Analysis of Non-ferrous Tudor and Stuart Artefacts from Southwark, London

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Introduction

Approximately 200 non-ferrous metal artefacts from the excavations of Tudor and Stuart sites in London were selected for scientific examination. The aim was to establish the range of alloys used to manufacture copper alloy and lead-tin alloy artefacts at this time and builds on earlier work by Bayley & Mortimer (1998) and Heyworth (1991).

Method of Analysis

Each artefact was analysed using energy dispersive x-ray fuorescence (EDXRF). Characteristic peaks were noted for a range of elements (Cu, Zn, Sn, Pb, Sb, As, Ni, etc) for each artefact and in the case of pewter artefacts the heights of the tin and lead peaks were recorded to allow the calculation of a Pb:Sn ratio. It should be noted that this cannot be regarded as a ratio of the proportions of these two elements as the two elements have different physical characteristics (density, fluorescent yield, etc).

The objects were not cleaned or sampled and were often presented as non-planar and non-level surfaces. The analytical results tend to reflect the chemical composition of any surface corrosion products as well as the core metal. The corrosion of alloys leads to the formation of surface deposits which can have very different chemical compositions from that of the original metal. In an alloy one element will tend to be more readily oxidised than the others, e.g. in a brass the zinc is more readily oxidised than the copper. In this way surface corrosion products will often have an increased amount of one of the alloy elements. This is further complicated by the stability of the corrosion products; some are soluble and so can easily be removed from the surface (e.g. many zinc corrosion products) while other will tend to remain (e.g. lead corrosion products). In extreme cases, where corrosion processes have resulted in the formation of a thick patina, a significant element in the original core metal may be completely undetectable at the surface using EDXRF. In addition, where an artefact has been fabricated from one alloy and then plated with another the EDXRF results will normally show the presence of elements in both core and coating.

The Artefacts

The Department of Greater London Archaeology (DGLA) of the Museum of London and the Museum of London Archaeology Service (MoLAS) carried out excavations on a number of sites in Southwark adjacent to the Thames between 1986 and 1992. These sites included historically known royal or great houses (the Rosary and Fastolf Place) and the excavations recovered large quantities of Tudor and Stuart artefacts. The artefacts included a wide variety of personal ornaments and household objects made from pewter and copper alloys. Table 1 lists the numbers of artefacts which have been analysed from each site.

Site code	Site name		Pewter	Copper alloy	Total
ABO92	Abbots Lane	Rosary	76	92	168
BRA88	Braidwood Street	Rosary	2	2	4
GAS88	Gun and Shot Wharf	Rosary	1	4	5
MOR86	Morgans Lane	Rosary	1	0	1
SYM88	Symond Wharf	Rosary	2	5	7
UPP88	Unicorn Passge	Fastolf Place	3	6	9
BTH88	Bethel Estate	Fastolf Place	2	0	2

Table 1. Site codes and names and the numbers of pewter and copper alloy artefacts from each site

Lead-Tin Alloys

For each of the pewter (i.e. lead-tin alloy) artefacts analysed the height of the lead and the tin peaks (counts) was recorded. These figures were used to calculate a lead:tin ratio which should indicate whether the metal was more-or-less pure lead (Pb:Sn >15), a clear alloy of lead and tin (Pb:Sn 0.25–15), or more-or-less pure tin (Pb:Sn <0.25). While a more subtle classification of composition could shed light on subtle variations in alloy manufacture and use, the corroded nature of most of the objects would make such a system unreliable. For exactly the same reason no attempt has been made to assess the presence or absence of copper in the pewters (despite previous analyses which suggest that copper was regularly added to medieval and later pewters).

It should be noted that antimony, arsenic and mercury were undetected in any of the pewters despite historical references to the use of these elements to harden tin and pewters (and in the case of antimony; the presence of an antimony ingot in the assemblage).

The individual results of the analyses are listed in the appendix. As a whole, out of 86 lead-tin artefacts analysed 18 were more-or-less pure lead, 31 were made from pewter and 38 were more-or-less pure tin. This appears to show a preference for tin-rich alloys over lead-rich ones (a preference which can be detected in contemporary written sources).

There were few clear correlations between artefact type and alloy composition. This may in part be due to the corroded state of the samples and the qualitative nature of the analysis. The tableware (spoons and vessels) all tended to be made from more-or-less pure tin with some use of pewter. Pewter was used to manufacture a range of everyday items such as buckles, miniature artefacts and dress hooks. More-or-less pure lead had a limited range of uses, e.g. tokens and

weights. These results are similar to those carried out on slightly earlier lead-tin alloy artefacts by Bayley & Mortimer (1998) and Heyworth (1991).

