Staffordshire Hoard
Research Report 10

Scientific analysis of the Staffordshire Hoard Seax Set

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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
354	169	Hilt-collar in gold, of narrow form, with a cap and garnet cloisonné decoration.
370	167	Hilt-collar in gold, of high form, with garnet cloisonné decoration.
376	55	Miniature pommel, of cocked-hat form, in gold with garnet cloisonné decoration.
449	168	Hilt-collar in gold, of high form, with garnet cloisonné decoration.
690	225	Plain hilt-ring cast in gold.

The British Museum

DEPARTMENT OF CONSERVATION AND SCIENTIFIC RESEARCH

Scientific analysis of the Staffordshire Hoard seax set

Science Report PR07444-16

E. S. Blakelock

Abstract:

Analysis of a seax set from the Staffordshire Hoard was carried out during Phase 2 of the analytical study of the Hoard, following an initial pilot study of 16 gold objects which demonstrated that some form of deliberately induced depletion gilding had been employed to remove both silver and copper from the surface of many of the objects, perhaps to improve the colour at the manufacturing stage (Blakelock 2013, 9-11).

The surface and sub-surface energy dispersive X-ray analysis in a scanning electron microscope (SEM-EDX) of five gold pieces making up the seax set (K376, K354, K690, K370 and K449) expands the dataset for the investigation of surface enrichment and allows for intercomparison between the separate pieces.

The analysis of the gold alloy has revealed that two of the garnet cloisonné hilt-collars and the hilt-ring (K370, K449 and K690) are made of a similar gold alloy and have the same style of cloisonné, confirming they form a set. Hilt-collar K354 had a similar composition although the copper content was lower than the others from the set, perhaps indicating that it was made from a separate batch of gold. The results also indicated that the hilt-collars and hilt-ring of the seax set had been surface-treated to create a more golden surface.

Pommel K376 is a clear outlier as it has a different alloy composition, with a higher silver content, to the other pieces and shows no evidence that it was deliberately surface treated. This suggests that it may be a later addition or replacement to the seax set.

CSR Project no. PR07444-16
August 2014
External Registration Numbers: Staffordshire Hoard K376, K354, K690, K370 and K449

Introduction

The analysis of a group of five pieces from the Staffordshire Hoard referred to as the seax set (Figure 1) is part of a larger English Heritage-funded research project on the Staffordshire Hoard, "Contextualising Metal-Detected Discoveries: Staffordshire Anglo-Saxon Hoard".[1] The results from a 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.

Figure 1. The five objects (K376, K354, K690, K370 and K449) that make up the seax set. Top right shows K370 and bottom right shows the damaged side of hilt piece K449 with the slot for the blade on the top.

The analysis of the gold alloy composition of the objects making up the seax set not only expands the dataset for the investigation of surface enrichment but also allows for intercomparison between associated objects of one set.

[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/.

Methodology

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 under high vacuum conditions, 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 accessed 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) prior to analysis.

Results

Pommel K376

The pommel K376 has garnet cloisonné decoration on both sides and along the top (Figure 2). The base of the pommel is a separate sheet of gold with an opening designed to take the tang of the missing iron blade (Figure 3 left). This sheet has been damaged, probably when dismantling the seax before burial, providing access for analysis of the cell wall of the central garnet (Figure 3 right)

Figure 2. K376 with garnet cloisonné design on the side and top of the pommel.

Three areas were analysed on the pommel to ensure that the results were representative of the entire object (Table 2); the base sheet, an edging strip and a cell wall. The results suggested that the base and the edging strip of this piece are similar in composition (Figure 4). There was only *c*.0.4-1.0 wt% loss of silver from the surface of this object (up to 5% difference from core to surface), which is too small to be certain it was deliberately enriched. The analysis of the interior cell wall (Figure 3 right) revealed no loss of silver at the surface and an increase of copper, which could indicate contamination from solder, the core

[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.

composition was similar to the other components.

Figure 3. left) The base sheet of pommel K376, right) damaged central garnet cell (scale bar 2 mm).

Area analysed	No. of analyses		Wt % Au	Wt % Ag	Wt % Cu
Base sheet surface	10	Average	71.5	26.8	1.7
		Standard Deviation	*1.01*	*1.06*	*0.09*
Base sheet sub-surface	24	Average	70.3	27.8	1.8
		Standard Deviation	*1.04*	*1.01*	*0.06*
Base sheet scratch	5	Average	70.6	27.9	1.5
		Standard Deviation	3.11	2.81	0.31
Edging strip surface	12	Average	73.6	24.0	2.3
		Standard Deviation	*0.94*	*0.63*	*0.32*
Edging strip sub-surface	25	Average	73.0	24.4	2.6
		Standard Deviation	*1.42*	*1.34*	*1.01*
Cell wall surface	6	Average	71.1	24.7	4.1
		Standard Deviation	*1.58*	*1.37*	*0.24*
Cell wall sub-surface	9	Average	70.3	24.8	4.9
		Standard Deviation	*1.60*	*2.27*	*1.41*

Table 2. SEM-EDX surface and sub-surface compositions of the pommel K376. The results are normalised.

