Analysis of some copper-alloy items from HMAV *Bounty* wrecked at Pitcairn Island in 1790.

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Abstract

The underwater site of HMAV *Bounty* and the area of the mutineer settlement at Adamstown on Pitcairn Island were investigated archaeologically during a four-month expedition in 1998 and 1999. Due to high energy environmental conditions on the maritime site and human activity associated with collecting or recovering material post the vessel's wrecking in 1790, only 147 artefacts and or concretions remained to be recovered during the maritime excavation. These artefacts consequently represent a unique collection of provenanced material from which a chemical and metallurgical investigation can be undertaken. Comparative analysis was conducted between some copper maritime and terrestrial artefacts to reveal the extent of recycling by the mutineer settlement. Further comparative analysis was conducted between copper artefacts from HMAV *Bounty* and HMS *Sirius* (1789), as both vessels were extensively refitted a year apart at Deptford dockyard on the Thames before both departed on voyages to the Pacific. Copper-iron composite objects found on the *Bounty* wreck-site were identified as Bent's pins which have not been found previously in the artefact assemblage of two contemporary RN vessels excavated in the Pacific.

Keywords: Copper alloy, chemical characterisation, metallography,
HMAV *Bounty*, Bent Pins.

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1. Introduction

Archaeological investigations of the mutineer settlement on Pitcairn Island and the shipwreck site of HMAV *Bounty* produced a variety of typologically similar copper alloy artefacts. To understand the use and extent of recycling of *Bounty* material within the mutineer settlement, chemical and metallurgical studies were undertaken on a number of copper alloy artefacts from both these sites and other local sites where material could have been acquired over the period of occupation.

Pitcairn is a small volcanic island rising abruptly out of the deep waters of the eastern South Pacific Ocean at latitude 25º 04′ south, longitude 130º 06′ west. The island is cliff-bound and open to full ocean swell, limiting access to the island to small boats capable of negotiating the surf. There is no safe anchorage and little flat land; indeed the island lacks almost every convenience conducive to settlement.

In January 1790, a small British naval vessel carrying 28 people arrived at Pitcairn. The ship was the *Bounty* and until a successful mutiny in April 1789, the vessel had been employed in an ambitious expedition to collect breadfruit in Tahiti for transport to British plantations in the West Indies (Bligh, 1937). Since the mutiny, the mutineers had suffered a number of reversals, culminating in a split between those who wished to settle at Tahiti, and those who, along with Fletcher Christian, chose to remain with the ship and search for a place secluded from the eyes of the world.

Pitcairn Island served this purpose particularly well and it was there that the mutineer's hoped to evade Royal justice. The establishment of a settlement required equipment and material and the primary source of this for the mutineers was the *Bounty*. Dissent amongst the remaining mutineers continued on Pitcairn Island, culminating in murders and the *Bounty* being burnt at anchor and the remainder sunk as a result of the fire.

The underwater site of the *Bounty* wreck lies in Bounty Bay, and the areas of the mutineer settlement at Adamstown were investigated archaeologically during a four-month expedition in 1998 and 1999. One of the primary archaeological research parameters and the initial impetus for this study was to ascertain the extent of recycling of material from the *Bounty* to the mutineer settlement. Bronze sheathing nails constituted the largest single artefact group recovered from the wreck site and they represent a significant resource with potential multiple applications within the mutineer settlement (Figure 1) (Erskine, 2000). Besides nails, copper sheathing, a keel bolt and several copper iron composite objects were discussed.

Although several copper alloy nails recovered from Adamstown sites appear to be *Bounty* nail types, a more positive identification of the nails is not possible without metallographic examination and chemical characterisation. Potentially the nails may also have originated from a number of other wrecks in the Pitcairn group: *Wildwave* (1858), *Cornwallis* (1875), *Khandeish* (1875), *Acadia* (1881), *Oregon* (1883), *Bowden* (1893) and *St James* (1918). Physically the *Bounty* maritime site sheathing nails appear curved from use, the common length is 40 mm with very slight variations and approximates to an imperial measurement of 1½ inches. The head of each nail is flat and round with a diameter of 10 mm and is conical under the head before forming a tapering, square-sectioned shank, ending in a sharp point. The physical uniformity of sheathing nails offers a potentially useful indicator of salvage and recycling of material from the *Bounty*.

