Staffordshire Hoard Research Report 12

Analysis of the Staffordshire Hoard Great Cross (K655, K657, K658, and K659), Gem Setting (K1314) and Inscribed Strip (K550)

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2014

This report forms part of
The Staffordshire Hoard: an Anglo-Saxon Treasure
edited by C. Fern, T. Dickinson and L. Webster
and published by the Society of Antiquaries of London

Information about this report

This report was produced in 2014 as part of Stage 1 of the project, i.e. before fragments were joined and catalogued. The concordance of the K numbers given in the report to the catalogue numbers as they appear in the final publication is as given below. The list also includes the names of the objects as used in the final publication.

K number	Catalogue number	Name in publication
550	540	Strip-mount in gold with Latin inscriptions and gem-setting.
655	539	Mount in gold of cross form with animal art and gem-settings (part).
656	539	As above
657	539	As above
658	539	As above
659	539	As above
1314	539	As above

The British Museum

DEPARTMENT OF CONSERVATION AND SCIENTIFIC RESEARCH

Analysis of the Staffordshire Hoard Great Cross (K655, K656, K657, K658 and K659), gem setting (K1314) and inscribed strip (K550)

Science Report PR07444-19

E. S. Blakelock

Abstract:
The results from a pilot study of 16 sheet gold objects, mostly hilt plates, from the Staffordshire Hoard undertaken to determine whether there was evidence of any surface enrichment and/or depletion of the gold alloy (Blakelock 2013) clearly showed that in many cases there was a significant but not consistent enrichment of the gold content at the surface due to the depletion of both copper and silver.

Therefore a larger study of more objects from the Staffordshire Hoard was undertaken (Blakelock 2014). The surface and sub-surface energy dispersive X-ray analysis in a scanning electron microscope (SEM-EDX) of five gold pieces making up the Great Cross (K655-K659), gem setting K1314 and the inscribed strip K550 expands the dataset for the enrichment study and allows for comparison between the separate pieces.

The construction of the cross is unusual, with an engraved front face reinforced by a separate, undecorated sheet of gold on the back. The analysis showed that the alloy of the two sheets forming the cross (80.8–82.9 wt% Au, 16–17.8 wt% Ag, 1.0–1.4 wt% Cu) are of closely similar composition but higher in gold than the alloy of the gem settings. The analytical results for all four gem settings (K656-659) are closely similar, confirming that all are contemporary. The analysis also showed that K1314 has a similar composition to the round gem settings although it has a different style of bezel setting. The metal repair of the cabochon stone in K659 on the other hand has a distinctive composition suggesting a later repair rather than a contemporary re-use of a damaged stone.

Comparison between the Great Cross components, gem setting K1314 and the inscribed strip revealed that the composition of the core gold alloy of the inscribed strip was distinct from the core alloy composition of the sheets that form the Great Cross. The inscribed strip is closer in composition to the gem settings, although it has a slightly higher copper content. It is possible that the gem setting K1314 may relate to the inscribed strip K550, but all the gem settings have a very similar composition so it is not possible based on composition alone to determine whether D-shaped gem setting K1314 is associated with the Great Cross or the inscribed strip.

Surface gold enrichment was detected on all of the components but most enrichment was evident on the decorated front sheet of the cross, and the central gem setting, adding to the evidence that components were treated individually before being assembled in the workshop. The choice of a higher gold alloy for the cross may have been a deliberate decision by the goldsmith, as this would have been the most visible part of the object, whereas the gold of the gem settings would have been largely obscured by the cabochon stones.

CSR Project no. PR07444-19
12th August 2014
External Registration Numbers: Staffordshire Hoard K655, K656, K657, K658, K659 and K1314

Introduction

This study forms part of a larger English Heritage-funded research project on the Staffordshire Hoard, "Contextualising Metal-Detected Discoveries: Staffordshire Anglo-Saxon Hoard".[1] Analysis was carried out on five gold alloy pieces that are believed to have originally made up the Great Cross, which, like the other items in the Hoard, had been deliberately dismantled before burial (Figure 1a). The construction of the sheet gold cross is unusual, with an engraved front face reinforced by a separate, undecorated sheet of gold behind it, presumably joined with solder though none was accessible for this analytical study. Analysis was also carried out on the inscribed strip (K550) and the gem setting (K1314), currently believed to be associated with the D-shaped space at the base of the Great Cross (Figure 1b and 2), although a similar D-shaped gem setting is apparent at the end of the inscribed strip.

a b

Figure 1. a) The Great Cross (K655) with one gem setting still attached and with four associated gem settings of the same style (K656, K657, K658, K659), and top centre, the D-shaped gem setting (K1314). b) View of the Great Cross showing the D-shaped space at the base.

