Counterfeit Shillings of George III 1816-1820
(iii) Metallurgy

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The previous notes have presented details of the reference collection of counterfeit shillings of George III dated 1816-1820[(1)] and a description of the pieces in terms of the appearance of the metal.[(2)] The metal descriptions were as follows:

A Unidentifiable copper based alloy: copper, brass, bronze etc. Usually with a green/black oxide layer. **AS** shows some silvering.
B Brass - yellow coloured. **BS** shows some silvering.
C Copper - a definite pink colour. **CS** shows some silvering.
S Silver coloured alloy – some may be genuine silver coins.
T Tin - zinc, lead, and alloys such as white metal or pewter that go dull grey or black, often with blistering or powdery corrosion (Tin pest). **TS** shows some silvering.

Cross plots of (i) the weight vs the density via Archimedes of the counterfeits or (ii) density via approximate volume vs density via Archimedes both produced three distinct clusters of measurements mostly consistent with the visual observation.

(1) Tin
(2.1) Copper Alloys
(2.2) Brass
(2.3) Copper
(3.1) Good Silver?
(3.2) Silver?

The following sections will pick out a few typical pieces from each group along with a few outliers and determine the metals using XRF analysis. A hand-held Thermo-Scientific Niton XL2 GOLDD with an extended metals calibration was used for the analysis, in each case on an approximate 6mm diameter circle at the centre of the obverse. A separate analysis and different calibration is used to check for the presence of mercury, which is a known part of the process for silver plating. This will be followed by a look at some pieces that show high proportions of the original silvering.

(4) Silver Plating

For each piece, the previously determined parameters are also included for completeness. A consistent method is used to present the results as follows:

1816160 – Unique reference number
Weight (g), diameter (mm), thickness (mm), Grade, metal, plating (%), Density by Archimedes (g/cm^3), Density by volume (g/cm^3).

Main metals in red, Minor metals in black,
Trace metals typically < 0.2%. Mercury in ppm.

For each group the main metals are always in the same order for that group, but the minor and trace elements are listed in decreasing rank order. The mercury in ppm is determined using a separate measurement and different calibration on the XRF analyser. Hg < LOD means the mercury was below the level of detection of the XRF machine.

1. The Tin Group.

1816160
m 4.3281 g, d 23.78 mm, h 1.66 mm, Grade 35, metal T, plating 0%, ρ_{Arch} 7.214 g/cm^3, ρ_{Vol} 5.871 g/cm^3.

Sn 89.6%, Sb 4.5%, Cu 2.0%, Si 1.4%, Al 1.2%, Pb 1.4%, Others Zn, Bi < 0.2%. Hg 516 ppm.

1817159
m 4.4522 g, d 23.63 mm, h 1.56 mm, Grade 30, metal T, plating 0%, ρ_{Arch} 7.582 g/cm^3, ρ_{Vol} 6.508 g/cm^{3+}.

Sn 88.6%, Sb 5.7%, Cu 0.9%, Si 2.2%, Al 0.9%, Pb 1.5%, Others Fe, P, Zn, Bi < 0.2%. Hg < LOD.

1818030
m 4.0787 g, d 23.69 mm, h 1.80 mm, Grade 20, metal T, plating 0%, ρ_{Arch} 6.913 g/cm^3, ρ_{Vol} 5.141 g/cm^3.

Sn 84.6%, Sb 7.4%, Cu 4.7%, Si 2.0%, Bi 0.4%, Others Pb, Fe, Zn < 0.2%. Hg < LOD.

1819283
m 3.8150 g, d 23.61 mm, h 1.48 mm, Grade 10, metal T, plating 0%, ρ_{Arch} 6.962 g/cm^3, ρ_{Vol} 5.888 g/cm^3.

Sn 85.76%, Sb 9.8%, Cu 2.2%, Si 1.3%, Pb 0.6%, Others Ag, Zb, Bi < 0.2%. Hg 231 ppm.