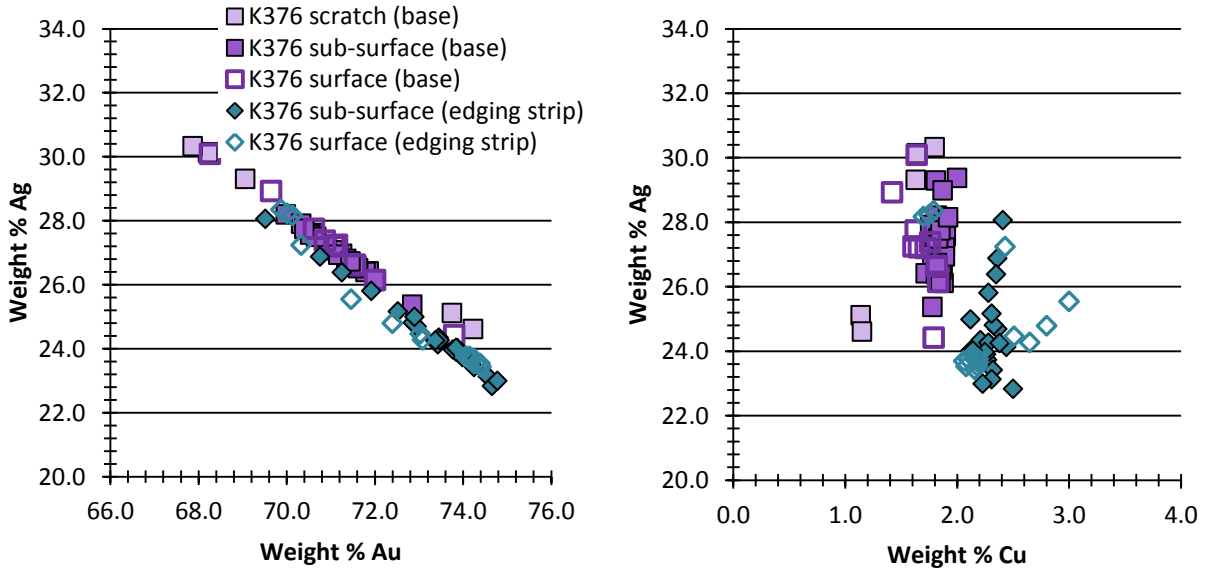

Figure 4. Plots of gold *vs* silver and copper *vs* silver contents, from SEM-EDX analysis, showing the similarity between the sub-surface and surface analyses of the base sheet and the edging strip of K376.

Hilt-collar K354

K354 is one of the hilt-collars and has a double row of garnets decorating the side (Figure 5). There is a gold sheet across the top with a perforation for the tang. The pommel K 376 has left an impression on this sheet (Figure 6 left).

Figure 5. K354 showing the garnet cloisonné design on the side of the hilt-collar (right scale bar 5 mm).

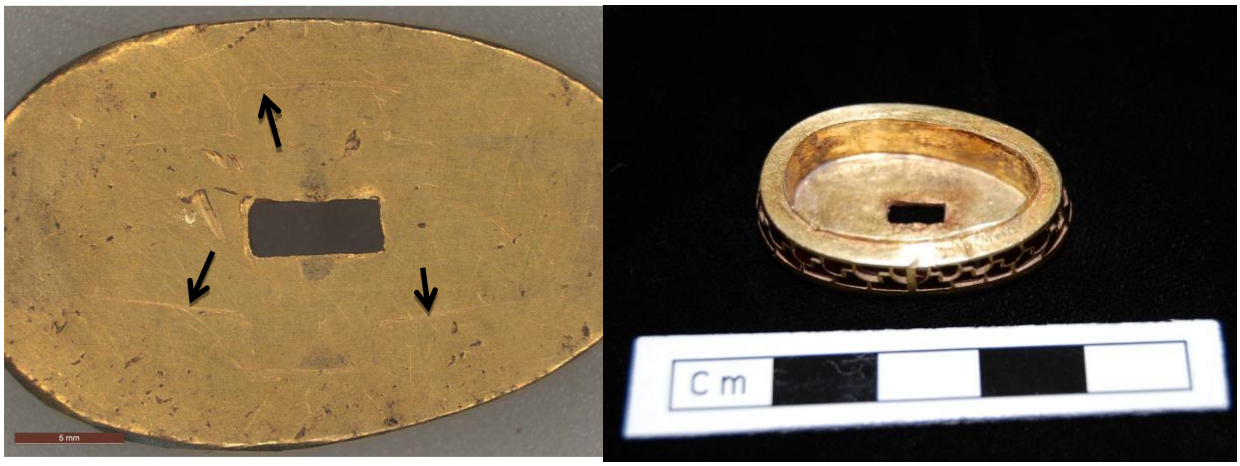

Figure 6. K354 showing the sheet of metal with the opening for the tang. The image on the left shows the impression of the pommel K376 (scale bar 5 mm).