Figure 1: Nails with typological features described as common to *Bounty* assemblage (Scale in mm).

Other possible distinguishing features include the fact that the other wrecks in the Pitcairn Island group all occur in the second half of the 19th Century and thus fall into a period after the widespread introduction of Yellow (or Muntz) metal. Muntz metal was an alloy formed by combining copper (60%) and zinc (40%) and, by the 1850s, was used by both British colonial and foreign shipping (Bingeman et al, 2000; Staniforth, 1985). The use of this metal represents a technological innovation that would clearly separate the artefacts by their chemical signature. Equally, *Bounty* nails were produced in a uniform way which was casting in this period. Metallurgical examination would quickly identify if any of the other more modern nails were produced by other methods, eliminating them from the study. In order to positively identify the source of copper alloy nails found at Adamstown sites, sheathing nails from the *Bounty* site and the wrecks of the *St James*, *Bowden* and *Acadia* were sent for chemical analysis to the Advanced Analytical Centre at James Cook University. Metallographic analysis was conducted at the Museum of Tropical Queensland.

A secondary focus of this research was instigated by the physical and temporal association between the refit of HMAV *Bounty* and of HMS *Sirius*, the latter wrecked at Norfolk Island (latitude 29.02 S, longitude 167.93 E). Both vessels were extensively refitted for long distance voyaging at the

Deptford works on the Thames, approximately one year apart. The *Sirius* was finally and extensively refitted in 1786 (Samuels, 1983) and the *Bounty* in 1787. The period is important as the refits happened in a time of great metallurgical experimentation and technological innovation for the British RN (Royal Navy) (Knight, 1973) The short time frame between refits potentially offers an insight into the rate of new technologies being introduced into naval vessels for the purposes of improvement to capacity and longevity, or equally it could reveal information about ship yard working practices. Copper artefacts from the *Sirius* have been reported and studied for the quality of the material and historical methods of manufacture (Samuels, 1983; MacLeod, 1991; Stanbury, 1994) Consequently chemical characterisation data collected from the *Bounty* copper based artefacts were compared with the published data associated with artefacts recovered from the *Sirius*.

2. Method

2.1 Preparation

Metal samples were cut from nails, bolts and sheathing. Samples were sectioned using a continuous rim diamond saw. Those to be studied by Scanning Electron Microscopy (SEM) and optical microscopy (OM) were mounted into Canadian Balsam and then polished on a polurethane lap to <3 micron of deformation. Samples selected for SEM were then carbon coated.

Samples selected for OM were etched with a ferric chloride ($FeCl_3$) – hydrochloric acid (HCl) solution (50 gms $FeCl_3$, 10ml HCl made up to 1litre with ethanol). Effective etching took place after immersion of the samples for approximately 5-10 seconds.

Samples selected for chemical analysis by Inductively Coupled Plasma – Mass Spectrometry (ICP-MS) were prepared as follows:

The samples were first soaked in acetone to remove any oily dirt, then the samples were air dried. The second step of cleaning is an acid mix leaching to remove any corrosion until a fresh surface was exposed, thereafter the samples were rinsed with Milli-Q water and dried.

To dissolve the samples, a mixture of 20 ml HCl and 10 ml HNO3 plus 5 ml of water was prepared for 1 g of sample, and the beaker was gently heated to speed up the dissolution process. After dissolution, the resulted solution was transferred quantitatively to a 100 ml flask and was filled up to the mark with Milli-Q water.

2.2 Instrumentation and measurement

The elements of interest were measured by a Varian UltraMass 700 Inductively Coupled Plasma Mass Spectrometer (ICPMS). A multi-element standard solution purchased from a reputable commercial source was used to externally calibrate the ICPMS. Indium (In, atomic number 49) was used as an internal standard to correct for matrix effects and the instrument drift.

The detection limits for all elements analysed are:

Element	Detection Limit in ppm
Ag	0.05
Bi, Sb, Sn, Ni	0.1
Zn, As	1
Cu, Pb	5
Fe	100

Cu, Pb, Fe have higher detection limits because of their significant concentrations in the samples. The Relative Standard Deviation for data in Tables 1, 2, 3 is < 2%.

