The Leichhardt nameplate – a report on authenticity testing

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Introduction

The use of science in the examination of historical objects is a process that aids in making an object talk and live. It also has a more serious side – it is often used to assess the likelihood of an object being misrepresented. Examination of historic objects is exciting as you unravel questions and find more questions that beg to be answered. The examination of the LUDWIG LEICHHARDT nameplate has been exciting for the research team. Many secrets were unwrapped and questions posed.

The investigation was done by David Hallam from the National Museum of Australia, Dr Ian MacLeod from the Western Australian Museum and Alana Lee, Cultural Heritage Research Centre, University of Canberra. In cases like the Leichhardt plate a collaborative approach is essential to ensure the best facilities and knowledge are available for addressing the problem.

The problem

The question we had to answer was, 'was this plate made in 1848 or was it a later fabrication?' Sounds simple, but how can you 'date' metals? You can't carbon date or use another technique to find out how long an object has been around, but you can look at:

- the technology of production
- methods of fabrication
- evidence of the environment it has been in
- evidence of stresses it has been under.

Together these will provide 'causal links' to the object's provenance or they will show the links are non existent. If the links exist then the story is real and we can tell it truthfully.

Methods and approach

Visual examination

David Hallam examined the plate visually and under a Leitz binocular microscope with image capture and analysis capacity.

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SEM examination

The plate was examined in collaboration with Dr Ian MacLeod at the CSIRO Australian Resources Research Centre in Bentley, Western Australia using an environmental Scanning Electron Microscope (SEM) for elemental and morphological details. Energy Dispersive Spectroscopy X-ray Microanalysis was used to determine the elemental analysis.

Raman examination

A Raman microscope was used to examine the plate at the University of Canberra Raman facility in collaboration with Alana Lee. Raman microscopy is a non-destructive spectroscopic analytical technique. The sample is illuminated with a laser beam and the light that is remitted from the sample is analysed by comparison with known reference samples in a computer. Typically it is used to identify organic and inorganic compounds and complements infrared spectrometry. It is widely used in heritage studies and forensics.

Results

Visual examination

The plate is 146.3 mm long, about 20 mm wide and 1.4 to 1.6 mm thick. It has a hole in the upper side, roughly in the centre. The plate has been inscribed with the letters 'LUDWIG.LEICHHARDT.1848'. The 'C' of 'LEICHHARDT' is under the pinhole.

The base metal is 'yellow' in colour but covered with surface scratches, dents and oxides. Nowhere on the plate was a smooth flat surface observed. Reddish 'copper' metal overlays the yellow brass and in places it can be seen to be pealing from the substrate. Darker coloured patina is present on the lower areas of the surface. The surface was filed after it was stamped and engraved. The file marks and letters are corroded and have a deep patina.

View of the Leichhardt plate under the microscope. Photo: David Hallam.

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The inscription was done with a series of letter stamps with some use of a burin type engraving tool for the numbers. The letters are filled with a black substance which has been over painted in white. Numerous accretions and corrosion deposits are evident in letters, scratches and indentations.

The back side of the plate is rougher than the face and a deeper black is present in the corrosion products. In several areas gouges and cuts are evident. ‘Strike through’ is also quite noticeable from some of the letters on the face. Some file and dressing marks are also present. The ‘copper’ film covers a high proportion of the surface.

SEM examination

The SEM examination is detailed in a separate report by Ian MacLeod, published on the National Museum of Australia website at http://www.nma.gov.au/collections/recent_acquisitions/leichhardt_nameplate/index.html

Raman examination

The plate was found to have colloidal carbon in the letters. TiO2 was verified in the letters. Other paint marks were analysed but have proved difficult to identify.

Discussion

Observations of the plate

The historical evidence indicates that the plate was retrieved from the remnants of a firearm that was in the fork of a tree that had been burnt. The plate was removed from the burnt butt of the firearm and the firearm was discarded.