Figure 2. Unattached D-shaped gem setting K1314 (left), and inscribed strip K550 (right)

[1] The Staffordshire Hoard is a large collection of Anglo-Saxon gold and silver metalwork. Discovered in a field near the village of Hammerwich, near Lichfield, in Staffordshire, England on 5 July 2009, it consists of more than 3,500 fragments, most of which appear to be from military fittings. For more information visit http://www.staffordshirehoard.org.uk/.

The results from the pilot study of 16 gold objects, mostly hilt plates, from the Staffordshire Hoard undertaken to determine whether there was evidence of any surface enrichment and/or depletion of the gold alloy (Blakelock 2013) clearly showed that in many cases that there is significant but not consistent enrichment of the gold content at the surface due to the depletion of both copper and silver. The analysis of deep scrapes, probably made when dismantling the objects before burial, indicated the expected loss of copper from the surface during burial, and little loss of silver. However, the results from undamaged surfaces of the same pieces suggest that some form of deliberately induced depletion gilding was carried out by the goldsmiths to remove both silver and copper from the surface of sheet gold components, perhaps to enhance their golden colour. Therefore a larger study of more objects from the Staffordshire Hoard is being undertaken (Blakelock 2014).

The analysis of the gold pieces making up the Great Cross, inscribed strip and D-shaped gem setting (K1314) expands the dataset for the surface enrichment study and allows for a comparison between the pieces.

Methodology

Gold analysis

A combination of optical microscopy and scanning electron microscopy-energy dispersive X-ray analysis (SEM-EDX) was used.[2] The optical microscope was used to select areas for SEM-EDX analysis using a Hitachi S-3700N Variable Pressure SEM, used at high vacuum, set at an acceleration voltage of 20 kV and an acquisition time of 150 seconds. Images were recorded in the secondary electron (SE) mode. The EDX compositional data were obtained using an Oxford Instrument INCA EDX microanalysis system with an INCAx-act Silicon Drift Detector (SDD).

The degree of surface enrichment in gold, and depletion in copper and silver, was determined by comparison of surface analysis and the analysis of small sub-surface areas representing the core or bulk alloy composition, which were reached by scraping the surface of the gold with a small tool under the optical microscope. The tool had a 0.9 mm wide edge and was sharpened to a chisel less than 0.2 mm wide. The scraped areas were usually not larger than 1 mm^2. The areas analysed were degreased with industrial methylated spirits (IMS).

Results

Cross K655

The analysis of K655 (Table 1 and Figure 3) revealed a *c*.3.4 wt% loss of silver from the surface of the decorated sheet (a difference of *c*.21% in the proportion of silver in the alloy from surface to core). The back sheet also showed a loss of silver (*c*.1.5 wt%, with a difference of *c*.9% from surface to core). Comparison of the sub-surface compositions of both sheets (Figure 4) shows them to be made of a similar but not identical gold alloy.

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[2] The report PR07444-10 (Blakelock 2013) details the methodology and standards used in the initial pilot enrichment study carried out at the British Museum and the experiments assessing potential errors for the SEM-EDX analysis.

Area analysed	**No of analyses**		**Wt% Au**	**Wt% Ag**	**Wt% Cu**
Front decorated sheet surface	8	Average	87.1	12.6	0.3
		Standard Deviation	*1.40*	*1.40*	*0.09*
Front decorated sheet sub-surface	12	Average	83.0	16.0	1.0
		Standard Deviation	*0.56*	*0.47*	*0.16*
Back base sheet surface	8	Average	83.2	16.3	0.5
		Standard Deviation	*0.74*	*0.67*	*0.09*
Back base sheet sub-surface	10	Average	80.8	17.8	1.4
		Standard Deviation	*1.41*	*1.09*	*0.36*

Table 1. SEM-EDX surface and sub-surface compositions for the front and back sheets of K655 (the results are normalised).