SEM studies were performed with a JEOL 840 JXA scanning electron microprobe, operating at 15 kV accelerating voltage. Optical microscopy studies were undertaken on an Olympus PME3 microscope with a Polaroid Polapan B/W ISO 400/27^o attachment for optical photography. ICP-MS analyses were obtained from a Varian UltraMass.

3. Results

3.1 *Sheathing*

Copper sheathing a RN vessel was standard procedure by 1787, the date of the *Bounty's* refit. Sheathing from *Acadia*, *Bowden, Bounty* and several land sites on Pitcairn Island were chemically analysed (Table 1). Two samples collected from land sites (LF0037 and LF0045) were both highly corroded. The elements being analysed in this study precluded corrosion products and the significant weight % absence in the data of these samples reflects both the condition of the samples and the method of analysis. The material from the *Bowden*, *Acadia* and sample LF0045 is chemically in proportion to the composition of 'yellow metal' being two parts copper to one of zinc. The Bowden and Acadia samples have major components of: copper 61-63% and zinc 33 -37% respectively. LF0045 has major components of: copper 58.4% and zinc 24.0%. This dates this material to originating in the nineteenth century and metallurgically distinct from the *Bounty* artefact assemblage.

The main impurities in the copper sheathing recovered from the *Bounty* site, Steve Christian's Dunkan in Adamstown and sample LF0037 are; arsenic, lead and bismuth. Arsenic causes an increase in the microhardness of the metal during cold working. MacLeod in his study of the S*irius* sheathing notes that "since the maximum amount of arsenic occurs in the bulk sheathing material, it is reasonable to assume that the vessel was covered with good quality sheathing" (McLeod, 1991). This interpretation is then equally valid for the *Bounty* sheathing. The maximum amount of arsenic in the *Bounty* and *Sirius* sheathing is 0.882 % and 0.826% weight respectively. For both vessels this proportion of arsenic is at the lower end of the range for ancient alloys (McLeod, 1991; Scott, 1991)

The sheathing excavated from terrestrial sites, the Dunkan and LF0037 have a positive chemical correlation with the samples analysed from the *Bounty* wreck site and quantifiably demonstrates that there was recycling of sheathing metal from the vessel. Whilst it is not possible to positively correlate *Bounty* samples to particular production batches, it is possible to say that their major and trace metallurgical composition is indicative of methods of manufacture and refining techniques prior to the introduction of yellow metal. The samples are chemically similar in their makeup.

3.2 *Sheathing Nails*

Metallurgical and chemical analysis of copper alloy nails recovered from Pitcairn Island, and the wrecks of the *Bounty*, *St James*, *Bowden* and *Acadia* were conducted as complementary studies to typological analysis. The results were comparatively studied with the aim of identifying the source of the sheathing nails found on Pitcairn Island and quantifying the extent of recycling from the *Bounty* to the mutineer settlement on Pitcairn Island (Table 2).

Metallurgical analysis of sheathing nails recovered from the *Bounty* site revealed that all of these nails were cast. Of the seven nails sectioned, three nails have evenly distributed small, spherical porosity. The remaining four samples are very porous, with large unevenly distributed spherical voids and with two distinct phases visible.

Since all the *Bounty* site nails studied were produced by casting, the sheathing nails analysed in this study and collected from the Adamstown settlement were inspected for comparison. All the nails analysed from the mutineer settlement were made by casting.

Chemical analysis was undertaken to compare and contrast all the samples. The only element besides copper in a weight percent > 1 is tin; all other elements are present only in trace proportions. Similar proportions of arsenic appear in both the *Bounty* and *Sirius* sheathing nails, the latter described as an arsenical tin bronze (Samuels, 1983) The high tin content affords a higher level of corrosion resistance and hardness to the metal.

Significant variation does occur in the ratios of copper: tin, and tin: arsenic within the *Bounty* site samples. Of the seven nails removed from the *Bounty* site, two nails have neither significant tin nor arsenic. One nail recovered from Adamstown cemetery is 99.7 % weight copper with trace levels of tin and
0.7 % weight concentration of arsenic. Variation to this extent is explicable by the use of different ore bodies for producing the metal, the level of technology in the mid-eighteenth century and the standards of manufacturing processes.

