significant stress and creasing may need humidification i.e. areas that have been attached to metal objects are the creases are causing the area to break.

There are also elements that would be affected by a total immersion wash such as the buttons. Two buttons were present and evidence of three more from iron corrosion staining. Wet washing could potentially damage the buttons that have survived and remove the evidence of the buttons that have not survived and 'minimum intervention is therefore considered the appropriate treatment for archaeological textiles in order to preserve both the artefact and information relating to function and survival' (Brooks *et al.*, 1996, 16).

DRY CLEANING AND MANUAL CONSERVATION TREATMENT

A mechanical dry clean was performed on all textile panels to remove the initial layer of surface dirt. This consisted of using a dental pick to dislodge the hard crust of soil on the surface, using a stabbing motion to loosen the particles; in heavily crusted areas the back curve of the dental pick was used to remove larger areas.

A wooden stick was used for the soil with a very thin surface layer, caution was taken to use a minimal dragging or sweeping motion, as this would impregnate the soil further into the woven fibres and cause abrasion to the surface fibres. Although this was a very time consuming method, it was necessary so that further damage would not weaken the wool fibres. Wool is a relatively weak fibre and any major mechanical motion could break the fibres (Finch & Putnam, 1977, 16).

A vacuum with a small nozzle covered with tulle was used on a low suction to remove the dust and soil (Powerhouse Museum, 2013).

Most of the soil had formed a hard crust and was easy to breakdown with a stabbing motion, this loosened the soil from the textile and fell away easily. Some of the soil was still soft and white particles were evident, these were most likely to be a calcite or soft chalk in the soil. The smaller textiles were contained in a polypropylene bag that was cut down the middle and used to restrict the amount of dirt in the work place. All panels were transferred onto corrugated board in order to limit the amount of handling.

Creases in the material relaxed after the soil was removed, putting less strain on the textile. No humidification was needed and the decision to not put further stress on the textile was taken. This could have resulted in further corrosion of metal compounds present and further swelling and binding of materials (Timar-Balazy & Eastop, 2012, 16). Stabilisation of the rip and tears in the panels were decided against, as this would be adding additional new materials to the panel. Sewing into the panel to stabilise the tear may create undesirable holes because of the fine weave.

The textiles are unlikely to be handled in the future and will be stored appropriately so that there will be no stress to the tears and rips to cause further damage.

DYE TEST

After the initial dry clean had taken place the next step was to remove the metal objects that were attached to each panel. A mechanical clean was not effective in removing the metal and other methods were explored. To loosen the corrosion, deionised water would be used first used. Deionised water or distilled water is an aggressive solvent and cleaner by dissolving large ion compounds and has a high solubility rate (Timar-Balazsy & Eastop, 2012, 187). The water has all ion cations removed and therefore when introduced to a textile with high metal compounds the water takes on the metal ions effectively removing them from the textile.

If this method were not effective then further introduction of a chelating agent such as Ethylenediaminetetraacetic acid (EDTA) would be used. To ensure that dye would not be lost on the introduction of water, a colourfastness test was performed.

The test would identify if the dye is colourfast when using deionised water and to observe the reaction of liquid when introduced to the fibres. CCI notes states that a test with deionised water should be undertaken before the introduction of any chelating agent or conservation grade detergent to the textile (CC1 notes, 2008, 13/14). The test was performed on the back of the small button panel on the cleanest part of the textile. A few drops of deionised water was dropped onto the textile and covered with blotting paper, MylarTM and a weight. The water soaked in very rapidly due to the nature of wool as it has a high saturation point (Timar-Balazsy & Eastop, 2012, 51).

It was shown that the dye is colourfast against water and stable on the introduction of liquid. No dye was transferred to the blotting paper after 30 seconds, 2 minutes, 5 minutes and 15 minutes. No watermarks were visible on the textile.

