# Finding evidence of a lost explorer: Ludwig Leichhardt 1848 not just a nameplate and a provenance study?

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Abstract
*The National Museum of Australia (NMA) acquired a name plate from Ludwig Leichhardt's 1848 expedition across Australia. The paper looks at the analysis of the metal and corrosion products from that name plate by various non-destructive techniques including SEM and Raman microscopy. By analysis of the object we have found information on the technology of production, methods of fabrication, evidence of the environment it has been in and evidence of stresses it has been under. Through application of appropriate analytical techniques the process has yielded a marriage of historical record and scientific analysis which has created a remarkable provenance of the object.*

Keywords: copper, brass, analysis, SEM, Leichhardt, corrosion, environment.

**Introduction**
For over 150 years, the remains of explorer Ludwig Leichhardt, his companions, and the expedition's horses, mules, bullocks and equipment have lain somewhere in the Australian outback. Just where, is one of the great mysteries of Australian history.
The National Museum of Australia's recent acquisition of the Ludwig Leichhardt nameplate (see figure 1) helps to shine a light on that mystery. The nameplate, while not telling us where Leichhardt ended up, is the first artifact from the 1848 expedition to have a corroborated provenance and shows that he made it at least two-thirds of the way across the continent. This represents a major achievement for a European at that time.
The Museum spent twelve months working on the nameplate. The process yielded a marriage of historical record and scientific analysis which has created a remarkable provenance of the object.
This paper explores the analysis of the plate and looks at the paucity of data available on brasses in the 19th and 20th century. Due to the word limit of this paper further detailed information is available in the references.

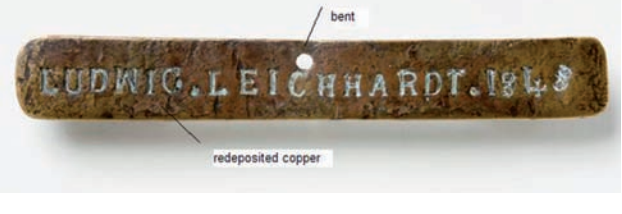


*Figure 1: Nameplate "Ludwig Leichhardt 1848", Photo Dragi Markovic Copyright National Museum of Australia*

**Historical**
Leichhardt is of great significance to Australian history on account of his earlier journey 1844-45 from Moreton Bay on the east coast to Port Essington on the north coast, a journey of 5000 kilometres for which he won international recognition. Leichhardt was one of the most acute early observers of the Australian environment and his work continues to be analysed today. In 1848 Ludwig Leichhardt left Moreton Bay settlement in Queensland on an expedition to cross Australia from east to west.
The nameplate is a piece of brass marked "Ludwig Leichhardt 1848". It was discovered attached to a partly burnt firearm in a bottle tree (boab) near Sturt Creek (see figure 2), between the Tanami and Great Sandy Deserts, just inside Western Australia from the Northern Territory border. The tree was inscribed with an 'L' (a number of these L trees have been identified elsewhere and accepted as having been marked by Leichhardt on his final journey). The discovery was made around 1900 by an Aboriginal man working for drover and prospector Charles Harding. Harding disposed of the firearm but recognised the plate as something of value and carefully looked after it. Harding used to polish the plate by rubbing it with fireplace ash. Mr Reginald Bristow Smith got to know Harding and in about 1917-18 was given the plate whilst still a teenager. It was subsequently loaned to L.A. Wells, a surveyor and explorer. In 1937 the plate and Leichhardt's fate were debated by Somerville (1937). The plate went to the SA Survey Department and the department soon lost awareness of the plate's true ownership. The plate passed into other government agencies and ended up with the SA Libraries Board. It was eventually recovered by the Bristow Smith family and in 2005 they offered the plate to the National Museum of Australia.


*Figure 2: Relative positions of Sturt Creek and Moreton Bay*

**The problem**

The question we had to answer was, "was this plate made prior to 1848 or was it a later fabrication?" Sounds simple, but how can you "date" metals? You cannot carbon date or use any other technique to find out how long they have been around but you can look at:

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

Together these will give "causal links" to the objects provenance or they will show the links are non existent. If the links exist then the story is plausible and we can tell it truthfully.