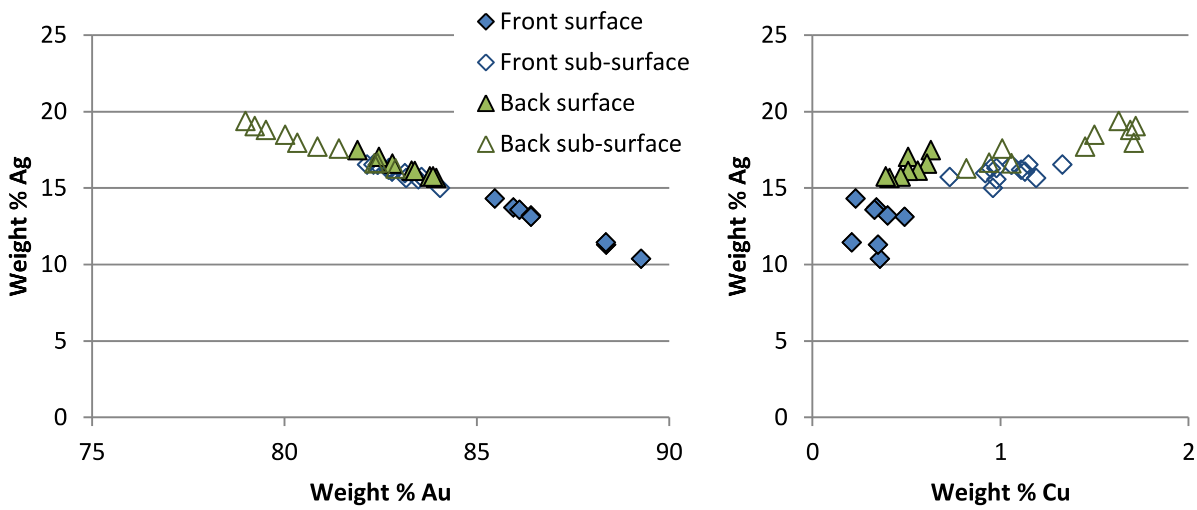


Figure 3. Plots of gold *vs* silver and copper *vs* silver contents, from SEM-EDX analysis, showing the differences between the sub-surface and surface analyses of both sheets, particularly noticeable for the engraved front sheet.

Figure 4. Details of cross K655 showing the deeply engraved front sheet and where damage has caused it to peel away from the backing sheet (scale bar 5 mm).

Gem Settings K656, K657, K658, K659 and K1314

The analysis undertaken on the underside of the base of the gem settings K656, K657 and K658 revealed a *c.*2.6-8.9 wt% loss of silver from the surface, a difference of *c.*10-34% from surface to core, suggesting a deliberate surface treatment had been carried out.

Area analysed	No of analyses		Wt% Au	Wt% Ag	Wt% Cu
K656 surface	10	Average	82.0	17.6	0.4
		Standard Deviation	*1.49*	*1.49*	*0.04*
K656 sub-surface	14	Average	71.4	26.5	2.1
		Standard Deviation	*0.60*	*0.64*	*0.07*
K657 surface	6	Average	76.4	22.6	1.0
		Standard Deviation	1.02	1.01	0.07
K657 sub-surface	10	Average	72.3	25.6	2.1
		Standard Deviation	0.64	0.72	0.11
K658 surface	10	Average	76.2	23.0	0.8
		Standard Deviation	*0.47*	*0.47*	*0.05*
K658 sub-surface	12	Average	72.4	25.6	2.0
		Standard Deviation	*0.27*	*0.25*	*0.05*
K659 surface	10	Average	74.6	23.9	1.5
		Standard Deviation	*0.45*	*0.44*	*0.08*
K659 sub-surface	14	Average	72.1	25.8	2.1
		Standard Deviation	*0.88*	*0.86*	*0.06*
K1314 surface	6	Average	75.5	23.3	1.2
		Standard Deviation	*1.68*	*1.66*	*0.13*
K1314 sub-surface	10	Average	71.0	27.0	2.0
		Standard Deviation	*1.61*	*1.62*	*0.07*

Table 2. SEM-EDX surface and sub-surface compositions of the components of the gem settings analysed (the results are normalised).