The deionised water limited the amount of airborne dust when mechanically removing the corrosion and the pipe with a dental pick, however was not successful in removing the pipe as anticipated, an EDTA spot test was performed and monitored and reacted well with the textile.

Archaeological iron consists of various layers of corrosion products, the outer layer of the corrosion would consist of deposits of soil minerals, small rocks, sand and clay. Underneath is a layer of iron corrosion of a lower oxidation state lying on top of the metal itself (Sewlyn, 2004, 295). Untreated iron will continue to corrode causing further damage to the textile it is attached to and will continue to corrode even if stored at less than 15% RH (Sewlyn, 2004, 297 & Turner-Walker, 2012, 5). The RH of the room in which the textile was being treated was 46.5% therefore was actively corroding.

On the large panel where the hollow pipe was attached a dry clean was necessary to understand how the pipe was adhered, therefore the soil and corrosion surrounding the pipe was first removed by dental picks and wooden stick and carefully vacuumed away *(See Figure 3)*. MylarTM was placed underneath the corrosive pipe isolating the dust and soil from the already clean textile. More archaeological textiles were also attached to the join on the underside of the pipe that was not part of the main body of this panel.

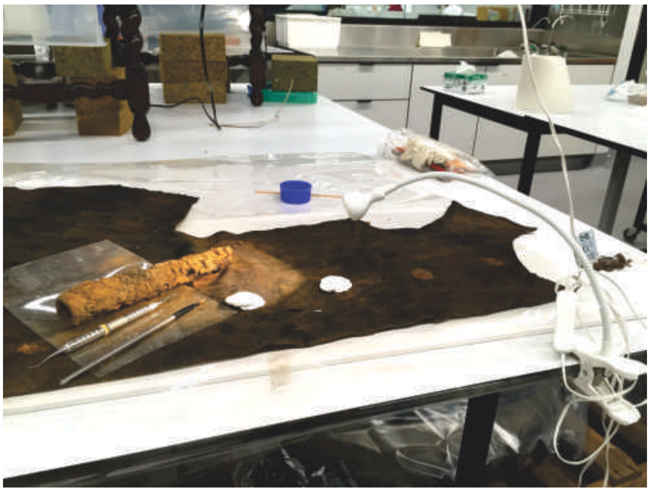

Figure 3: Metal pipe attached to the woollen fibres the by a 4cm join. Photo taken after the mechanical clean around the join. MylarTM was placed underneath the pipe. © Photographed McCullagh, 2015

Chelating agents are used to remove localised metallic corrosion stains from textiles by removing the metal ion from its surrounding environment (Rodgers, 2004, 167; Timar-Balazsy & Eastop, 2012, 221). EDTA is most commonly used in textile conservation and can be used either by immersion or localisation. It has a low cleaning power and ideal for unstable archaeological textiles (Landi, 1998, 72).

By removing the metal from the textile this would prevent further reaction and will ensure long-term stability of the textile. EDTA can form up to 6 bonds with the metal ion, effectively surrounding the metal ion and reacting as a 'claw' to remove the metal ions from the textile (Zuhmdahl & Zuhmdahl, 2010, 965).

The remaining two buttons were covered with Tyvek™ (woven polyester material) throughout the dry clean and removal of the pipe to prevent further damage. A solution of 5% w/v ETDA was made with distilled water and applied to the joins. The solution penetrated around the pipe and onto the textile, ensuring that the solution was localised which minimalised the amount of moisture exposed to the wool.

Mechanical removal using a dental pick was undertaken by scraping away at the metal, however the fibres weakened considerably and the separation of the fibres to the metal is not possible without the fibres breaking. The area was rinsed with deionised water to remove EDTA from the area. Consideration was taken to ensure that the removal of the pipe by scraping the area of pipe instead of the fabric.

Overall this could not be helped as the pipe has completely impregnated itself into the fabric, and separation was unachievable without irreversible damage. The fibres around the pipe broke leaving a hole where the pipe was attached. Removal of the pipe was essential, as further corrosion would have occurred penetrating the textile if left attached.