**Methods of study**

The provenance of the plate was examined historically. The plate was also examined by non-destructive techniques ie. visually, microscopically, either with Raman microscope or a scanning electron microscope (SEM). The plate was examined the plate visually and under a Leitz binocular microscope with image capture and analysis capacity. Afterwards the plate was studied at the Commonwealth Scientific Industrial Research Organisation (CSIRO), Australian Resources Research Centre in Bentley, Western Australia using an environmental Scanning Electron Microscope for elemental and morphological details. Energy dispersive X-ray microanalysis (EDX) was used to determine the elemental analysis. A Raman microscope was used to examine the plate at the University of Canberra Raman facility in collaboration with Alana Lee.

**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 small hole located centrally in the upper side edge of the plate. The plate has been inscribed with the letters "Ludwig Leichhardt 1848". The "C" of "Leichhardt" is under the small hole. The base metal is "yellow" in colour but covered with surface scratches, dents and oxides. No smooth surfaces were observed on the plate. Reddish "copper" metal overlays the yellow brass and in places it can be seen to be peeling from the substrate. Darker coloured patina is present on the lower areas of the surface. The surface has been filed after it was stamped and engraved. The file marks and letters are corroded and have a deep patina.

The inscription has been done with a engineer's letter stamps and a burin type engraving tool for the number 8 (see figure 3). 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 typeface of the lettering was not identified but appears consistent with the engineering and signage from the first half of the 19th century.

The verso 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. A "copper" film covers a high proportion of the surface (see figure 4).

It is stated that 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

*Figure 3: Photographic image of the final date stamps "48" showing multiple burin cut on "8", Photo Dragi Markovic Copyright National Museum of Australia*


*Figure 4: Photographic image of the verso, note "strike though" and deep cuts, Photo Dragi Markovic*

of the plate. The indentations in the end near the “48” are below the file marks indicating this surface pre-dated the making of the plate (see figure 1). It is a rough surface with indent marks from the forming process.
The finishing of the plate is somewhat rough and ready application indicates a skilled metal smith did not make or engrave the plate.

*SEM-EDS examination*
Examination was limited to non-destructive surface analysis methods and so the object was placed in an environmental cell utilising a low vacuum chamber of a SEM and examined using the backscattered secondary electron image mode. SEM-EDX analysis shows the plate is a α-β brass of 62% copper, 34% zinc and 2% lead (see figure 5 and table 1).

*Raman examination*
The plate was found to have colloidal carbon in the letters. $TiO_2$ was verified in the letters. Other paint marks were analysed but have proved difficult to identify positively.

**Discussion**
Copper, zinc and brass production in the early 19th Century
In the early 19th century brass was 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 of the base metals. At this time cementation was being phased out in favour of making brass from zinc metal. Indications are that the Leichhardt plate was made with the latter process as its zinc concentration, at 36% 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.

*Table 1: EDAX analysis of the Leichhardt plate (The letters after the elements denote the X-ray energy used to determine the element)*

| | | | | | | |
|---|---|---|---|---|---|---|
| Spot 006c | | | | General analysis “WI” | | |
| Element | Wt % | At % | | Element | Wt % | At % |
| C K | 45,72 | 61,1 | | Al K | 0,29 | 0,69 |
| O K | 25,76 | 25,85 | | Pb M | 2,02 | 0,62 |
| Mg K | 1,32 | 0,87 | | Cl K | 1,6 | 2,88 |
| Al K | 1,55 | 0,92 | | Ca K | 0,14 | 0,22 |
| Si K | 3,43 | 1,96 | | Cu K | 59,38 | 59,79 |
| S K | 8,57 | 4,29 | | Zn K | 36,58 | 35,8 |
| Cl K | 0,49 | 0,22 | | | | |
| K K | 0,34 | 0,14 | | Spot 1b | | |
| Ca K | 9,44 | 3,78 | | Element | Wt % | At % |
| Fe K | 0,44 | 0,13 | | Al K | 0,66 | 1,56 |
| Cu K | 2,96 | 0,75 | | Pb M | 0,35 | 0,11 |
| | | | | Cl K | 0,26 | 0,47 |
| Spot 004b | | | | Ca K | 0,1 | 0,16 |
| Element | Wt % | At % | | Cu K | 61,86 | 61,93 |
| C K | 49,21 | 72,28 | | Zn K | 36,77 | 35,78 |
| O K | 11,8 | 13,01 | | | | |
| Mg K | 2,35 | 1,71 | | Spot 004c | | |
| Al K | 2,05 | 1,34 | | Element | Wt % | At % |
| Si K | 3,86 | 2,43 | | S K | 6,48 | 11,87 |
| P K | 0,83 | 0,47 | | | | |
| Pb M | 4,26 | 0,36 | | | | |
| Cl K | 2,24 | 1,11 | | Cl K | 2,26 | 3,75 |
| K K | 1,57 | 0,71 | | | | |
| Ca K | 2,91 | 1,28 | | | | |
| Ti K | 0,33 | 0,12 | | | | |
| Fe K | 0,85 | 0,27 | | | | |
| Cu K | 15,97 | 4,43 | | Cu K | 91,26 | 84,38 |
| Zn K | 1,77 | 0,48 | | | | |