1820249
m 4.7400 g, d 23.64 mm, h 1.74 mm, Grade 20, metal T, plating 0%, ρ_{Arch} 7.270 g/cm^3, ρ_{Vol} 6.206 g/cm^3.

Sn 80.2%, Sb 9.1%, Cu 5.6%, Si 0.9%, Pb 4.1%, Others Zn, Bi < 0.2%. Hg < LOD.

As expected, the major component of these pieces is tin, but there is also antimony and copper present in all the pieces, sufficient for the metal to be called pewter. There are ranges of compositions for pewter, but typically tin (85–99%), antimony (approximately 5–10%), and copper (2%). Lead can also be added as a hardener. The presence of silicon is interesting in the range 0.9-2.2%. This might be dirt on the surface or a residue from the casting process. Two if the pieces show traces of mercury 1816160 and 1819283. This may be a residue from a silvering process.

2. The Copper Alloys, Brass and Copper Group

2.1 Copper Alloys – no obvious silvering

1816014
m 4.8493 g, d 23.33 mm, h 1.57 mm, Grade 10, metal A, plating 0%, ρ_{Arch} 8.082 g/cm^3, ρ_{Vol} 7.225 g/cm^3.

Cu 71.4%, Zn 8.9%, Si 8.9%, Pb 3.7%, Al 3.1%, P 2.4%
Others Fe, Bi, Ag < 1.0%. Hg 900ppm.

1817149
m 4.7230 g, d 23.99 mm, h 1.64 mm, Grade 20, metal A, plating 0%, ρ_{Arch} 8.379 g/cm^3, ρ_{Vol} 6.371 g/cm^3.

Cu 77.0%, Zn 5.5%, Si 7.2%, Pb 1.6%, Al 3.0%, P 2.1%, Ag 1.6, S 1.1%, Others Fe, Bi < 0.5%. Hg 2700 ppm.

1818086
m 4.8860 g, d 23.59 mm, h 1.56 mm, Grade 10, metal A, plating 0%, ρ_{Arch} 8.572 g/cm^3, ρ_{Vol} 7.166 g/cm^3.

Cu 83.9%, Zn 13.7%, Si 0.6%, Pb 0.6%, Al 6.8%,
Others Bi, Sn, Fe, < 0.4%. Hg < LOD.

1819245
m 5.0560 g, d 23.74 mm, h 1.64 mm, Grade 30, metal A, plating 0%, ρ_{Arch} 8.808 g/cm^3, ρ_{Vol} 6.965 g/cm^3.

Cu 88.3%, Zn 8.3%, Si 1.22%, Pb 0.3%, Ag 0.7%, S 0.4%
Others Bi, P, Fe, < 0.2%. Hg < LOD.

1820189
m 5.0886 g, d 23.60 mm, h 1.49 mm, Grade 35, metal A, plating 0%, ρ_{Arch} 9.212 g/cm^3, ρ_{Vol} 7.807 g/cm^3.

Cu 88.3%, Zn 9.3%, Si 0.4%, Pb 0.4%, Bi 0.4%, S 0.4%
Others P, Ag, Fe, < 0.2%. Hg 595 ppm.

Pieces were chosen that exhibited no visible plating, thus the presence of mercury in all of the pieces is interesting though it is typically just above the Limit of Detection (LOD) for the XRF analyser.

The presence of 5-14% zinc with a consistent presence of lead at about 1% confirms the pieces to be all members of the brass family of alloys. A scratch test on the edge would probably reveal a pink coppery colour typical of a low zinc brass.

The presence of silicon is again likely a surface contamination.

2.2 Brass – no obvious silvering

1816016
m 5.0765 g, d 23.44 mm, h 1.52 mm, Grade 20, metal B, plating 0%, ρ_{Arch} 8.604 g/cm^3, ρ_{Vol} 7.740 g/cm^3.

