It's all in the nameplate; brass and bronze in colonial Australia

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Abstract

The analysis of a series of Aboriginal breast plates in the collections of the National Museum of Australia has illustrated the development of early metallurgical processes and the effective reworking of shipwreck fittings into functional objects. The presence of minor alloying constituents has a major impact on the formation of the zinc-rich β phase of brasses which can confer better physical properties on the alloy. The impact of composition on materials performance is reviewed.

Résumé

Les analyses d'une série de plaques de poitrines aborigènes dans les collections du Musée National d'Australie ont illustré le développement des premières procédures métallurgiques et la réutilisation efficace des équipements des épaves en objets fonctionnels . La présence de composants d'alliage mineurs a un impact majeur sur la formation de la phase β riche en zinc des cuivres qui confère de meilleures propriétés physiques aux alliages. L'impact de la composition sur les performances des matériaux est revu.

Synopsis

El análisis de una serie de pectorales aborígenes en las colecciones del Museo Nacional de Australia ha ilustrado el desarrollo de procesos metalúrgicos pasados y la eficaz recontrucción de armamentos de barcos hundidos en objetos funcionales. La presencia de componentes de aleación de poca importancia tiene un gran impacto en la formación de la fase β rica en zinc de latones que pueden otorgar mejores propiedades físicas a la aleación. Se analiza la influencia de la composición en el rendimiento de los materiales.

Keywords

brass, bronze, australia, breastplates, gorget, XRF, analysis

Introduction

Scientific examination of historical objects is a process that aids in making an object talk and live and is often used to assess the likelihood of an object being misrepresented. Recent analysis of the Leichhardt nameplate has illustrated the value of forensic analyses as a collection management and authenticity verification tool (Hallam 2007). The National Museum of Australia (NMA) has a collection of 60 breast plates which have varying degrees of documentation including some which have date and/or location stamps associated with them that attest to their use as name badges for significant indigenous leaders from colonial times to the mid 20th century (Macquarie 1814). The question with the Leichhardt plate that had to be answered was, "is this plate made in 1848 or was it a later fabrication?" Dating metal artefacts involves the combination of information relating to 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 real and we can tell it truthfully. The main problem exposed by the Leichhardt nameplate was the lack of information about the availability, composition and character of copper brasses and bronze in colonial Australia. At the same time one of the authors, David Kaus, was examining the breastplates and the dated plates gave us the start of a data set of known provenance for brass and bronze analysis from the period 1836 through to the 1930's.

Brass and bronze; use and production in Australia

We often assume that metal usage in Australia followed the trends that were apparent in the United Kingdom in the 18th and 19th centuries but forget that the colonies were limited by materials and skills. Both had to be imported until local skills, production and industries were able to fill market demands. This was to take many decades. The early colony experienced a lack of skilled tradesmen; this indicates that there could not have been much metalworking. However, about 1793, a convict blacksmith was making "... one iron hand-mill a week..."; government records from 1797 to 1799 indicate the manufacture of kettles, sledgehammers and tomahawks, among other things; apprentice blacksmiths and wheelwrights were indentured by 1807 and a 'large government vessel' was built between 1802 and 1804. All imply metalworking of some sort. A Tasmanian foundry built a steam engine in 1834. Copper was being imported into the Australian colonies prior to this, implying foundry work (Linge 1979). We know that by 1840 Sydney and Hobart had working foundries reprocessing metal for local use.

> "Foundries had flourished in New South Wales, using pig-iron imported from Britain, which they increasingly supplemented with recycled scrap-iron ... By the 1830s there were quite sizeable foundries in Sydney ..." (Jack 1994). Copper alloys were also imported from Britain.
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> "... we must direct attention to Mr. Dawson's foundry, which is generally considered to be the first in the Colony. It was established in 1833 ... iron work, of more than *four tons weight*, has been cast here with success." (Fowles 1849).

Salvage of metal from shipwrecks

Apart from importing new metal for local manufacturing use there is plenty of evidence that metal was salvaged from shipwrecks near Sydney in the early days of the colony. Great efforts were made to salvage cargo, and there are records of the salvage of seal oil, valuables such as plate, and pork in casks. The recovery of iron and other metals was also undertaken.