Copper Alloys

The classification of the EDXRF analyses of the copper alloys relied on a simple visual assessment of the relative heights of the characteristic peaks making use of experience gained in the regular assessment of alloy type using this method. No attempt was made to quantify the amount of any element present. The alloy names are based on those used by Bayley (in Egan & Pritchard 1991: 13-17).

Alloy	**Number**	**Alloy**	**Number**	**Total**
Brass	59	Leaded brass	10	69
Brass/copper	7			7
Brass/gunmetal	2			2
Copper	9	Leaded copper	2	11
Bronze	2	Leaded bronze	6	8
Gunmetal	3	Leaded gunmetal	6	9
Total	82		24	106

Table 2. Proportions of different copper alloys

The results for each artefact are listed in the appendix and the results are summarised in table 2. The table shows that brass was by far the commonest alloy used in this period. Over half of all the analysed copper-based artefacts were made from brass. This reflects a chronological trend of increasing use of brass in medieval and post-medieval copper alloys (cf. Heyworth 1991: 391-2).

Many of the copper alloys also contained small amounts of impurities which are not recorded in the appendix. Chief among these was nickel which was detected in over half of the samples. Many others also contain appreciable amounts of arsenic and/or antimony.

Conclusions

Given the limitations of the analytical technique which was applied to these artefacts it has been possible to identify some broad trends. Amongst the pewter artefacts there appears to be a preference for tin-rich alloys, a trend which has been noted in similar medieval artefacts. It is perhaps surprising, given the availability of a range of possible alloying elements (e.g. antimony) that these do not appear to have been used. This may reflect the conservatism and adherence to regulations of a guild-based industry. The increased use of brass amongst copper alloys noted in medieval artefacts is also noted here.

Further Work

The EDXRF analysis of Tudor and Stuart artefacts from London has highlighted the lack of previous analytical work on non-ferrous metals of this date. Further investigation of the

production and use of non-ferrous alloys during this period is recommended. This period sees the emergence of a range of historical sources including the first ‘scientific’ texts and guild regulations. The development of non-ferrous metallurgy immediately prior to the start of the Industrial Revolution deserves further study.

References

Bayley, J. & Mortimer, C. 1998. Analysis of lead/tin alloy objects. In G. Egan *The Medieval Household.* Medieval finds from excavations in London: 6. London: The Stationary Office, 180B3.

Egan, G. & Pritchard, F. 1991. *Medieval Finds from Excavations in London: 3 Dress Accessories*. London: Stationary Office.

Heyworth, M. 1991. Metallurgical analysis of the dress accessories. In G. Egan & F. Pritchard *Medieval Finds from Excavations in London: 3 Dress Accessories*. London: Stationary Office.

Appendix

All of the artefacts analysed are listed in the following table. The values for Pb and Sn are the total number of counts at the most distinctive characteristic energies (12.6 keV for the lead Lβ and 25.2 keV for the tin Kα). The alloy names given in the last column is based on an assessment of the relative heights of a range of characteristic peaks. As many of the samples had corroded surfaces, quantitative analyses were not possible.