Cu 82.6%, Zn 14.0%, Pb 1.2%, Si 0.5%,
Others Fe, Sn, Bi, Ag < 0.4%. Hg < LOD.

1817125
m 5.2164 g, d 23.40 mm, h 1.79 mm, Grade 35, metal B, plating 0%, ρ_{Arch} 8.551 g/cm^3, ρ_{Vol} 6.776 g/cm^3.

Cu 75.4%, Zn 21.3%, Pb 1.1%, Si 0.4%, S 1.1%,
Others Ag, Bi, Fe < 0.3%. Hg 390ppm.

1818016
m 5.2110 g, d 23.65 mm, h 1.49 mm, Grade 20, metal B, plating 0%, ρ_{Arch} 8.405 g/cm^3, ρ_{Vol} 7.961 g/cm^3.

Cu 67.1%, Zn 30.4%, Pb 0.7%, Si 0.6%, S 0.4%,
Others Bi, Fe, < 0.2%. Hg 414ppm.
Matches library metal – C330PbBs.

1819250
m 4.0930 g, d 23.37 mm, h 1.28 mm, Grade 15, metal B, plating 0%, ρ_{Arch} 8.599 g/cm^3, ρ_{Vol} 7.455 g/cm^3.

Cu 69.4%, Zn 29.1%, Pb 0.9%, Si 0.1%,
Others Bi, Fe < 0.1%. Hg < LOD
Matches library metal C260CartBs – cartridge brass.

1820071
m 4.3953 g, d 23.68 mm, h 1.31 mm, Grade 35, metal B, plating 0%, ρ_{Arch} 8.453 g/cm^3, ρ_{Vol} 7.618 g/cm^3.

Cu 82.4%, Zn 16.0%, Pb 0.6%, Si < LOD,
Others Fe, Bi, Ag, Sn < 0.3%. Hg 345ppm.

Pieces were chosen that exhibited no visible plating, thus the presence of mercury in three of the pieces is interesting though it is typically just above the Limit of Detection (LOD) for the XRF analyser.

The presence of 15-30% zinc is the source of the yellow colour and with a consistent presence of lead at about 1% confirms the pieces to be all members of the brass family of alloys.

2.3 Copper – no obvious silvering

1816127
m 4.6099 g, d 23.49 mm, h 1.51 mm, Grade 40, metal C, plating 0%, ρ_{Arch} 8.537 g/cm^3, ρ_{Vol} 7.045 g/cm^3.

Cu 93.6%, Zn 5.30%, Pb 0.4%,
Others Fe, Bi, Ag, Sn < 0.2%. Hg 378ppm.
Matches library metal - C210Gilding.

1817010
m 5.0464 g, d 23.95 mm, h 1.51 mm, Grade 30, metal C, plating 0%, ρ_{Arch} 8.553 g/cm^3, ρ_{Vol} 7.481 g/cm^3.

Cu 91.6%, Zn 6.2%, Pb 0.7%,
Others Sn, Fe, Bi, Si < 0.3%. Hg 855ppm.
Matches Library metal – C310PbBs.

1818023
m 5.6724 g, d 23.87 mm, h 1.64 mm, Grade 30, metal C, plating 0%, ρ_{Arch} 8.863 g/cm^3, ρ_{Vol} 7.729 g/cm^3.

Cu 92.9%, Zn 5.1%, Pb 0.9%,
Others Sn, Fe, Bi, Ag < 0.3%. Hg 543ppm.
Matches library metal - C210Gilding.

1819215
m 5.1567 g, d 23.55 mm, h 1.66 mm, Grade 40, metal C, plating 0%, ρ_{Arch} 9.286 g/cm^3, ρ_{Vol} 7.132 g/cm^3.