"We are sorry to state that nothing could be saved from the wreck of the James, except her best anchor, and an inconsiderable part of her sails, everything else being either buried or washed away by the surf." (Anon 1804a),

"On the 11th of June the wreck [of the Porpoise] was set on fire, and such of the iron taken on board the Marcia as could be saved." (Anon 1804b),

"The hull of the George private colonial schooner, some time since wrecked at Two-fold Bay, has been consumed, as no hopes of getting her off remained, and her iron-work brought up in the Venus." (Anon 1806).

Australian production of copper

Copper ore was first reported in Australia in 1800, with a sample probably from the Moss Vale area. It was discovered on the West Coast of Tasmania in 1827, and at Molong Creek in 1829. "... the first ten tons of copper ore mined in the Commonwealth ..." were taken from Kapunda in 1843 and smelting of the ores began in 1849 and ceased production in 1878 with the primary ores being the copper-iron sulphides chalcopyrite $CuFeS_2$, bornite Cu_5FeS_4 and chalcocite Cu_2S and gangue minerals included hematite (Randall 1989). The first copper ore near Sydney was mined in NSW in 1845 where a smelter was established. (Ellis 1967). The famous Burra Burra mine in South Australia was discovered in the same year and smelting of the rich copper carbonate ore commenced in 1849 and operations ceased in 1867 having yielded more than 50,000 tonnes of copper (Grguric 1994). By the mid 1850's over five per cent of the worlds copper was supplied by Australian mines and smelters.

Breastplates in Australia

> "4. That the Natives should be Divided into District Tribes, according to the several Districts they usually reside in, – and that each Tribe should elect its own Chief, who the Governor will distinguish by some honorary Badge.
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> 5. That the Chief of each Tribe is to adjust all Differences that may arise between the Individuals of his own Tribe; and that he shall also be held accountable to the Governor for their general conduct, and that through him all the grievances of his Tribe shall be addressed." (Macquarie 1814).

On 27 December 1814 Lachlan Macquarie, governor of New South Wales between 1810 and 1821, wrote a set of instructions for committee members of the Native Institution, a school for Aboriginal children at Parramatta, to talk to the Aborigines about at the following days 'conference' also at

Parramatta. Macquarie was trying to have some kind of working relationship with the Aborigines where they could co-exist in harmony. The history of settlement up to that point had been dotted with conflict where lives had been lost on both sides. Macquarie' plan comprised seven points that covered four matters:

- The setting up of a school for Aboriginal children.
- Establishment of a chieftainship system.
- Settling willing Aborigines as farmers on parcels of land.
- An annual congress or conference at Parramatta, to be held on 28 December, where Aborigines were invited to a feast and to bring up matters with the government.

The story here concerns Macquarie's chieftainship and its "honorary Badges", outlined in points 4 and 5 of his plan and quoted above, and the resulting tradition. Over time the presentation of breastplates was to expand to the point where their presentation was for all sorts of reasons. Macquarie had created a phenomenon that was to last the best part of a century and a half. His "honorary Badge" took the form of a crescent-shaped metal plate engraved with the name of the chief and his 'tribe' that was hung around the neck. These plates have been known by several names – breastplate, king plate, brass plate and gorget to mention a few. They are referred to here as "breastplates", for this is the term most widely used in both the indigenous and non-indigenous communities. This term has been in use since the early 19th century when Macquarie used it in his diary on 25 May 1816 (along with "gorget").

Macquarie was a reformist governor who played a fundamental role in the change of New South Wales from a penal colony to a free settlement. He had a more enlightened attitude toward the indigenous inhabitants than most of his predecessors. Macquarie was concerned to have a working relation with the Aborigines but he did take a 'carrot and stick' approach where he rewarded friendly and co-operative people while he at times treated recalcitrant Aborigines rather harshly, to the point where he approved the shooting of men who did not surrender when directed. At different times he tried a range of incentives to prevent further conflict.

Breastplates were only one form of reward given to Aborigines. At different times they were also given blankets, clothing and food in particular and, on rare occasions, parcels of land. This was also true for non-Aboriginal people who were rewarded for services to the government when they were not paid for them, although none were given breastplates.

Figure 1. A typical breastplate with name and district bordered by an Emu and a Kangaroo. This one from the NMA collection was presented to Mr Cobble in the later 19th century on Mogil Mogil pastoral station in North Western New South Wales

Breastplates (Figure 1) are the one cross-cultural item from the colonial period to survive into the 21st century in any number. Today, there are almost 300 breastplates in public collections in Australia. All state museums hold at least one and the largest collection is held in Canberra's National Museum of Australia. There are more in private ownership, including by Aboriginal people, but the actual number is not known.