The analysis of K659 also revealed a *c.*1.9 wt% loss of silver from the surface, a difference of *c.*7% from surface to core (Table 2). Analysis was also carried out on the metal used to repair the large cabochon garnet (Figure 5), which has a significantly higher silver content than the alloy of the original setting, suggesting a later modification. Further, more silver was detected on the surface than the sub-surface for the repair alloy (Table 3 and Figure 6). This enhanced silver on the surface is not a common situation so repeat analyses were carried out, which confirmed that the differences are real.

Figure 5. Gold alloy repair of gem in K659 (right scale bar 5 mm).

Area analysed	No of analyses		Wt% Au	Wt% Ag	Wt% Cu
K659 base surface	10	Average	74.6	23.9	1.5
		Standard Deviation	*0.45*	*0.44*	*0.08*
K659 base sub-surface	14	Average	72.1	25.8	2.1
		Standard Deviation	*0.88*	*0.86*	*0.06*
K659 repair surface	8	Average	57.3	41.0	1.7
		Standard Deviation	*0.53*	*0.57*	*0.06*
K659 repair sub-surface	12	Average	58.7	39.5	1.8
		Standard Deviation	*1.47*	*1.48*	*0.14*

Table 3. SEM-EDX surface and sub-surface compositions of gem setting K659 (the results are normalised).

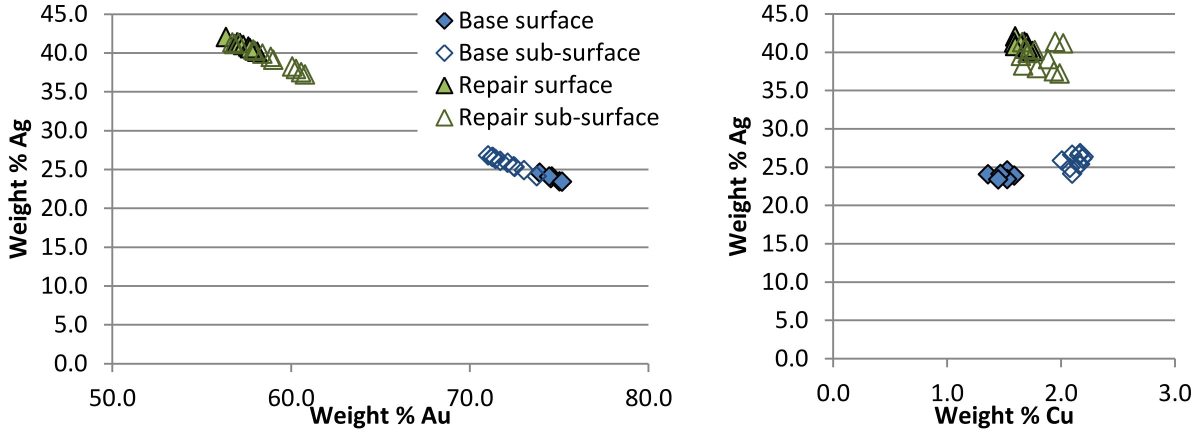


Figure 6. Plots of gold *vs* silver and copper *vs* silver contents, from SEM-EDX analysis, showing the differences between the sub-surface and surface analyses of gem setting K659.

The cabochon garnet of K659 has concentric circles engraved into the face (Figure 7 left). This may originally have held gold inlays as seen on a square headed brooch from Faversham, Kent (Figure 7 right, British Museum, registration no. MLA 1096.1870).