Cu 88.7%, Zn 8.4%, Pb 0.7%,
Others Si, Fe, Bi, Ag < 0.7%. Hg 285ppm.
Matches a library metal – C310PbBs

1820162
m 5.0102 g, d 23.45 mm, h 1.43 mm, Grade 40, metal C, plating 0%, ρ_{Arch} 9.349 g/cm^3, ρ_{Vol} 8.112 g/cm^3

Cu 92.0%, Zn 5.5%, Pb 0.6%, Si 1.1%,
Others Ag, Bi, S, Fe < 0.3%. Hg 694ppm.

Pieces were chosen that exhibited no visible plating and had an obvious pink coppery colour. The presence of mercury in all of the measurements is interesting though it is typically just above the Limit of Detection (LOD) for the XRF analyser.

The presence of 5-10% zinc with a consistent presence of lead at about 1% confirms the pieces to be all members of the brass family of alloys, though the low zinc content allows the pink copper colour to dominate.

3 The Silver Group

3.1 Good Silver?

1816132
m 5.5890 g, d 23.69 mm, h 1.47 mm, Grade 35, metal S, plating 0%, ρ_{Arch} 9.980 g/cm^3, ρ_{Vol} 8.626 g/cm^3.

Ag 92.8%, Cu 3.7%, Si 1.3, Fe 1.1%, Al 0.7%,
Others Pb, Au, Zn < 0.2%. Hg 243ppm.
Genuine coin.

1817104
m 5.3893 g, d 23.66 mm, h 1.48 mm, Grade 25, metal S, plating 0%, ρ_{Arch} 9.980 g/cm^3, ρ_{Vol} 8.282 g/cm^3.

Ag 92.5%, Cu 3.1%, Si 1.3, Fe 1.4%, Al 1.2%,
Others Pb, Au, Bi < 0.3%. Hg 198ppm.
Genuine coin.

1818058
m 5.3802 g, d 23.59 mm, h 1.55 mm, Grade 25, metal S, plating 0%, ρ_{Arch} 10.151 g/cm^3, ρ_{Vol} 7.942 g/cm^3.

Ag 95.3%, Cu 0.6%, Si 1.7, Fe 0.5%, Al 1.3%,
Others Pb, Au, Zn < 0.3%. Hg 2005ppm.
Genuine coin, surface enriched by past environment.

1819193
m 5.2210 g, d 23.53 mm, h 1.29 mm, Grade 20, metal S, plating 0%, ρ_{Arch} 10.442 g/cm^3, ρ_{Vol} 9.307 g/cm^3.

Ag 93.1%, Cu 5.8%, Si 0.5,
Others Pb, Au, Bi <0.2%. Hg < LOD
Genuine coin.

1820170
m 5.5052 g, d 23.49 mm, h 1.42 mm, Grade 25, metal S, plating 0%, ρ_{Arch} 10.811 g/cm^3, ρ_{Vol} 8.946 g/cm^3

Ag 95.1%, Cu 2.3%, Si 1.17, Al 0.9%
Others Pb, Au, P, Bi < 0.2%. Hg 278ppm.
Genuine coin, surface enriched by past environment.

As anticipated, these pieces are all genuine coins which have suffered in some way giving them an odd colour or surface texture. The presence of mercury in four of the pieces is interesting but is typically just above the Limit of Detection (LOD) for the XRF analyser.

3.2 Silver?

1819136
m 4.8852 g, d 23.75 mm, h 1.54 mm, Grade 40, metal S, plating 0%, ρ_{Arch} 8.423 g/cm^3, ρ_{Vol} 7.161 g/cm^3.

Ni 47.5%, Cu 43.0%, Zn 7.8%,
Others Co, Ag, Pb < 0.6%. Hg 19400ppm

1819140
m 4.4804 g, d 23.80 mm, h 1.41 mm, Grade 35, metal S, plating 0%, ρ_{Arch} 8.454 g/cm^3, ρ_{Vol} 7.143 g/cm^3.