Analysis of the surface of a scratch probably made when dismantling the seax before burial revealed a similar silver content to the sub-surface and a small loss of copper, as would be expected from natural burial corrosion. The analysis of the surface and core alloy of the top of the hilt collar revealed a *c*.3.7 wt% loss of silver from the surface, a difference of *c*.27% from surface to core (Table 3). This is indicative of treatment to deliberately enrich the gold colour of the metal and that the ancient scratch had cut though this enriched surface layer.

Hilt-ring K690

K690 has no decoration and the outside surface has been burnished smooth but the surfaces in contact with the pieces K354 and K370 are rough (Figure 7).

Analysis revealed a *c*.8.1 wt% loss of silver from the surface, a difference of *c*.27% from surface to core (Table 3), suggesting deliberate enrichment of the gold surface of this piece also. Analysis of the surface of a scratch probably made in dismantling the seax before burial revealed a lower copper but only a slightly lower silver content to the sub-surface

results confirming this conclusion.

Figure 7. K690, a plain gold hilt-ring; the picture on the right shows the rough surfaces where the hilt-ring was in contact with K354 and K370 (scale bar 1mm).

Hilt-collar K370

The hilt-collar K370 has garnet cloisonné decoration (Figure 8) with an interlaced serpent design. The top of the collar is stepped to allow K690 to fit into place (Figure 8 right). Inside the hilt-collar there is a join between two separate sheets (Figure 9 left).

Figure 8. The garnet cloisonné design of K370.

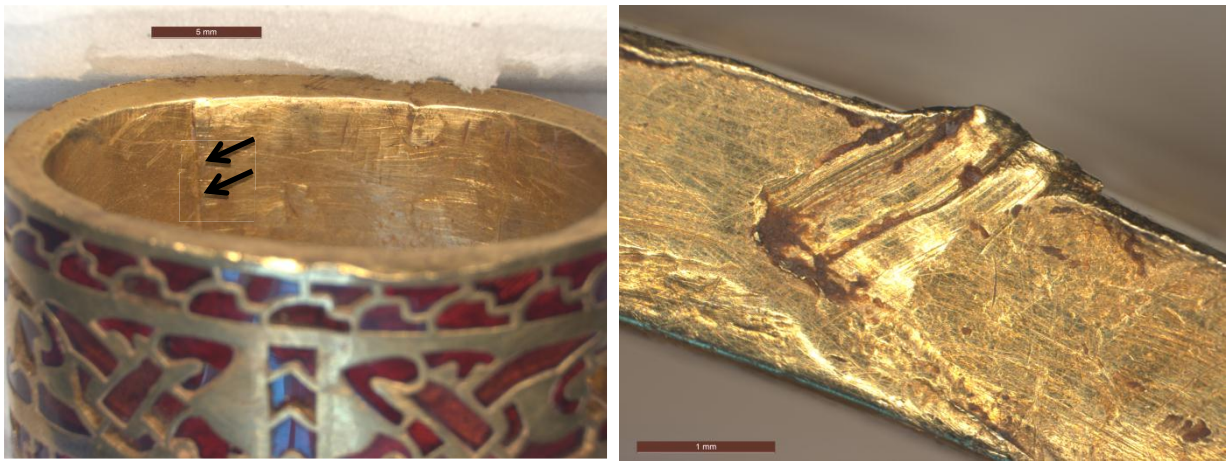

Figure 9. K370 showing the join between sheets of metal used to construct the piece (scale bar 5 mm) and on the right a deep scratch with the same patina as the rest of the surface (scale bar 1 mm).

Analysis of the alloy composition of the hilt-collar revealed a *c*.1.3 wt% loss of silver from the surface, a difference of *c*.9% from surface to core (Table 3) suggesting deliberate enrichment of the gold surface of this piece also. Analysis of the surface of one of the deep scratches, most likely made when the collar was being removed from the blade before burial (Figure 9 right), revealed a lower copper but only a slightly lower silver content to the sub-surface results, adding weight to this conclusion.