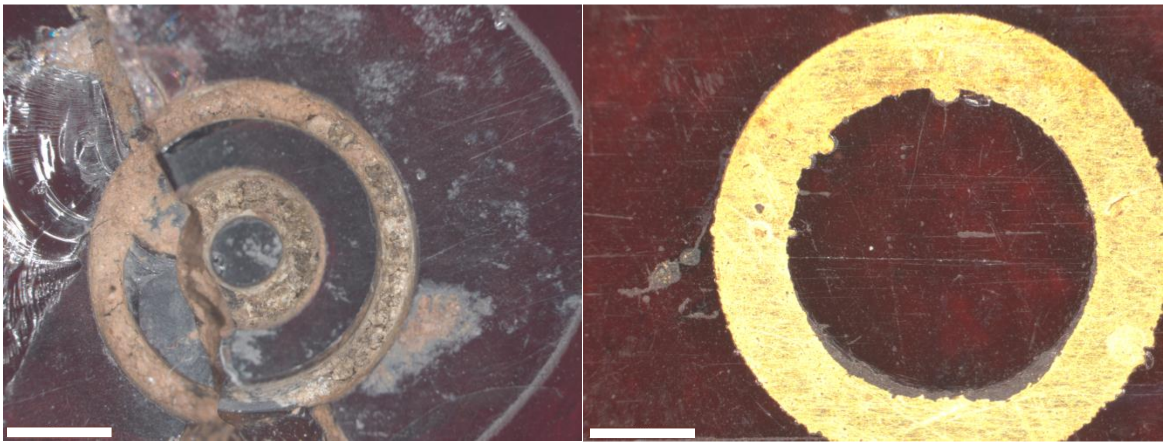


Figure 7. Engraved concentric circles in the cabochon garnet of K659 (left). The right image shows the gold inlay in the slab cut garnet of the Faversham square headed brooch (British Museum, registration no. MLA 1096.1870). Scale bars 1mm.

Close examination of K1314 shows that it differs slightly from the other gem settings (Table 2). It has a plain bezel setting rather than the claw setting seen on the other pieces (Figure 8). However, its distinctive filigree border is similar to both those on the round settings of the cross and the wire border of the empty D-shaped setting on the inscribed strip (Figure 2).

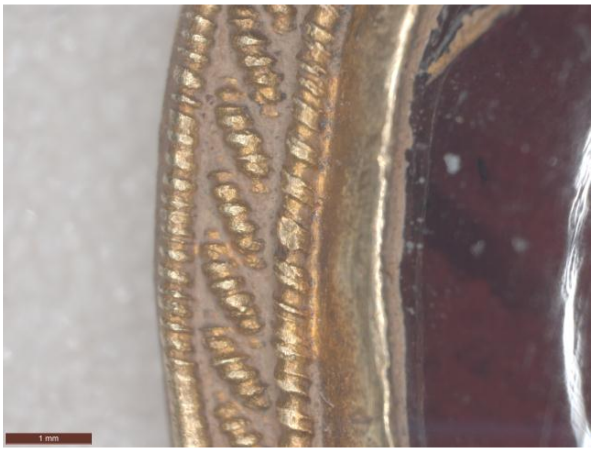


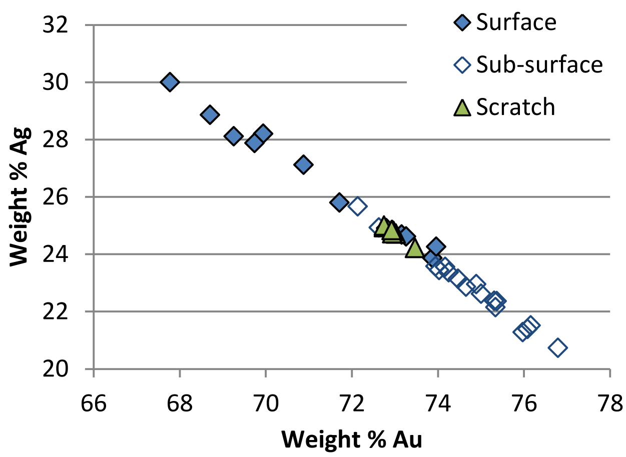
Figure 8. The plain bezel setting of K1314 (left), compared to the claw setting of K657 (right). Scale bar left) 1mm, right) 2mm.