Cu 51.6%, Zn 24.6%, Ni 17.7%, Fe 1.5%
Others Sn, Pb, Co, S < 0.9%. Hg 3800ppm

The presence of Nickel in both of these pieces, suggests later manufacture than the original coinage. Nickel can be found as an accidental component (~2%) of some Syrian Bronzes around 1500BC. The Chinese were using a white copper called Baitong at about the same time. After 1822, Nickel was a by-product of the manufacture of cobalt blue but was not smelted in large quantities until 1848 (in Norway). The addition of Nickel to steel began on an industrial scale in 1889. With this in mind, these two pieces were certainly made after the 1850s, possibly as late as 1900, after which their grade would be too good to blend in with the very worn George III silver then circulating.

The mercury content is well above the limit of detection for the XRF analyser, and as the pieces show no signs of being plated this must be either in the alloy, or the surface of the coin may have been rubbed with some mercurous amalgam to colour the surface.

4 Silver Plating

1816172
m 5.0775 g, d 23.80 mm, h 1.75 mm, Grade 50, metal B, plating 100%, ρ_{Arch} 9.067 g/cm^3, ρ_{Vol} 6.522 g/cm^3.

Cu 81.1%, Ag 9.5%, Zn 8.3%,
Others PB, Mo, Bi, Fe < 0.4%. Hg 9300ppm.

1816322
m 4.8530 g, d 23.67 mm, h 1.55 mm, Grade 45, metal A, plating 100%, ρ_{Arch} 8.856 g/cm^3, ρ_{Vol} 6.412 g/cm^3.

Cu 84.8%, Ag 8.6%, Zn 5.0%,
Others Pb, S, Si, Mo < 0.5%. Hg 8600ppm.

1816347
m 4.6990 g, d 23.61 mm, h 1.58 mm, Grade 10, metal T, plating 60%, ρ_{Arch} 8.883 g/cm^3, ρ_{Vol} 6.793 g/cm^3.

Ag 52.3%, Sn 39.2%, Sb 3.1%,
Others Re, Si, V < 2%. Hg 73000ppm.
Very heavy silver plate on a tin core, last digit of date visible on flap of silver. Tin pest has eaten away at the edge and is also blistering through the silver plating.

1819167
m 5.1906 g, d 23.86 mm, h 1.79 mm, Grade 50, metal B, plating 98%, ρ_{Arch} 9.437 g/cm^3, ρ_{Vol} 6.485 g/cm^3.

Cu 85.76%, Zn 8.2%, Ab 4.2%,
Others Pb, S, Si, Fe < 0.5%. Hg 18000ppm.

1819290
m 5.5390 g, d 23.75 mm, h 1.80 mm, Grade 45, metal B, plating 100%, ρ_{Arch} 8.891 g/cm^3, ρ_{Vol} 6.946 g/cm^3

Ag 85.6%, Zn 8.6%, Ag 4.2%,
Others Pb, Si, S, Fe < 0.6%. Hg 12000ppm.

Counterfeits 1816322 and 1819290 were both acquired in the 2010s, thanks to Paul and Bente Withers, from a small group that had been discovered in a bank vault in Edinburgh some years before.

The systematically high mercury content for all of these pieces suggests that the silver plating was created using a mercury amalgam evaporation method. This would also explain the very thin silvering that allows the underlying metal to be seen by the XRF analysis.

Discussion and Conclusions

In the same manner as shown previously, the following figure plots the density as determined from the volume against the density as determined using Archimedes for the 32 pieces presented above.