On the other panels the metal was not as easy to remove. The last piece to be conserved consisted of two sleeves joined together by two separate metal objects about 15 cm apart. The sleeves were very distorted with lots of folds and pleats putting stress on the heavily embedded iron corrosion on the surrounding areas of the metal and fabric.

During treatment the fabric was breaking severely as many areas were not supported, the fibres broke even prior to the application of EDTA. A 5% w/v EDTA solution was used on the areas to separate the metal and the fabric however this again severely weakened the fibres and this method was halted to avoid further breaks.

It was possible that the iron objects would not completely detach from the fabric as 'overtime metals irons cay migrate to and eventually completely replace the organic constituents of the material, leaving a mineralised replica, known as pseudomorph, of the fibres and the textile structure' (Annis, 2012, 194). This may in fact be the case and microscopic analysis is needed to determine if the fibres have pseudomorphed and mineralised.

Overall Treatment Time

The treatment for the mechanical dry cleaning of the textile fragments totalled 96 hours.

SCIENTIFIC ANALYSIS

We do not always understand the full story of an object or a textile when it arrives at a conservator's bench. Our intention is to extract information and piece together the story and historical significance of the artefact. Much of the information we require is not documented and therefore observational skills and scientific analytical techniques are essential in providing this information. Deciding which techniques should be used to answer questions on the conservation of the textile must be established in order to determine the optimum preservation outcome (France, 2004, 3).

The questions that need to be answered are; what is the type of material? How degraded is the fibre? What are the chemical contents of the textile? and Why has this textile survived in a wet anaerobic burial? More questions will be raised throughout the investigation as new evidence comes to light and a clearer understanding of the textile is revealed.

Establishing the state of the textile and the degradation of the fibres is key to understanding the textile's strength and chemical stability (France, 2004, 3).

These factors will also help to understand the provenance of the textile at a more analytical level by unveiling other historical evidence that is present from soil and other particulate matter (Garside, 2009, 355).

Preliminary investigations using microscopy and FTIR were undertaken to identify the material during the initial stages of treatment and further examination using these techniques are described below. Further investigation using scanning electron microscopy (SEM) was undertaken to further determine the state and degradation of the wool fibres.

Portable x-ray fluorescence (pXRF) was used to understand the chemical compounds of the textile. It was decided that a burn test was unnecessary to perform on the textile to identify the fibre as there were other methods of analysis available that were less destructive.

THE STRUCTURE OF WOOL

The hypothesis was that the textile was mostly likely to be wool. The structure of wool can easily be identified visually by microscopy. Each fibre has a multifaceted sheath where surface cells overlap to look like scales also known as the cuticle (Gohl & Vilensky, 1983, 69 & Timar-Balazsy & Eastop, 1998, 49), however, the variation in smoothness of scales will vary with types of breeds and the processing treatment prior to manufacturing (The Textile Institute, 1985, 6).

Silk fibres on the other hand have a smooth continuous surface and are triangular in structure causing the silk fibres to slightly twist (Gohl & Vilensky, 1983, 85). These two protein structures are visually very different and this will ensure easy identification.

Wool proteins are made up of 19 amino acids and belong to a group called hard keratins known as *a*-keratin (Timar-Balazsy & Eastop, 1998, 48). The group of amino acids has a high content of sulphur called cysteine that makes wool fibres sensitive to alkaline conditions. 'Protein fibres contain amorphous and crystalline regions. The high sulphur content are concentrated in the amorphous regions' (Gillard *et al*, 1994, 133) and the bonds are generally attacked first which results in a breakdown of the fibres.

In acid conditions, the sulphur bonds have better stability and hold their structure therefore surviving in burial conditions but will break down through oxidisation once exposed in an aerobic environment (Gillard *et al,* 1994, 133). It is important to test the soil that the textile was buried in to understand the chemical degradation process of the fibres. The soil that the textile was found in was extremely acidic which contributed to the survival of the textile.