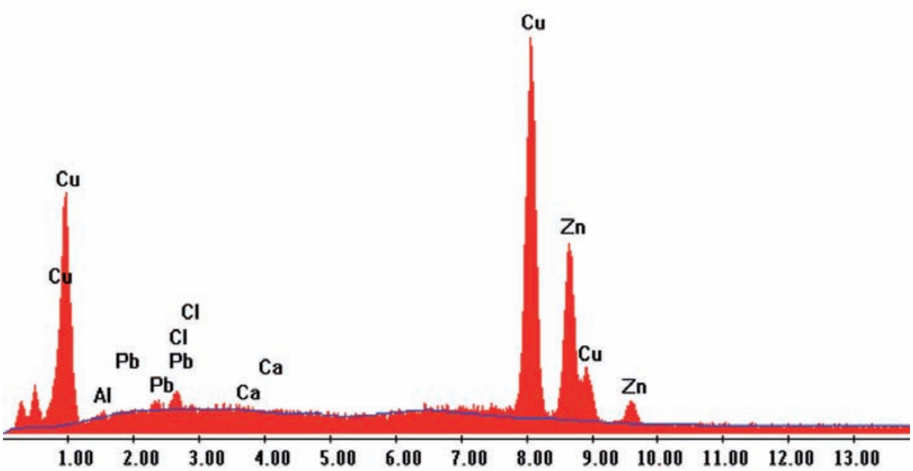


*Figure 5: Typical X-ray analysis spectrum of the plate, showing the presence of the principal alloying elements of copper and zinc as well as a small percentage of lead and some chloride*

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 the cladding materials (Viduka 2004). At 36% zinc this plate is not Muntz metal. From 1879 electrolytic copper was produced in Swansea this produced the pure metals we are accustomed to today. Modern metals (post 1885) have much lower impurity levels than a 1830-40's metal would have had. Data on brass and copper compositions and availability in the 1840's in Australia was hard to find and most had to be sourced from maritime conservation sources for comparison purposes. Note how in table 2 the lead concentrations drop as we move forward into the 20th century.

*Table 2: Comparative copper and brass compositions*

| Source | Date | Cu% | Zn% | Pb% | Sn% | reference |
|---|---|---|---|---|---|---|
| Rapid brass nail RP 0000 | 1807 | 70,4 | 26,39 | 1,9 | 0,32 | MacLeod 2006 |
| Gem brass bolt no GE 2366 | 1835 | 65,6 | 32,4 | 1,2 | 0,1 | MacLeod 2006 |
| Leichhardt plate average | 1848 | 59,71 | 36,68 | 1,51 | 0 | MacLeod 2006 |
| Mary Hamilton bolt SI 15 | 1857 | 67,7 | 31,5 | 0,67 | 0,04 | MacLeod 2006 |
| Sheathing Acadia | 1881 | 62,9 | 33,2 | 0,4 | 0,03 | Viduka 2004 |
| Sheathing Bowden | 1891 | 61,9 | 33,2 | 0,42 | 0,02 | Viduka 2004 |
| Nail Bowen | 1889 | 81,7 | 17,13 | 0,5 | 2,53 | Viduka 2004 |
| Nail Saint James | 1918 | 56,9 | 32,8 | 0,46 | 0,39 | Viduka 2004 |