While it is difficult to precisely date many, there are about 80 where at least the year of presentation is known, if not the actual date. Collectively, the nation's public collection has some of the earliest known breastplates and the National Museum collection has two dated 1930, the most recent known to exist. A record has been found for only one being presented after this date, in 1946, although people were still wearing them into the 1950s, if not later.

Analysis of the breast plates

Owing to their historic nature the breastplates could not be subjected to any form of destructive analysis and so a portable XRF unit (Keymaster Tracer III-V Portable Light Element XRF Analyser with Peltier cooled Ag-free Si-PIN detector and Re X-ray tube target) was used to examine the composition of the surface of 60 of breastplates in the NMA collections. It is clear from visual inspection that some of the breast plates have suffered from extensive wear and some corrosion, which is consistent with the historical nature of the objects and the extensive amount of wear and tear that they had experienced during an extensive working life.

Since the materials performance of brasses is acutely sensitive to the amount of zinc that they contain, in terms of whether or not the brass is simplex (single phase) or duplex ($\alpha + \beta$) phases, it is useful to consider the impact of impurities on the overall performance of brasses. When alloying elements such as silicon are present they exert a strong effect on the microstructure with 1% Si acting as if it were 10% zinc. Aluminium exerts a six fold increase in concentration of zinc while tin doubles the value, iron 0.9, manganese is 0.5 and nickel, owing to its solubility in the copper rich α phase, has a reducing effect on the equivalent amount of zinc of –1%. When the XRF analyses are tabulated in terms of the analytical concentration of zinc and the zinc equivalents, some interesting patterns emerge. Inspection of Figure 2 shows that for brasses with greater than 27.5% Zn the formal single phase (Zn < 32.7%) and the duplex phase brasses showed a common relationship between the zinc equivalents and the analytical concentration of zinc,

$$Zn_{equiv.} = 0.3175 + 0.9897\ [Zn].$$

This relationship had a very good R^2 (square of the correlation coefficient for the linear regression analysis) value of 0.9923 for forty analyses. This implies that the amount of tin, lead, iron, manganese in the high zinc brasses has a standard ratio of impurities in it and the intercept value of 0.32 wt% simply reflects the solubility of the impurity or minor alloying elements in a solid solution of zinc. This relationship also supports a common metallurgical processing regime to produce the duplex and high zinc brasses.

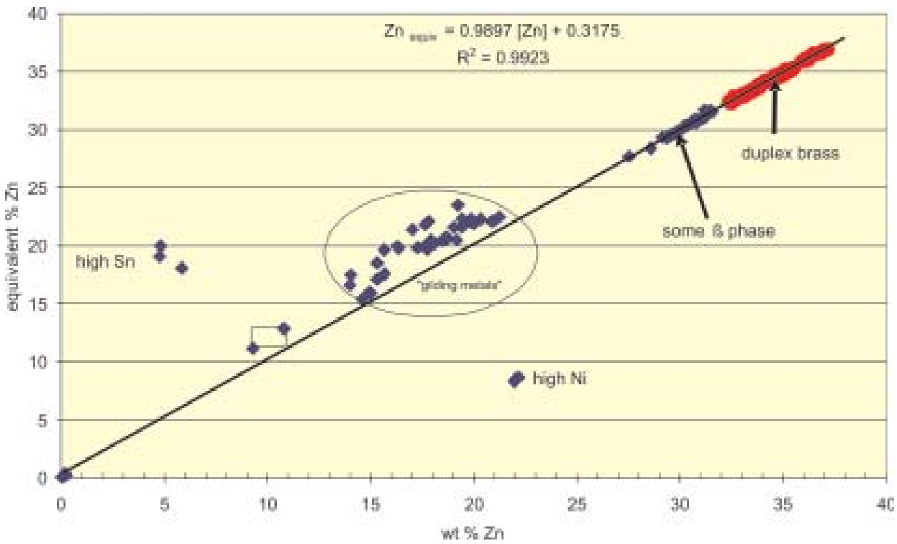

Figure 2. Plot of zinc equivalent vs. zinc content for the breastplates

Brasses in the range 14% < Zn < 21% generally have an elevated zinc equivalence compared with that observed with the higher zinc brasses. The breast plate with a zinc equivalent of 19% and only 5% zinc was in fact a leaded tin bronze and the 22% Zn brass with a zinc equivalent of 9% had a very high nickel content. These alpha brasses fall into the general category of "gilding metals" with binary copper-zinc combinations with zinc contents ranging from 10%–20%, as reported by the Copper Development Association.