When a piece of metal is removed from the substrate it is likely to be forced and bent. Bending will result in the copper coating and oxides being ‘popped’ off the surface, as they are not compressible. This is evident around the pinhole. After the plate was bent it was straightened as evidenced by light hammering indentations. Corrosion on the plate is consistent with extended outdoor exposure in a humid environment. The plate shows evidence that it was made from recycled metals through the roughness of the surface and the scratched and indented nature of the back of the plate. The finishing of the plate is somewhat rough and ready. The typography of the letters is consistent with the period but the application indicates a skilled metal smith did not make the plate.

The composition of the plate is α-β brass of 62% copper, 34% zinc and 2% lead.

Copper, zinc and brass production in the early nineteenth century

The copper production process was basically unchanged from medieval times till the mid-nineteenth century when it was improved by better smelter design and better reverberatory furnaces.

The ore was calcined several times to reduce the sulphur content to about 11%. The calcine was mixed with suitable fluxes and a molten ‘matte’ of copper and iron sulphides was produced as pigs. These pigs were heated slowly to produce cakes of ‘blister’ with a copper content of about 98.5%. The blister was remelted and polled with green wood sticks to produce an oxygen-reduced copper metal that was cast into billets of ‘tough pitch’. Often lead was added to the mix to further reduce the oxygen content. This raw copper would still have copper and iron sulphide impurities in the metal structure.

Brass was then produced either by a cementation process with zinc oxide (which had a limited upper zinc concentration of 32% (Newbury et al 2005) or by mixing the base metals. In the

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early nineteenth century cementation was being phased out in favour of making brass from zinc metal. Indications are that the Leichhardt plate was made by this process as its zinc concentration is greater than the 32% limit for cementation. We currently suspect the zinc was of English origin but we can only prove this with further microanalysis.

Until 1832 copper was used exclusively for cladding ships. In that year Muntz patented a brass of 60% copper and 40% zinc which gradually supplanted copper as cladding material (Viduka 2004). At 36% zinc the Leichhardt plate is not Muntz metal. From 1879 electrolytic copper was produced in Swansea that comprised the pure metals we are accustomed to today. Modern metals (post 1885) have much lower impurity levels than metals manufactured in the 1830s and 1840s. Table 1 shows how the lead concentrations in brass drop as we move forward into the twentieth century. SEM tests show the brass dates from the first half of the nineteenth century, owing to the presence and percentage of lead. The crystal structure of the metal is consistent with brass from the early 1800s. The Leichhardt plate is consistent with what would be expected for brass of the 1840s period.

Table 1 – Composition of brass 1807–1918

Source	Date	Cu	Zn	Pb	Sn	ref
Rapid brass nail RP 0000	1807	70.4	26.39	1.9	0.32	m
Gem brass bolt no GE 2366	1835	65.6	32.4	1.2	0.1	m
Leichhardt plate average	1848	59.71	36.68	1.51	0.0	m
Mary Hamilton bolt SI 15	1857	67.7	31.5	0.67	0.04	m
Sheathing *Acadia*	1881	62.9	33.2	0.4	0.03	v
Sheathing *Bowden*	1891	61.9	33.2	0.42	0.02	v
Nail *Bowen*	1889	81.7	17.13	0.5	2.53	v
Nail *Saint James*	1918	56.9	32.8	0.46	0.39	v

Manufacture of the plate

The plate appears to be manufactured from recycled metal. The indentations in the end near the ‘48’ are below the file marks, indicating this surface pre-dated the making of the plate (see photo above). It is a rough surface with indent marks from the forming process.

The plate was manufactured by cutting and forming it out of a larger piece of metal. This piece appears to have been fitted to a relieved area by filing. The rounded nature of the edges is hard to explain, however the corrosion and replated copper indicate it was made that way. The stamping of the letters was done on a hard surface and the plate was not attached to the object. The plate was then finally fitted and held in place with a pin. The typeface of the lettering was not identified but is consistent with the early 1800s.

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Analysis of plate surface

Corrosion

The plate surface is extensively corroded and has a layer of redeposited copper. The surfaces, cracks and letters contain corrosion products that were examined and analysed by SEM.

The corrosion profile was consistent with exposure to a corrosive environment after the plate was made.