SITE CODE	FIND No	Description	Date	Pb	Sn	Pb:Sn	Alloy type
ABO92	23	Dress-hook	1450-1550 ?	9118	160	56.99	Lead
ABO92	26	Sheet (waste ?)	1450-1550 ?				Copper/brass
ABO92	28	Thimble	1450-1550 ?				Brass/copper
ABO92	33	Button	???				Brass
ABO92	55	Dress-hook	1450-1550				Brass/gunmetal
ABO92	69	Sheet (waste ?)	1450-1550 ?				Copper
ABO92	76	Dress-hook	1450-1550 ?				Brass
ABO92	80	Dress-hook	1450-1550				Brass
ABO92	90	???	???	21366	213	100.31	Lead
ABO92	94	Candle holder	1450-1550 ?				Brass
ABO92	95	Sewing ring	1450-1550 ?				Leaded brass
ABO92	102	Knife handle	1450-1550 ?				Leaded brass
ABO92	119	Thimble	1450-1550 ?				Brass
ABO92	128	Spoon	1450-1550	317	6795	0.05	Tin
ABO92	130	Spoon	1450-1550	430	2328	0.18	Tin
ABO92	133	???	???	20369	264	77.16	Lead
ABO92	143	???	???				Copper
ABO92	145	???	1450-1550 ?	12435	2837	4.38	Pewter
ABO92	154	Dress-hook	1450-1550 ?	3709	2445	1.52	Pewter
ABO92	182	Button	1450-1550 ?	59	3005	0.02	Tin
ABO92	185	Dress-hook	1450-1550 ?				Brass
ABO92	200	Dress-hook	1450-1550				Brass
ABO92	334	Weight	1530-1570	9934	245	40.55	Lead
ABO92	339	Figurine	1530-1570	5573	264	21.11	Lead
ABO92	341	Syringe ? lid ?	1530-1570				Silver
ABO92	365	Spoon	1530-1550	48	3049	0.02	Tin
ABO92	379	Thimble	1530-1550				Brass
ABO92	380	Button	???	2277	1832	1.24	Pewter
ABO92	400	Miniature mount	1500-1550	3381	2328	1.45	Pewter
ABO92	422	Thimble	1530-1550				Brass
ABO92	426	Wire	1530-1570				Gunmetal
ABO92	438	Thimble	1530-1550				Brass
ABO92	440	Collar/pendant ?	1530-1550				Brass
ABO92	445	Dress-hook	???	1373	4231	0.32	Pewter
ABO92	456	Thimble	1530-1550				Brass/copper
ABO92	464	Spoon	1530-1550	531	3323	0.16	Tin
ABO92	470	Dress-hook	1600-1800 ?				Leaded Gunmetal
ABO92	492	???	???	344	6865	0.05	Tin

SITE CODE	FIND No	Description	Date	Pb	Sn	Pb:Sn	Alloy type
ABO92	504	Weight	???	9032	307	29.42	Lead
ABO92	513	Vessel (patch repair)	1530-1550	369	7172	0.05	Tin
ABO92	514	???	???				Copper
ABO92	516	Ingot	1530-1550	5602	3503	1.60	Pewter
ABO92	520	Vessel (fragment)	???	176	12260	0.01	Tin
ABO92	523	Coin	???	26779	312	85.83	Lead
ABO92	526	Spoon	1550-1600	299	7245	0.04	Tin
ABO92	527	Spoon	???	167	5163	0.03	Tin
ABO92	536	Wire finger ring	1530-1550				Brass
ABO92	555	???	???	24231	303	79.97	Lead
ABO92	599	ditto the hook	1530-1570	14146	3000	4.72	Pewter
ABO92	599	ditto the hook	???				Brass
ABO92	610	????	???				Brass
ABO92	611	Dress-hook	1500-1550				Brass
ABO92	614	Spoon	1530-1550	370	7058	0.05	Tin
ABO92	616	Token	1550-1600	28370	239	118.70	Lead
ABO92	648	Repair to vessel	???	3721	1607	2.32	Pewter
ABO92	654	Miniature plate	1630-1650	4883	4171	1.17	Pewter
ABO92	657	Whistle	1575-1600	102	3188	0.03	Tin
ABO92	691	Buckle	1550-1600				Brass
ABO92	692	Buckle	1550-1600				Brass
ABO92	730	Vessel (wall)	1630-1650				Copper/brass
ABO92	780	Spoon	1650-1700				Brass
ABO92	781	Dress-hook	1550-1600	912	3277	0.28	Pewter
ABO92	785	Candle holder	1630-1650				Brass
ABO92	796	Stud	1630-1650	1858	4583	0.41	Pewter
ABO92	799	Spoon	1650-1700				Brass
ABO92	804	Bird feeder	1550-1600	9567	162	59.06	Lead
ABO92	827	Stud	???	3095	2925	1.06	Pewter
ABO92	859	Token	1500-1550	854	8287	0.10	Tin
ABO92	868	Spoon	1500-1550	2954	5481	0.54	Pewter
ABO92	877	Sheet (waste ?)	1500-1550				Brass
ABO92	882	Buckle	1675-1700				Bronze
ABO92	888	Weight	1675-1700	174	7595	0.02	Tin
ABO92	892	Miniature (plate ?)	1675-1700	6142	3082	1.99	Pewter
ABO92	893	Coin weight	1675-1700				Brass
ABO92	900	Spoon	1650-1700				Brass
ABO92	902	Miniature measurer	???	10296	140	73.54	Lead
ABO92	927	Miniature plate	1675-1700	5773	3083	1.87	Pewter
ABO92	931	Weight	???	11183	183	61.11	Lead
ABO92	944	Finger ring	1450-1550 ?	62	3270	0.02	Tin
ABO92	958	???	???	6052	2307	2.62	Pewter
ABO92	969	???	???				Brass
ABO92	973	Ingot	1675-1700	7763	215	36.11	Lead
ABO92	976	Miniature (plate ?)	1630-1650	6446	3172	2.03	Pewter
ABO92	1003	Button	1630-1650				Leaded gunmetal
ABO92	1008	Button	1630-1650				Leaded brass