FOURIER TRANSFORM INFRARED SPECTROSCOPY

FTIR is used to identify compounds in textiles by analysing polymer structures in fibres through IR radiation. The wavelengths emitted are absorbed by the chemical bonds present in the textile thus resulting in identification of material (Greaves & Saville, 1995, 46). The chemical bonds in archaeological textiles will have inevitably deteriorated, which may give anomalistic results however, will still classify the type of fibre.

Testing was performed previously to help identify whether the textile was either wool or plant based material such as cotton for initial conservation treatment. Further testing was needed to confirm that all panels were the same protein fibres. Only one panel was tested during the initial scientific analysis for identification, this was because the initial conservation treatment was time consuming and only the button panel was subsequently cleaned to a standard where a satisfying reading could be taken.

It was essential that all panels were tested and classified as the same material even though it is highly probable that they were the same material. FTIR was performed on all textile panels and three readings were taken on each panel on the cleanest areas. A minimum of three readings is important as there may be irregular random readings that may not correlate, thus the readings would then be inconclusive.

Readings were taken on four types of unaged wool as a comparison to the aged archaeological wool as these types of wool were readily available. Ideally, a comparison between aged and degraded wool would have produced better results however, this was not accessible. Accelerated aging of wool would have been a possibility where the wool is aged using UV lighting and heat however this was not possible to due time restraints.

All types of wool selected were from breeds that existed during the 19th century.

The readings show that the comparisons of the archaeological wool to the unaged wool are very similar. Each type of wool peak at the same wave number however varies in height slightly.

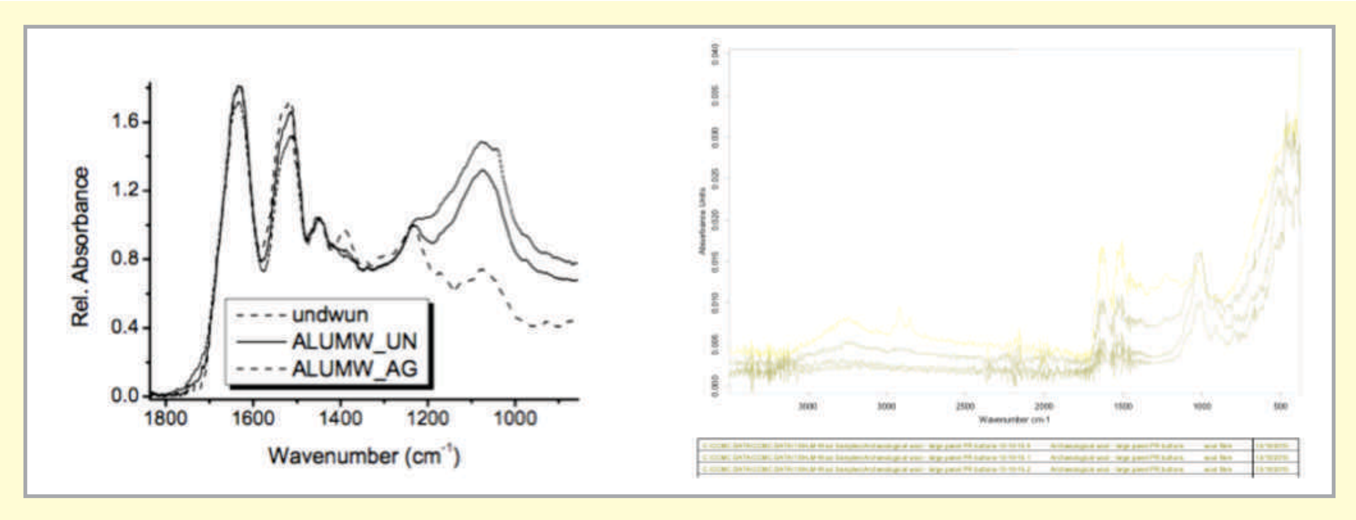

Figure 4: A comparison to aged wool with a dye on the left and the readings from the archaeological textile on the right show similar readings. The archaeological textiles peaks at 1040cm-1 may be due to a dye used (Odlyha, 2007, 13)

This indicates that the archaeological textile is a similar wool, however there are many variants that can cause different height proportion in the spectra of wool which will include type of sheep wool, manufacturing processes, dyes, ageing by heat and light and will be taken into consideration whilst analysing the readings.