Of the remaining trace elements, there is sufficient variation in the concentrations to negate their use as unique identifying features individually or collectively. However, when studying all the sampled material, it is readily apparent that it is the absence of zinc in significant quantities, typically <1% by weight, which separates the *Bounty* artefact assemblage from that of the *St James*, *Acadia* and

Bowden shipwrecks. Only one artefact LF37.3 , recovered from the Adamstown settlement, has a weight % concentration of zinc. This nail is cast but is typologically dissimilar to the *Bounty* site nails and chemically is significantly different from the sampled artefacts.

3.3 *Bolts*

HMAV *Bounty* was bought in by the RN in 1787 for £1900. The vessel was extensively refitted under the waterline and her bolts were changed from iron to copper with the addition of copper sheathing for the hull at the cost of approximately £2400. A keel bolt (ZA100) from the *Bounty* was chemically and metallurgically analysed. This bolt had been previously recovered from the *Bounty* site by Steve Christian in the 1970's (Christian, 2000).

The bolt is essentially pure copper with trace amounts of arsenic, lead, tin and zinc (0.390, 0.201, 0.038 and 0.013 weight % respectively). Metallurgical analysis of the keel bolt revealed the extensive work hardening required for a keel bolt which needs to combine both strength and corrosion resistance. The bolt was made and cast under reducing conditions. After casting, the metal was probably hot forged, then cold forged to give tensile strength and hardness. This cold working of cast copper, visible throughout the cross-section, is exemplified by the extensive twinning, the distribution of porosity, grain size, shape and the degeneration of the typically organised pattern of a cast metal (Figure 2).

According to Samuels, HMS *Sirius* was extensively refitted at Deptford yard in 1786 when the most technologically recent materials would have been added to the vessel (Samuels, 1983) A comparison between the chemistry of bolts from both vessels (ZA100 and SI 32C) reveals that the bolts, whilst manufactured from different ore bodies, are essentially the same product. Elements such as lead, silver and nickel are not affected through the process of manufacture and can be used in this purpose as distinguishing elements. The trace level of arsenic in the *Bounty* bolt is higher than the *Sirius's* and as elucidated, arsenic is largely beneficial because it increases the hardness of the bolt undergoing cold working (McLeod,1991). Neither ZA100 nor SI 32C has any significant level of zinc.

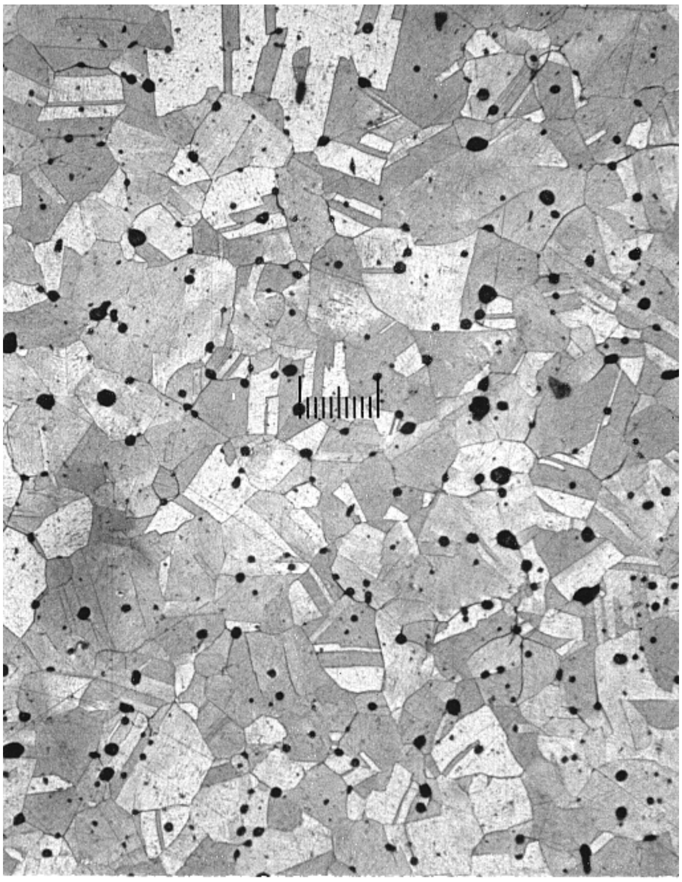

Figure 2: ZA 100 etched x 500 magnification. Cross section showing extensive twinning