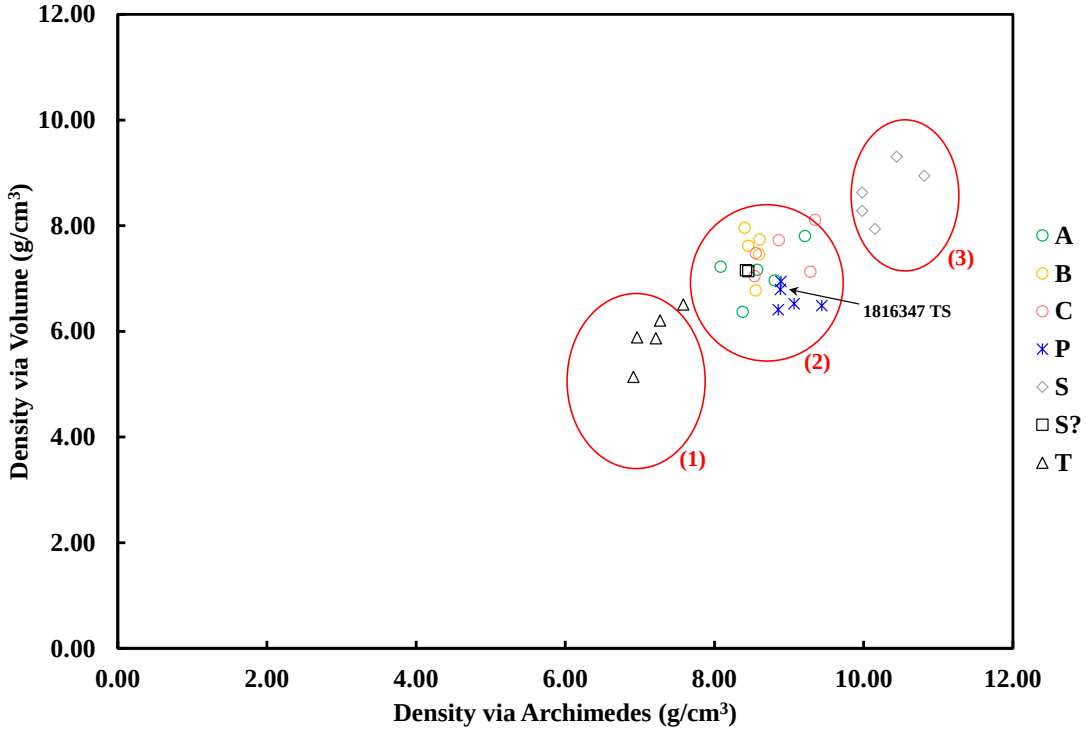

Fig. 1. Comparing density via estimated volume with density via Archimedes' method for the 32 pieces analysed in this note.

As expected, the XRF analysis of the 'tin' pieces confirms the visual estimation of the metal in Group (1), and the 'copper alloys, brass and copper' from Group (2) are also consistent. The 'silver' pieces in Group (3) are indeed genuine coins. The two odd-coloured silver pieces have been found to contain significant amounts of nickel, a metal not used in coinage applications until after the 1850s and likely some decades later for these counterfeits. The density of the nickel alloys is similar to the copper alloys. Four of the plated pieces are confirmed to belong to the brass alloys and the very heavy plating on the tin piece (1816347) has increased its average density so it falls well outside the 'tin' group.

Many of the pieces show traces of mercury (200-500ppm) likely from previous silvering, though is only just above the Limit of Detection using this XRF machine. Those pieces with complete silvering show the highest mercury contents (>3000ppm) suggesting the silvering was created using evaporation of a mercury-silver amalgam. The presence of mercury on some, but not all, of the genuine coins, is again at a low level and may be surface contamination. The nickel-based counterfeits also show mercury in appreciable proportions, which could be surface contamination or contamination of the bulk metal.

References

(1) G. Oddie. Counterfeit Shillings 1816-1820 (i) Reference Collection and Statistics. Link. https://britnumsoc.files.wordpress.com/2021/09/193-counterfeit-george-iii-oddie-blog-001.pdf

(2) G. Oddie. Counterfeit Shillings 1816-1820 (ii) The Observed Metals. Link. https://britnumsoc.files.wordpress.com/2021/09/197-counterfeit-george-iii-oddie-blog-002.pdf