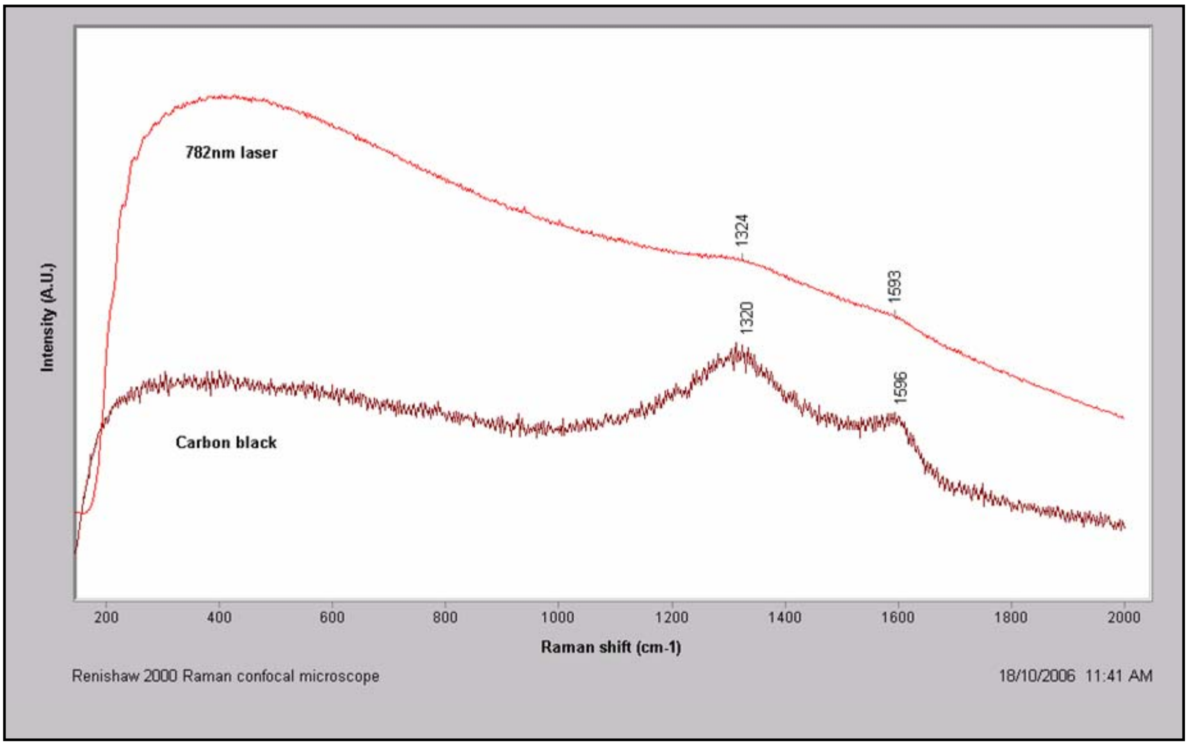
Indicators of this were:

- de-zincification
- redeposited copper
- the presence of sulphur and chloride in the corrosion products.

Some areas of the plate were found to have undergone extensive de-zincification (Macleod 2006) and this ties in well with the redeposited copper. The presence of sulphur is consistent with black powder which was used in muzzle-loading firearms of the time. Powder was often spilt during loading and these firearms produced much acidic smoke when fired. Similarly the high chloride concentrations could have come from the gun powder and/or the sweat of people and animals. This extensive corrosion indicates the plate has been in a wet humid environment for a considerable time.

The presence of zinc hydroxy chlorides indicates the plate was in an arid environment.