3.4 ***Copper – iron composite artefacts***

Copper - jacketed iron objects preliminarily identified as bolts were later identified as Bent pins (Erskine, 1999a, 1999b). In William Bent's 1778 patent, *No.1205 Ships' Blocks- A, a new kind of ships block which turn upon iron or steel pins or axels cased with metal*. Bent describes the manufacturing process as follows:

> "The Invention consists chiefly in the pin bolt or axle on which the shive turns being made of steel, iron, or cast metal called cast iron, and covered or cased with copper, brass, block tin, or pewter, or a mixture of the aforesaid metals, which is done in the following manner:- The pins of the blocks are made of iron or steel, which may be prepared for covering with metal by pickling, tinning, fluxing, or otherwise, or without such preparation, though the same thought to be preferable; after which a proper quantity of metal, consisting of brass, copper, tin, pewter, lead, or other metal, or a composition of all or any of the said metals, is melted and poured or cast upon the plus, which are previously put into a flask or mould, to which the said metal adheres, and thereby the pins become free from the inconvenience of rusting, which iron pins not covered are very liable to, and such pins so covered preserve a sufficient strength; and plus cased or covered as above specified may be applied to the purpose of bolting ships. The shives of the said blocks may be made of mahogany, lignum vitae, or other wood, with or without pieces or plates of metal fixed on each side in the centres to strengthen the wood; or the whole shive may be made of metal or of cast iron. If of cast iron the holes in the middle should be lined with metal, which may be done either by casting in the same manner as above described for covering the pins. The case block may be made of elm or any other wood."

A study of the artefact catalogues from HMS *Sirius* (1789) and HMS *Pandora* (1791), both contemporaneous vessels with the *Bounty* and equally commissioned by the RN for voyages to the Southern Hemisphere, revealed no copper jacketed iron objects in the published artefact assemblages (Stanbury, 1994; Campbell and Gesner, 2000)

Figure 3: ZA 43 Sectioned pin (scale in mm)

Three of the composite objects recovered from the *Bounty* shipwreck site were sectioned for chemical and metallurgical analysis, though only two had remaining core metal (Table 3; Figure 3).

3.5 Core

The core from ZA106 was significantly corroded and weight percentage analysis was not feasible. Analysis of the iron core in the two remaining samples ZA 98 and ZA 43 suggests that the cores were cast slugs with no subsequent work hardening. Visual observation of the corrosion evident in the remaining two pins shows corrosion more typical of cast iron than wrought. Within the iron core there were isolated pools of lead and tin as well as distributed copper with melt effects (Figure 4).

Whether the elements inside the iron core came from manufacture or deterioration cannot be categorically determined without more metallurgical research. At present there are only possible scenarios;

a) the elements now present in the iron core were included in the original melt to produce the slug,

b) the elements were a contamination from a general-use crucible, or

c) the elements are present due to a preferential corrosion process where they have migrated and solidified in voids in the pin's core.

If scenario (a) were the case, then the elements would have had to have formed as discreet elements upon cooling of the melt, coming out of solid solution. Metallurgical phase diagrams should be able to resolve the potential of this scenario.

If scenario (b) were valid, then the elements are contamination of the iron melt picked up from a crucible used also to pour the copper composition. However, the possibility of contaminated elements being more evenly distributed in the slug due to the pouring process, could result in this scenario being discounted.

Scenario (c) is supported by observations detailed in Figure 4. It appears likely that there has been a migration of elements caused by preferential corrosion. At the iron/copper-alloy interface, tin has been removed preferentially from the copper-alloy composition and then distributed near the interface boundary as an element within the iron core.

3.6 Casing

Chemical analysis of the copper alloy casings revealed similarities between the samples, particularly ZA 98 and ZA 43. ZA 106 has a reduced copper wt % and significant trace iron levels in the sample possibly associated with extensive corrosion. The chemical composition of the three casings has wt % of Cu, Sn, Zn and Pb and significant trace amounts of antimony. All these elements are described in Bent's patent in what he terms a metal composition.