A combined plot of the %Zn and differences between the zinc equivalent and Zn content against manufacture date is shown in Figure 3. The duplex brasses showed essentially no direct dependence of composition on the date of manufacture but the "gilding metals" appear to have a direct relationship with the date of manufacture, with the amount of zinc increasing by 0.11% per year between 1820 and 1900. The mean value of the difference between

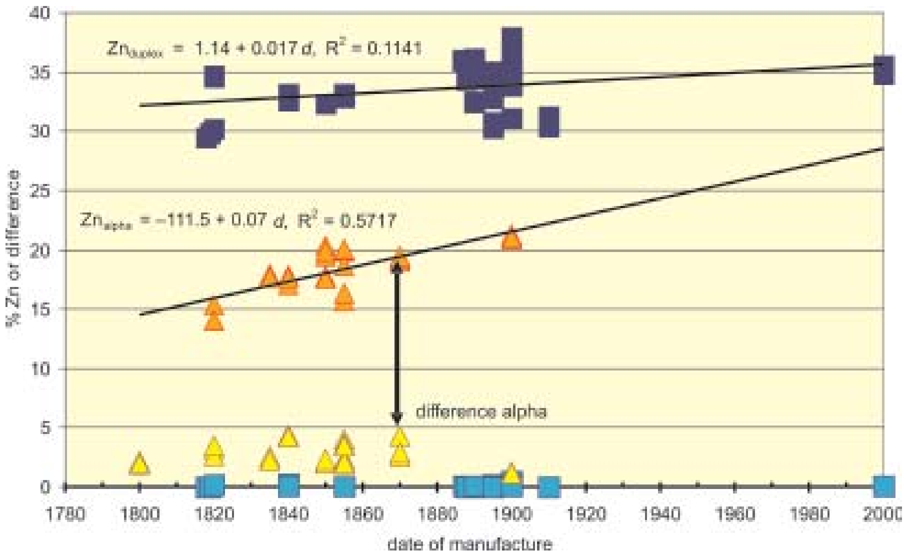

Figure 3. Plot of zinc equivalent and differences in zinc structural concentration. In order to see if there was any correlation between the composition and the date of manufacture of the breast plates the compositions of the brasses were plotted as a function of date. Where provenance data was not specific enough to provide a precise date, there was often sufficient evidence of an historical and stylistic nature to provide a range of dates e.g. 1840's so the mean date of 1845 was used in plotting the data

the zinc equivalent and the Zn concentration was –0.004 ± 0.133% for the high zinc brasses while the single phase brasses had a mean difference of 2.63 ± 0.94% for manufactured between 1820 and 1870. The low differences for the duplex brasses is a clear indication of them having been made under well developed metallurgical procedures using high purity zinc. Given that the intercept value in Figure 2 was 0.32% zinc equivalent there appears to be some systematic difference of approximately 2.31% zinc equivalent for the early colonial period.

Previous analyses by MacLeod in 1987 had studied the relationship between the sum of the trace metals in copper based alloys Σ_{trace} As + Sb + Ni + Ag + Bi and the sum of the alloying elements tin, lead and zinc to test if the compositions were accidental or deliberate. Despite the differences in the two analytical methods, wet chemical analyses of drilled cores for the shipwreck materials compared with XRF for the breastplates, similar patterns of distribution emerge. The data from both sources is seen in Figure 4 which shows the relationship between alloying constituents at the macro and micro levels. The abscissa value i.e. value of Σ_{trace} at zero alloying content reflects the inherent error associated with the analytical method since for one set of á-brass breast plates the value is –0.14 and a mixture of single and duplex brasses gave abscissa values of +0.13. By comparison, the shipwrecked materials analysed by wet chemical methods had values of 0.06 and 0.52 for the abscissa intercepts, which again reflect the relative reporting errors of the analytical methods. There is clearly a distinct similarity in the way in which the two sets of data reflect the presence of trace materials. Most of the shipwreck objects from the colonial period had very low bismuth contents, compared with 17th and early 18th century artefacts, so the absence of bismuth in the breast plates is not unexpected. The raw data shows that ten of the shipwreck objects, which range from manufacturing dates of 1720 for the *Zeewijk* gun, 1770 for fittings from HMS *Sirius* to 1807 from the American China trader *Rapid*, had very similar values of Σ_{base} and Σ_{trace} as the breast plates. Given that the earliest dates for the breast plates were c. 1800 and that manufacturing of copper in Australia did not really get operational until the 1850's, the presence of the same amounts of impurities in the same ratios for breast plates and ship fastenings makes it very likely that the plates were made from objects that had been imported into Australia as either spares or had come from the rich history of shipwrecks that littered the coast of early and present day Australia.