K550

There was a small loss of copper at the surface of the inscribed strip, which is suggestive of natural surface enrichment that can occur during burial (Table 4). There was also an increase in silver at the surface which may be contamination from the niello inlays. The surface of an ancient scratch had a similar composition to the sub-surface, so the increased silver present on the surface may indeed have occurred during manufacture rather than post deposition (Figure 9).

Area analysed	No of analyses		Wt% Au	Wt% Ag	Wt% Cu
Surface	12	Average	71.3	26.5	2.2
		Standard Deviation	*2.16*	*2.08*	*0.25*
Scratch	8	Average	74.7	22.9	2.4
		Standard Deviation	*1.26*	*1.31*	*0.14*
Sub-surface	18	Average	72.9	24.8	2.3
		Standard Deviation	*0.22*	*0.24*	*0.04*

Table 4. SEM-EDX surface and sub-surface compositions of inscribed strip K550 (the results are normalised).



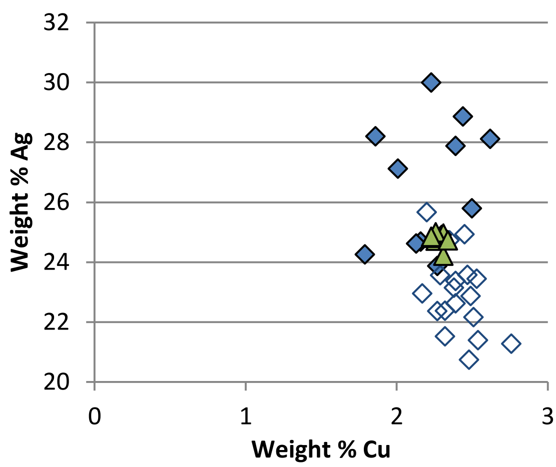


Figure 9. Plots of gold *vs* silver and copper *vs* silver contents, from SEM-EDX analysis, showing the differences between the sub-surface and surface analyses on the inscribed strip K550.

Discussion and conclusions

The construction of the cross is unusual, with an engraved front face reinforced by a separate, undecorated sheet of gold on the back. The analysis showed that the alloy of the two sheets forming the cross (80.8–82.9 wt% Au, 16–17.8 wt% Ag, 1.0–1.4 wt% Cu) are of closely similar composition, perhaps from the same batch of gold, and the front decorated sheet had been surface treated more extensively than the backing sheet. It is unclear whether the laminated structure was a design choice or whether the goldsmith was only able to obtain gold in sheets too thin to construct such a large object.

The core alloy composition of the front and back sheets of the cross (K655) is higher in gold than the alloy of the gem settings (Table 1, Table 2 and Figure 10). The analytical results for all four gem settings (K656-659) are closely similar confirming that all are contemporary. The analysis also showed that the D-shaped gem setting K1314 had a similar composition to the round gem settings, although it has a different style of bezel setting. By contrast, the metal repair of the cabochon stone in K659 has a distinctive composition suggesting a later repair rather than a contemporary re-use of a damaged stone. There was some surface enrichment on all of the gem settings. The analysis of the garnets used in K659 and K1314 demonstrated they were both Almandine type II garnets (Higgitt 2011).

The core alloy composition of the inscribed strip (K550) is distinct from the core alloy composition of the sheets that form the Great Cross. The inscribed strip is closer in composition to the gem settings, although it has a slightly higher copper content (Figure 10).