SITE CODE	FIND No	Description	Date	Pb	Sn	Pb:Sn	Alloy type
ABO92	1010	Button	1630-1650				Leaded gunmetal
ABO92	1024	Thimble	1630-1650				Leaded copper
ABO92	1093	Buckle (double oval)	1630-1650	12523	1369	9.15	Pewter
ABO92	1106	Miniature (chair ?)	1770-1900	5969	1351	4.42	Pewter
ABO92	1128	Buckle (for shoes)	1500-1550	5685	1500	3.79	Pewter
ABO92	1177	Coin forgery ? (farthing)	1675-1700	299	9740	0.03	Tin
ABO92	1191	???	1500-1600	98	2636	0.04	Tin
ABO92	1223	Scabbard chape	???	10438	1360	7.68	Pewter
ABO92	1249	Token	1770-1900				Copper/brass
ABO92	1251	Coin ?	1770-1900	As &Hg			Silver
ABO92	1259	Sheet (waste ?)	1500-1550				Brass
ABO92	1264	Ingot (bar)	1500-1550	4688	1954	2.40	Pewter
ABO92	1267	Spur	1675-1700				Brass
ABO92	1285	Vessel (rim)	1500-1550				Brass
ABO92	1301	Thimble	1630-1650				Brass
ABO92	1320	Coin	???	8811	158	55.77	Lead
ABO92	1321	Button	1630-1650	564	5062	0.11	Tin
ABO92	1392	Buckle (for shoes)	1500-1550	4338	1435	3.02	Pewter
ABO92	1396	Spoon	1500-1550	736	4632	0.16	Tin
ABO92	1398	Strap end	???	844	6501	0.13	Tin
ABO92	1405	Dress-hook	1630-1650				Brass
ABO92	1421	Spoon	1500-1550	618	1497	0.41	Pewter
ABO92	1438	Buckle	1550-1600				Leaded bronze
ABO92	1464	Weight	1500-1550	10008	212	47.21	Lead
ABO92	1472	Thimble	1630-1650				Brass
ABO92	1473	Thimble	1630-1650				Brass
ABO92	1483	Spoon	1500-1550	5149	4024	1.28	Pewter
ABO92	1506	Vessel (patch repair)	1500-1550	370	4527	0.08	Tin
ABO92	1508	???	???				Brass
ABO92	1515	Buckle plate	1500-1550				Brass
ABO92	1531	Sheet (waste ?)	1450-1550 ?				Copper
ABO92	1532	Sheet (waste ?)	1450-1550 ?				Brass
ABO92	1534	???	???				Leaded copper
ABO92	1535	Sheet (waste ?)	1450-1550 ?				Brass
ABO92	1544	Waste	1450-1550 ?				Copper
ABO92	1555	Mirror ?	1575-1600				Leaded bronze
ABO92	1573	Candle holder	1600-1700				Leaded gunmetal
ABO92	1577	Button	1630-1650	744	4947	0.15	Tin
ABO92	1586	Nail cleaner	1600-1800				Brass
ABO92	1619	Dress-hook	1600-1800				Brass
ABO92	1669	???	???				Leaded brass
ABO92	1728	Button	1650-1700				Tin ?
ABO92	1784	Buckle	1675-1700				Leaded brass
ABO92	1788	Bell	1500-1550	19253	3089	6.23	Pewter
ABO92	1795	Vessel (spout)	1500-1550				Leaded bronze
ABO92	1853	Sheet (waste ?)	1500-1550				Brass
ABO92	1853	Sheet (waste ?)	1500-1550				Brass/copper