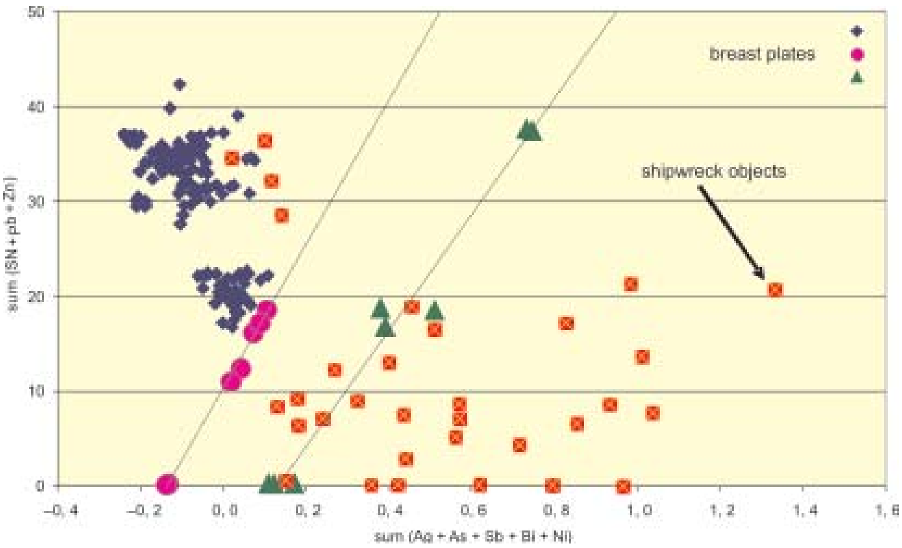

Figure 4. Plot of total base metals vs. the sum of trace metals in the breastplates

Further support for this hypothesis is found in the amount of iron that is present in the breast plates and in the ships fittings. Analysis by MacLeod in 1987 showed that many of the Dutch 17th Century bronze cannon were associated with iron impurities in the range of 1.5–3.5 wt. % which is consistent with metal recycling incorporating the iron from the chaplets that were used to separate the two halves of the mould. Iron contents of 0.7 ± 0.2% are typical of early 17th century bronze that has not been recycled. Plots of the iron content in shipwreck bronzes had fallen to 0.2 ± 0.1% by the middle of the 18th century but then began to increase to former 17th century values as more mines were brought into production and more ships fastenings were being made of non-ferrous metals. The mean iron content of 35 ships fastenings and guns from 1606 to 1860 was 0.54 ± 0.78% and the subset of 18th and 19th century shipwreck materials had mean iron contents of 0.22 ± 0.25% iron. The mean iron content of the breast plates in the collection of the National Museum of Australia was 0.19 ± 0.25 wt% iron, which would produce a zinc equivalent of 0.095 ± 0.125 % zinc or roughly one third of the intercept value reported above for the equivalent zinc concentration at zero analytical concentration of zinc. Given that many copper ore bodies are associated with mixed copper-iron sulphides such as bornite and chalcopyrite, it is not unexpected to find that iron is a major impurity in these alloys. The mine at Burra also reported iodargyrite or silver iodide and manganese oxide MnO_2 pyrolusite which all add to the zinc equivalent of the parent mixtures.

Conclusions

This is the preliminary work on the analysis of metals in the Australian colonial marketplace. Although unexpected, relationships can be found between the compositions of “unrelated” bronze and brass from the colonial times. These can be explained by the very special conditions that existed in the marketplace. As conservators and curators we need to use an evidence based approach to our collections and rely on information we find within objects through analysis rather than making assumptions based on unsubstantiated data.

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