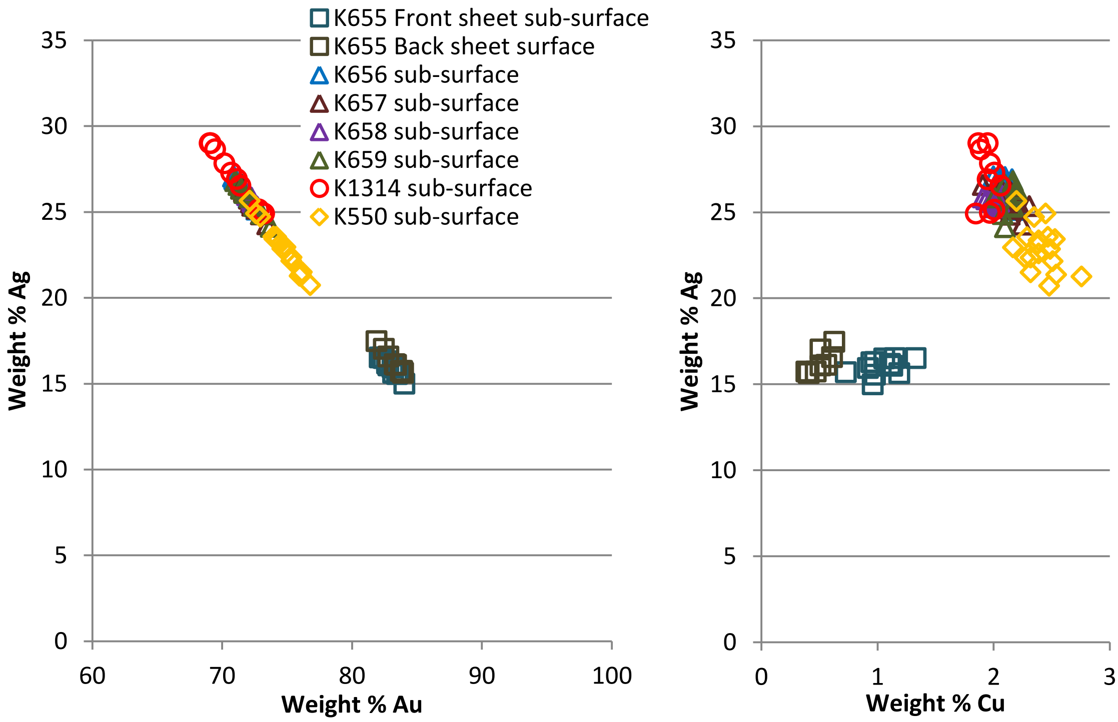


Figure 10. Plots of gold *vs* silver and copper *vs* silver contents, from SEM-EDX analysis, showing the differences between the sub-surface results for the components of the cross, K1314 and inscribed strip K550.

It is therefore possible that the gem setting K1314 may relate to the inscribed strip K550. However since all the gem settings have very similar compositions it is not possible, based on alloy composition, to group K1314 to either the Great Cross or inscribed strip. It is possible, given the similarities in their decoration, that both the Cross and the inscribed strip were made in the same workshop.

Surface gold enrichment was evident on all of the components but not all to the same degree. Most enrichment was evident on the decorated front sheet of the cross, and the central gem setting showed more surface enrichment that the other loose gem settings, adding to the evidence that components were treated individually before being assembled in the workshop. The choice of a higher gold alloy for the cross may have been a deliberate decision by the goldsmith, as this would have been the most visible part of the object, whereas the gold of the gem settings would have been largely obscured by the cabochon stones. The enhanced enrichment seen on the decorated front sheet of the cross compared to its backing sheet might also be explained by a wish to enhance the golden colour of the most important part of the object.

Acknowledgements

I would like to thank Aude Mongiatti, Susan La Niece and Catherine Higgitt for reading and commenting on the drafts of the report.

Thanks should also go to Janet Ambers and Catherine Higgitt, and for information about the garnets analysed at ALGAE. AGLAE beam time was made possible under the FIXLAB transnational access programme of the CHARISMA project. Financial support by the Access to Research Infrastructures activity in the 7th Framework Programme of the EU (Grant Agreement n. 228330) and the help of the AGLAE team is gratefully acknowledged.

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12th August 2014

CSR Project no. PR07444-19, British Museum
External Registration Numbers: Staffordshire Hoard K655, K656, K657, K658, K659 and K1314

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Staffordshire Hoard Research Reports

Staffordshire Hoard Research Reports were produced by the project

Contextualising Metal-Detected Discoveries: Staffordshire Anglo-Saxon Hoard

Historic England Project 5892

The Staffordshire Hoard is owned by the Birmingham City Council and the Stoke-on-Trent City Council and cared for on their behalf by Birmingham Museums Trust and The Potteries Museum & Art Gallery.

The Staffordshire Hoard research project was conducted by Barbican Research Associates Ltd and funded by Historic England and the owners.

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