Figure 4 shows three readings of the large button panel and an additional comparison to Shetland Moorit unaged undyed and Merino wool unaged dyed black. Noticeably, there are peaks between 1100cm-1 and 800cm-1 that do not correlate to the unaged wool. These peaks are consistent through all panels of the textile.

Much research has been undertaken by conservators into aged and unaged wool demonstrating that the effects of aging by environment, such as light and humidity, has a clear affect on the height of peaks. It indicates that fibres in the large panel are likely at different stages of degradation, and possible that proteins bonds have been altered by other environmental factors and minerals.

Parts of the textile will have been exposed to different chemical compounds in its burial state. Further testing by SEM and p-XRF will show chemical compositions that may have affected the fibre's deterioration.

Aging does not create random or extremely large peaks and therefore further investigation took place to understand the high peaks that are taking place between 1100 and 800. Research into the effects of dyes and mordants on historical wool has given suggestion to these peaks.

Testing on wool samples for alum mordants by Odlyha shows a definitive peak at 1040cm1- (figure 4), this means that the archaeological textile readings are possibly highlighting the type of dye that has been used (Odlyha, 2007, 13). It is possible that alum mordant has been used to dye the textile.

SCANNING ELECTRON MICROSCOPY

SEM is generally used to increase the resolution of the fibre compared to light microscopy and a more detailed picture is obtained of the surface of fibres (Greaves & Saville, 1995, 51). This type of analysis will confirm visually if the textile is wool or silk. It will also provide an insight into the fibre surface morphology that occurs with environmental degradation such as temperature, relative humidity (RH), biological attack, soiling and elemental damage (France, 2005, 6).

The high magnification of the fibres will determine how damaged or stable these fibres are and will have a direct result on the conservation treatment and storage of the textiles. Identification of the fibre using FTIR already determined that the textile is protein based and through research of fashion of frock coats from the 19th century it is most likely the textile is wool.

Four samples were taken from the textile from various different panels and bundles of threads.

All samples clearly show scales that indicate all fibres are wool and we can conclude that all fibres are wool including button coverings and the loose bundle of threads. *(See figure 5).*

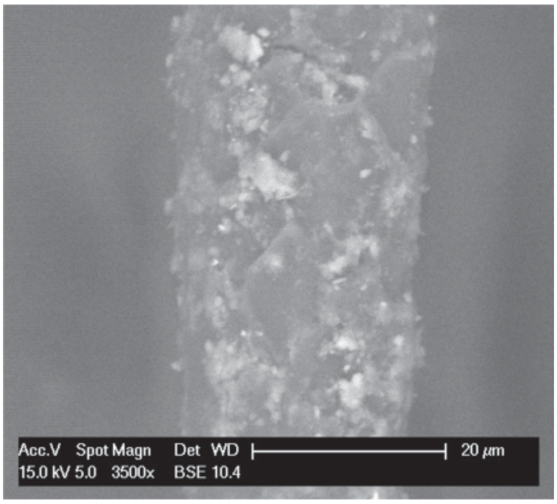

Figure 5: An image of a fibre from large proper right front panel using SEM. The fibre clearly shows the cuticles or scales indicative to wool and a coating of iron oxide. SEM 3500x magnification. © Photographed McCullagh, 2015

Some of the fibres were difficult to identify in certain areas as all samples had a coating that covered the surface of the fibre. The most common coating on the all fibres shown by the elemental spectra are iron, aluminium, potassium and silica. Iron oxide is present, which determines that the reactions observed during conservation treatment of the surface of the textile is a Fe2+ reaction between the attached metal and the atmosphere thus coating the fibres.