SITE CODE	FIND No	Description	Date	Pb	Sn	Pb:Sn	Alloy type
ABO92	1856	Spoon	1500-1550	2615	5944	0.44	Pewter
ABO92	1889	Coin weight	1500-1550				Leaded bronze
ABO92	1900	Thimble	1550-1600				Brass
ABO92	1904	Sheet (waste ?)	1500-1550				Brass
ABO92	1904	Sheet (waste ?)	1500-1550				Gunmetal
ABO92	1908	Coin	???	313	5148	0.06	Tin
ABO92	1992	Buzz-disc	1675-1700	6178	157	39.35	Lead
ABO92	2037	Sheet (waste ?)	1530-1550				Bronze
ABO92	2037	Sheet (waste ?)	1530-1550				Copper
ABO92	2040	Sheet (waste ?)	1530-1550				Brass
ABO92	2040	Sheet (waste ?)	1530-1550				Leaded brass
ABO92	2190	Token	1500-1550	27935	328	85.17	Lead
ABO92	2243	Buckle	1500-1550				Leaded brass/ leaded copper
ABO92	2395	Ingot (flattened bar)	1500-1550	8053	1311	6.14	Pewter
ABO92	2425	Sheet (waste ?)	1500-1550				Brass
ABO92	2425	Sheet (waste ?)	1500-1550				Copper
ABO92	2425	Sheet (waste ?)	1500-1550				Gunmetal
ABO92	2458	Candle snuffer	1550-1600				Brass
ABO92	2462	Buckle	1500-1550				Leaded gunmetal
ABO92	2464	Buckle plate	1500-1550				Brass
ABO92	2465	Buckle plate	1500-1550				Brass
ABO92	2513	Ingot	1630-1650	134	5976	0.02	Tin
ABO92	2540	'Waste" (window fitting ?)	1630-1650	7991	289	27.65	Lead
ABO92	2553	Ingot	1500-1550	99	6438	0.02	Tin
ABO92	2660	Coin weight	???				Brass
ABO92	2728	???	???				Brass
ABO92	2744	Vessel (candle holder ?)	1500-1550	3551	4768	0.74	Pewter
ABO92	2751	Mount	1500-1550				Leaded brass
ABO92	2752	Rattle	1500-1550	186	2711	0.07	Tin
ABO92	2852	Ingot	1675-1700				Antimony
ABO92	2891	Spoon	1500-1550	1497	1674	0.89	Pewter
ABO92	2899	Coin weight	1630-1650				Leaded bronze
ABO92	2906	Mount	1550-1600				Leaded gunmetal
ABO92	2971	(Vessel) sheet patch	1450-1550				Leaded bronze
ABO92	2976	Vessel (rim)	1550-1600				Copper/brass
ABO92	2977	Sheet (waste ?)	1550-1600				Brass/gunmetal
ABO92	2979	???	???	338	12101	0.03	Tin
BRA88	24	Thimble	1680-1710				Brass
BRA88	62	Spoon	1550-1700 ?	595	6556	0.09	Tin
BRA88	67	Spoon	1600-1700 ?	628	6776	0.09	Tin
BRA88	76	???	???				Leaded brass
BTH88	106	Spoon	1630-1700	1194	6649	0.18	Tin
BTH88	129	Spoon	1630-1700	1263	6912	0.18	Tin
GAS88	166	Spoon	1500-1550	275	3651	0.08	Tin
GAS88	189	Pin	1480-1550				Brass
GAS88	315	Strap-end	1600-1750				Brass
GAS88	321	Buckle	1480-1550				Copper/bronze

SITE CODE	FIND No	Description	Date	Pb	Sn	Pb:Sn	Alloy type
GAS88	455	Wire	1480-1550				Brass
MOR86	2	Spoon	???	1956	13218	0.15	Tin
SYM88	81	Spoon	1480-1500	7717	4728	1.63	Pewter
SYM88	121	Sheet (waste ?)	1500-1550				Brass
SYM88	160	Strap end	1500-1550	1418	13587	0.10	Tin
SYM88	175	Wire	1480-1550				Brass
SYM88	270	Wire	???				Copper
SYM88	347	???	???				Brass
SYM88	522	Wire	1500-1550				Brass
UPP88	53	???	???				Copper
UPP88	97	Sheet (waste ?)	1580-1600				Brass
UPP88	125	Spoon	1580-1600	230	7401	0.03	Tin
UPP88	126	Spoon	1580-1600	410	7396	0.06	Tin
UPP88	145	???	???				Leaded brass
UPP88	158	Sheet (waste ?)	1550-1600				Brass
UPP88	218	Spoon	1550-1600	241	6253	0.04	Tin
UPP88	303	Spoon	1600-1900				Brass
UPP88	304	Spoon	1600-1900				Brass