All the copper alloy casings are porous with an undistorted cast dendritic pattern. This is clear evidence that the copper alloy was cast in a mould directly to shape and that no cold work or work hardening was done after manufacture. Porosity associated with the last melt pool in the dendrites appears as essentially spherical bubbles throughout the cross sections of ZA 98 and ZA43. There is a visible difference in the distribution of porosity in ZA 106 as shape and number change near the copper/ iron interface.

ZA43 Cu- Fe Composite

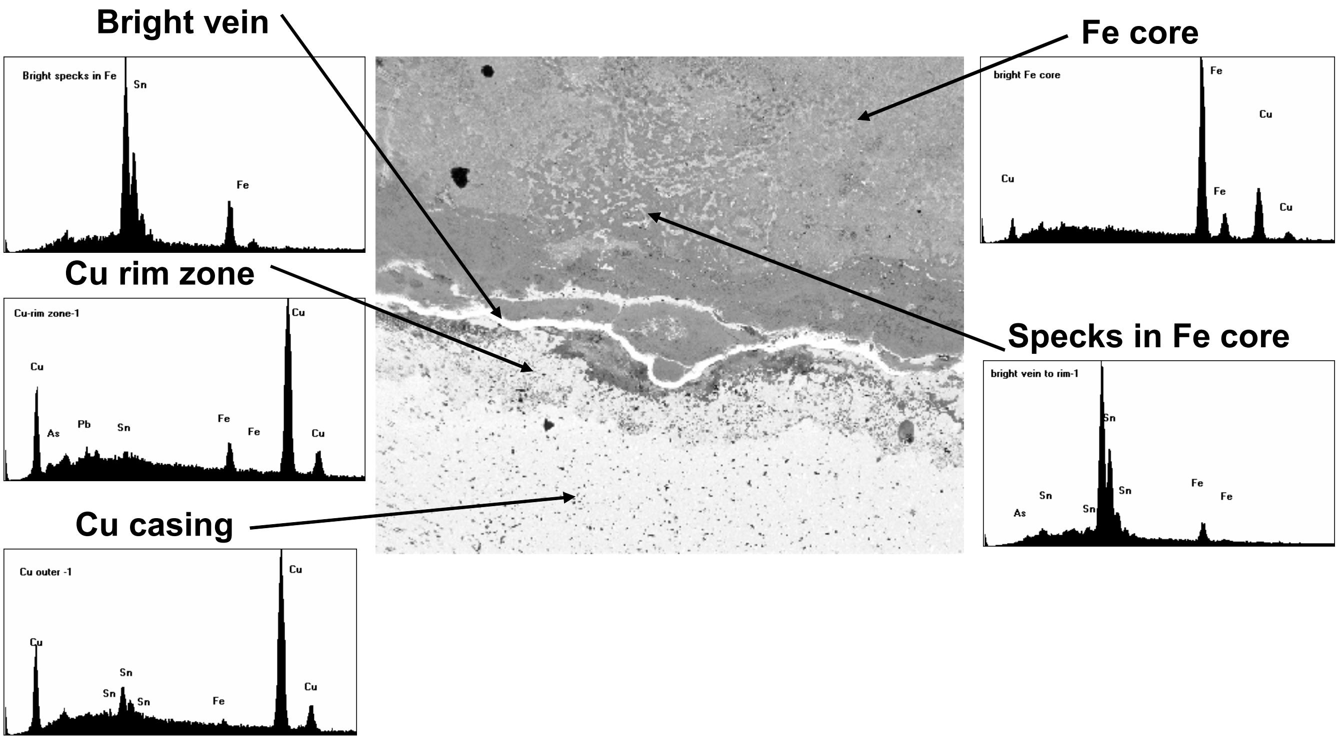

Figure 4: SEM image of Cu-Fe boundary ZA43

4. History

Typological identification and chemical analysis combine to identify the composite iron-copper alloy objects as most likely Bent pins for ships blocks. Without direct historical evidence, or knowledge of the chemistry of the ore source used by the original foundry, this identification cannot be conclusive.