**Corrosion of the plate**

The plate surface is extensively corroded and has a layer of redeposited copper (see figure 6). The surfaces, cracks and letters contain corrosion products that were examined and analysed by SEM-EDX (see figures 7 and 8).
The corrosion profile was consistent with exposure to a corrosive environment after the plate was made.
Indicators of this were as follows:

- Dezincification,
- 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) 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 from sweat of people and animals. This extensive cor-


*Figure 6: Nameplate "Ludwig Leichhardt 1848". Showing redeposited copper, Photo Dragi Markovic*

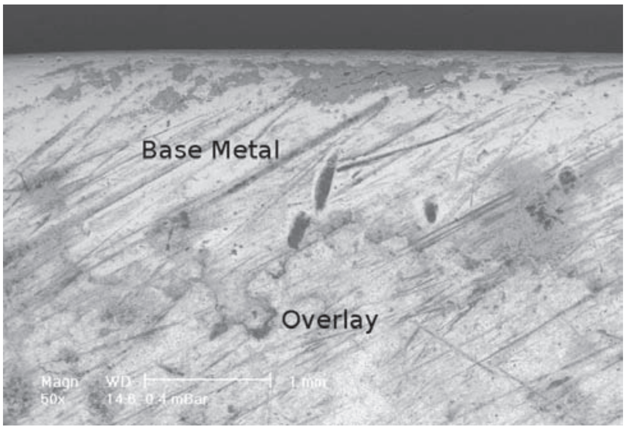


*Figure 7: Backscattered SEM x 50 image of upper section of plaque at "LU" area 1 showing the morphological differences between the upper and lower section at the "join" between the two layers of metal*

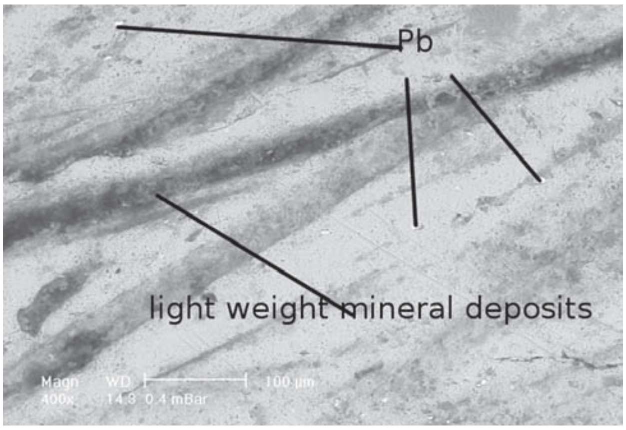


*Figure 8 Left hand SEM image x 400 image of upper section of "LU" area showing elongated lead (bright grey) micro-droplets of lead and light weight mineral deposits in the grooved surfaces. Right hand image of the same object but at x 1600 showing a distorted lead micro-droplet*

rosion indicates the plate has been in a wet humid environment for a considerable time. The presence of zinc hydroxychlorides indicates the plate was in an arid environment. This apparent contradiction occurs because it was exposed to both hot wet and hot dry environments during the trip, 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-EDX investigation to be present in the letters on top of carbon deposits. Raman analysis has confirmed this. SEM-EDX investigation has also identified titanium oxides in the lettering which provides information about later alterations of the nameplate. The letters were originally unpainted but were subsequently painted to highlight them. The painting is first indicated in a January 1935 photograph of the plate in the Adelaide Advertiser newspaper. Titanium oxides started to be used in paint from the 1930s.

## Conclusion

When conservators work with curators to reveal the stories from an object the eventual information unearthed can be far greater than was initially required. By analysis of the object we can find information on the technology of production, methods of fabrication, evidence of the environment it has been in and evidence of stresses it has been under even in the most unlikely places through application of appropriate analytical techniques.

In this case the amazing concurrence for the historical and analytical results combines to give causal links that confirm the objects provenance.

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