The images of all samples confirmed that there was a heavy coating surrounding the surface of many fibres. The elemental spectra on sample one confirmed that iron aluminium silicate and iron oxide was also present on threads. A crystalline structure was visible on sample one and is believed to be iron sulphide.

Often when archaeological textiles are air-dried they can become brittle and stiff causing the fibres to break, this depends on the degree of deterioration in the fibres (Scharff, 2014, 1). It was a concern that the fibres may have mineralised during the burial. Mineralisation of proteinaceous fibres can occur within days of burial and can preserve fibres (Gillard *et al.,* 1994).

Mineralisation is defined as 'combination and/or replacement of the organic matrix of the fibre with an inorganic one' (Gillard *et al.,* 1994, 132). The images taken of the samples indicate that there is no major mineralisation to the fibres although there are concerns of heavy coating of iron oxide. The textile is still supple and flexible however this may change if the Fe2 is not removed, this mineralisation process may still continue which would then cause the fibres to collapse and deteriorate. Further testing and analysis of the cross section of fibres to examine the structure on a more detailed level would have been preferable, however, this has not yet been undertaken.

X-RAY FLUORESCENCE

It is known that archaeological sheep wool absorbs metal ions from its environment, consequently the wool is likely to have absorbed metal ions from its environment prior to and during burial (Von Holstein *et al.,* 2015). The metals contained in the wool structure will provide a good indication of its possible use and the archaeological environment.

A p-XRF reading was taken on the buttonhole panel only. The reading confirmed that the textile contains significant quantities of chromium, lead, bromine and mercury, all levels are considered to be above the accidental levels that the textile could have absorbed from a surrounding environment. It is thought by the authors that the heavy metals that were used to preserve grain and which have contaminated the site, have also inadvertently contributed to the preservation of the textile.

CONCLUSION

We do not know why the frock coat was discarded into the rubbish pit at 462 Elizabeth Street, Melbourne or when this took place. It may have been for reasons that the frock coat had gone out of fashion and the wearer no longer wished to wear it. The style of frock coat has been dated to 1850's-1870's however this does not mean that the coat has been in a burial environment from this time.

The frock coat was considered an out-dated fashion from 1890's onwards and therefore could have been discarded around this time; consequently the coat may have been in a burial environment for less than 110 years. The coat did not reveal why it had been taken apart and discarded into the rubbish pit and we can only hypothesise that the coat may have been damaged whilst the wearer was working in the chaff mill and decided to take it apart and use it as a rag mopping up the floor of the mill where mercury and chromium would have been present when preserving grains, which may then explain why there were so many metal contaminants present.

What we do know is that although the heavy metals have contributed to the life of the coat, the iron corrosion present will now be counteracting the preservation that was achieved in the anaerobic environment. The ethical dilemma of preserving the coat for the long term or extracting information using invasive procedures will be an issue of deliberation. Although iron salts are considered a deterrent for microbial activity, the iron corrosion could be contributing to the deterioration of the textile; a contradiction for preservation in itself and this must be reviewed to fully understand the extent of the damage and to what degree the iron should be removed.

The textile will allow for further experimental research into the removal of archaeological iron on aged wool and a greater understanding of the deteriorating factors causing cell collapse in wool. It may also assist in determining if it is possible for the metals to remain within the protein bonds to help sustain the life of the textile. What is evident is that the textile may unlock information into long-term preservation for archaeological textiles and advance the research into the effects of metals on wool and whether this extends the life of archaeological textiles found in burial environments. Taking into account the rarity of such a find in Australia, archaeologists and conservators must take advantage of these opportunistic finds to broaden our scope in archaeological textile research.

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