Bent's pins were patented in 1778 during the American Revolutionary War, nine years prior to the *Bounty's* refit. During this period Walter Taylor was the monopoly holder of block supply to the RN and ships blocks with Bent pins were not standard issue. Research by Erskine, that he proposes to publish in the future, suggests that the Bent Pins were not standard issue to the *Bounty* but that Bligh deliberately obtained these pins specifically for the voyage (Erskine, 2004). An alternative theory for their presence has been put forward by Ron Coleman (ex Senior Curator Maritime Archaeology Queensland Museum). Coleman focuses on the practice of the dockyards at the time and suggests that since it was common in the period to reuse anything that was serviceable, it is also likely that when bought in by the Navy as the *Bethia,* the vessel was already equipped with those blocks and that they were simply re-used to alleviate further cost (Coleman, 2002). As the data is inconclusive in this matter and open for interpretation, the reason for the presence of Bent pins on the *Bounty* cannot as yet be definitely ascribed.

Regardless of the origins of the pins they were later reused by the descendants of the mutineers who sectioned them for decorative rings (Christian, 2000).

5. Conclusion

The source of copper sheathing, copper bolts, decorative jewellery and copper alloy nails found at Adamstown sites have been shown to have originated from the *Bounty*.

Chemical analysis of the material recovered during the 1999 Pitcairn Island expedition revealed that the copper artefacts associated with the *Bounty* have significantly different composition to those artefacts derived from later shipwrecks. Consequently, a picture of the mutineer settlements early utilisation of recycled *Bounty* material emerges. The one sheathing nail examined in the study that cannot be chemically matched with the *Bounty* artefact assemblage is also typologically dissimilar to the material and cannot be attributed.

Comparative studies between some *Bounty* and *Sirius* copper artefacts illustrate the similarity of the materials in their method of manufacture and metallurgical composition. The extensively cold worked copper keel bolts in both vessels' highlights the swift and uniform implementation of the Admiralty's 1786 directive to change all vessels to the 'new bolts'. A metallurgical analysis of the copper and iron composite artefacts recovered from the *Bounty* confirmed the typological identification by Erskine as Bent Pins for ships blocks, rather than bolts.

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Christian, S., (2000), verbal communication, direct descendant of Fletcher Christian, Pitcairn Island.

TABLE 1 COPPER ALLOY SHEATHING

Object	Object Reference	Site	Ag	Bi	Cu	Fe	Ni	Pb	Sb	Sn	Zn	As
SHEATHING	*Acadia*	wreck at Ducie Island (1881)	0.016	0.018	62.9	<0.01	0.027	0.402	0.006	0.029	33.20	0.032
	Bowden	wreck at Oeno Island (1889)	0.019	0.015	61.9	0.150	0.037	0.421	0.004	0.021	37.30	0.039
	Steve's dunkan	Bounty sheathing from Steve Christian's collection	0.009	0.039	74.3	0.137	0.018	0.283	0.017	<.005	0.091	0.620
	Bounty	Bounty wreck site (Area 7)	0.015	0.095	96.9	<0.01	0.022	0.115	0.023	<.005	0.001	0.534
	Bounty	Bounty wreck site (Area 7)	0.020	0.080	70.2	5.19	0.015	0.150	0.013	<.005	0.002	0.363
	Bounty	Bounty wreck site ZA122.3	0.025	0.131	88.6	<0.01	0.025	0.069	0.021	<.005	<.0005	0.882
	LF0037	Land site	0.00331	0.078	078.7	0.304	0.0195	0.107	<0.02	0.015	0.0299	0.466
	LF0045	Land site	0.00363	<0.015	58.4	0.0757	0.0304	0.261	<0.02	<0.015	24.0	0.0791

Table 1: Copper sheathing from HMAV *Bounty*, *Acadia*, *Bowden* and several land sites on Pitcairn Island.