Figure 1 – Two Raman of carbon on the Leichhardt nameplate



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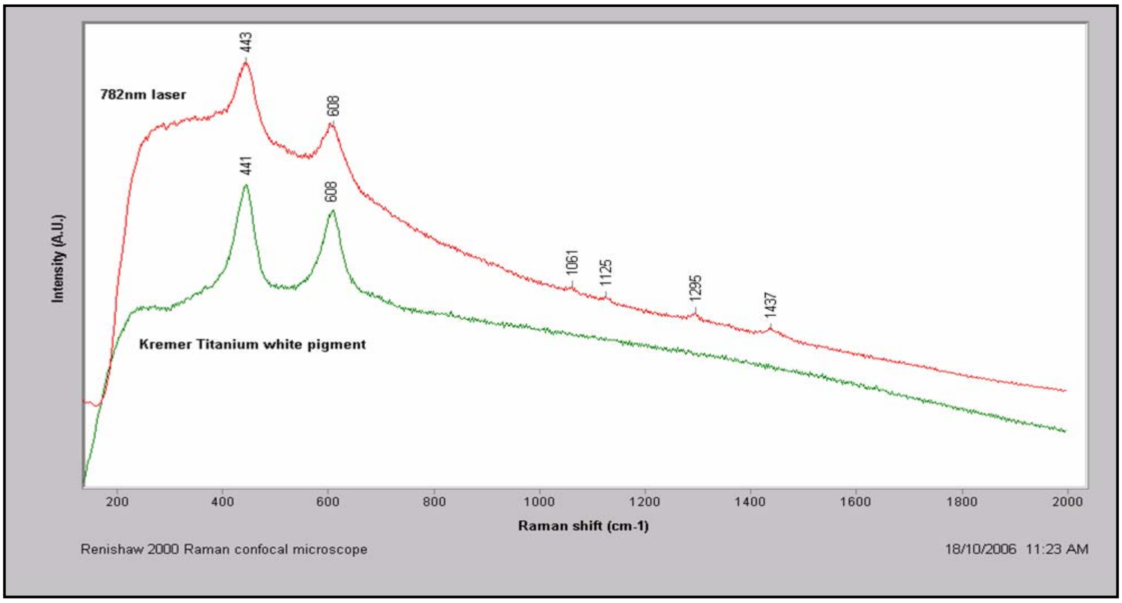
This apparent contradiction occurs because it was exposed to both hot–wet and hot–dry environments during Leichhardt's expedition, in its final resting-place and during its subsequent storage in South Australia.

The presence of other elements (potassium, aluminium and silicon) is consistent with rubbing with earth and fireplace ash.

Raman testing found colloidal carbon, which indicates exposure of the plate to a low temperature fire. This confirmed the SEM results. Titanium oxide was found by SEM to be present in the letters on top of carbon deposits. Raman confirmed this.

Figure 2 – TIO2 Raman



Further analysis

Non-destructive trace element analysis may enable us to fingerprint the origin of the zinc and copper that makes up the brass. This would allow us to learn more about the origins of the brass used in the nameplate. Likewise further analysis of the corrosion products and carboniferous matter would add to the information available.

Conclusions from the scientific analysis

- SEM tests, undertaken under the leadership of Dr Ian MacLeod of the Western Australian Museum, show the brass dates from the first half of the nineteenth century, owing to the presence and percentage of lead. The crystal structure of the metal is consistent with brass from the early 1800s.
- SEM proves the presence of sulphur, consistent with black powder which was used in muzzle-loading firearms of the time; powder was often spilt during loading and these firearms produced much smoke when fired.
- The presence of zinc hydroxy chlorides indicates an arid environment.

- The presence of other elements (potassium, aluminium, silicon) is consistent with rubbing with earth and fireplace ash.
- Raman testing found colloidal carbon. It is highly likely this indicates exposure of the plate to a low temperature fire.
- Expert visual examination confirms the corrosion product on the rear of the plate is consistent with brass in contact with wood (i.e. the stock of a firearm).
- The plate shows evidence of having been bent around the fastening hole, which would be expected from a plate removed from another surface (i.e. the stock of a firearm).
- The nameplate has been re-formed from another brass object (perhaps a marine nail or spike). Both the scoring that resulted from cold working of the metal and the lettering contain corrosion products which were laid down early in the object's life, therefore making it impossible for the plate to be a recent fabrication using nineteenth-century materials.
- SEM and Raman identified titanium oxides in the lettering.

When conservators work with curators to unpack the stories from an object, the eventual information unearthed can be far greater than was initially required. In this case the amazing concurrence for the historical and analytical results combines to give causal links that confirm the object's provenance.

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