TABLE 2 COPPER ALLOY NAILS

Object	Object Number	Site	Ag	Bi	Cu	Fe	Ni	Pb	Sb	Sn	Zn	As
NAIL	ZA20.1	*Bounty* site underwater	0.070	0.093	88.9	0.349	0.030	0.475	0.033	8.210	0.456	0.640
	ZA20.2	*Bounty* site underwater	<0.005	0.007	91.8	0.690	0.006	0.440	<0.005	0.102	0.450	<.150
	ZA20.3	*Bounty* site underwater	0.013	0.005	91.9	0.463	0.028	0.338	0.001	0.123	0.140	0.146
	ZA20.4	*Bounty* site underwater	0.025	0.085	90.6	1.200	0.027	0.366	0.039	5.130	0.170	0.391
	ZA20.5	*Bounty* site underwater	0.027	0.086	90.6	<0.01	0.029	0.321	0.028	3.336	0.077	0.316
	ZA20.6	*Bounty* site underwater	0.021	0.042	92.9	<0.01	0.026	0.380	0.025	2.680	0.187	0.486
	ZA20.7	*Bounty* site underwater	0.017	0.061	90.7	0.111	0.031	0.419	0.039	4.956	0.813	0.124
	LF0033.1	*Bowden* wreck at Oeno Island (1889)	0.019	0.014	80.0	0.327	0.221	0.473	0.020	0.573	17.00	0.156
	LF0033.2	*Bowden* wreck at OenoIsland (1889)	0.017	0.036	81.7	0.129	0.128	0.500	0.044	2.530	17.13	0.123
	LF0034	*St James* wreck at Oeno Island (1918)	0.019	0.004	56.9	<0.01	0.022	0.464	0.032	0.385	32.80	<.002
	LF0037	Field #37.73	0.033	0.015	88.1	<0.01	0.008	0.247	0.003	0.015	0.005	<.002
	LF0037.3	Field # 37.3 characteristics of *Bounty* nail	0.012	0.017	83.0	0.043	0.037	0.512	0.044	0.574	10.40	0.207
	LF0037 (5.2)	Field # 37.3 Cu alloy nail	0.016	0.079	88.7	0.160	0.025	0.421	0.041	5.480	0.837	0.125
	LF0042.1	Cemetery Adamstown	0.017	0.157	92.0	<0.01	0.027	0.318	0.035	4.400	0.134	0.272
	LF0042.2	Cemetery Adamstown	0.035	0.082	89.7	0.048	0.022	0.381	0.050	5.250	0.268	0.188
	LF0042.3	Cemetery Adamstown	0.017	0.121	99.7	<0.01	0.022	0.053	0.021	0.047	0.026	0.732
	18	*Acadia* (1881) wrecked at Ducie Island.	0.015	0.026	79.3	0.081	0.063	0.372	0.014	1.556	11.20	0.026
	19	*Acadia* (1881) wrecked at Ducie Island.	0.018	0.012	74.3	0.064	0.057	0.421	0.018	1.298	10.00	<.002
	20	Steve's Duncan	0.018	0.091	86.6	0.430	0.022	0.324	0.056	5.260	0.171	0.551

Table 2: Nails recovered from Pitcairn Island, and the wrecks of the *Bounty*, *St James*, *Bowden* and *Acadia.*

TABLE 3 COMPOSITE IRON - COPPER ALLOY PINS

Object	**Object Number**	**Site**	Ag	**Bi**	**Cu**	**Fe**	**Ni**	**Pb**	**Sb**	**Sn**	**Zn**	**As**
Pin Fe core	ZA43	*Bounty*	0.000	0.003	0.2	96.2	0.104	0.029	0.001	0.014	0.019	<.002
Pin Cu casing	ZA43	*Bounty*	0.037	0.078	82.2	0.596	0.078	7.460	0.426	2.120	2.410	0.302
Pin Fe core	ZA106	*Bounty*	0.004	0.011	4.1	57.1	0.005	1.240	0.005	0.753	0.124	<.002
Pin Cu casing	ZA106	*Bounty*	0.030	0.070	62.8	16.1	0.047	5.200	0.205	3.834	0.944	0.248
Pin Cu casing	ZA98	*Bounty*	0.081	0.075	86.4	0.177	0.090	6.600	0.622	2.177	1.352	0.687
Bolt Cu	ZA100	*Bounty*	0.022	0.087	96.6	0.187	0.021	0.201	0.013	0.038	0.013	0.390
Bolt Cu	SI 32C*	*Sirius*	0.236	nd	98.35	0.0093	0.094	0.22	0.162	0.47	0.029	0.06

Table 3: Composite objects recovered from the HMAV *Bounty* shipwreck site.

* MacLeod, (1985): 54-5; 59; Stanbury, (1994), Appendix 2.1