Hilt-collar K449

The hilt-collar K449 is decorated with garnet cloisonné (Figure 10) with a similar design to K370. The sheet at the base of the piece has an opening to allow the tang of the blade to be fitted (Figure 11). There was a rough and pitted area on the surface of this sheet which indicates the shape and location of the single edge blade (Figure 11). As has been noted on the other pieces, this hilt collar had evidence of damage probably made when it was removed from the seax blade before burial (Figure 12).

Figure 10. The garnet cloisonné design of K449.

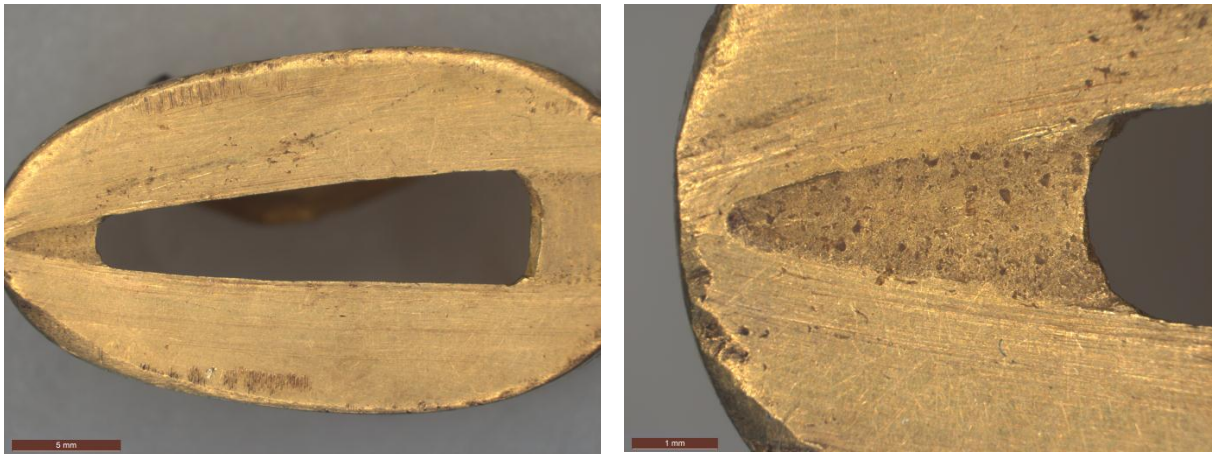

Figure 11. Impression of the single edged blade on the surface of the gold sheet of K449 (scale bar 5 mm) and a close up showing the difference between the polished surface and the rough and pitted impression (scale bar 1 mm).

Figure 12. Left) Damage on K449 made when it was forcibly dismantled before burial (scale bar 5 mm) and right) scrapes on the surface (scale bar 5 mm).

Analysis revealed a *c.*2.4 wt% loss of silver from the surface, a difference of *c.*16% from surface to core (Table 3). This suggests a deliberate surface treatment was carried out.

Discussion

Gold Composition

The results from the analysis of the gold alloy composition of the five pieces of the seax set are presented in Table 3. The core composition of most of the pieces fall within a similar range of alloys (81-85 wt% Au, 13-16 wt% Ag, 1-3 wt% Cu). The outlier is pommel K376 which has a higher silver content than the rest, (69-71 wt% Au, 26-29 wt% Ag, 1- 2 wt% Cu). With the exception of K376, the pieces show some evidence for deliberate surface enrichment.

		SEM-EDX surface			SEM-EDX sub-surface		
Object		**Wt% Au**	**Wt% Ag**	**Wt% Cu**	**Wt% Au**	**Wt% Ag**	**Wt% Cu**
K376	Average	71.5	26.8	1.7	70.3	27.8	1.8
	Standard Deviation	*1.01*	*1.06*	*0.09*	*1.04*	*1.01*	*0.06*
K354	Average	89.2	10.2	0.6	84.9	13.9	1.1
	Standard Deviation	*0.60*	*0.60*	*0.07*	*0.84*	*0.78*	*0.16*
K690	Average	92.2	6.9	0.9	82.4	15.0	2.6
	Standard Deviation	*2.04*	*1.79*	*0.27*	*1.14*	*1.24*	*0.13*
K370	Average	84.5	14.0	1.5	82.0	15.3	2.6
	Standard Deviation	*0.67*	*0.59*	*0.16*	*0.56*	*0.56*	*0.16*
K449	Average	85.3	13.1	1.7	82.2	15.5	2.3
	Standard Deviation	*0.73*	*0.62*	*0.16*	*1.04*	*0.94*	*0.14*

Table 3. SEM-EDX surface and sub-surface compositions of the five pieces from the seax set. The results are normalised.

When the gold against silver contents for all pieces of the seax set are plotted, two distinct groups can be seen (Figure 13), and possibly three when copper and silver concentrations are considered (Figure 14). Pommel K376 is a different gold alloy from the other pieces of the set, and there was no evidence for deliberate surface enrichment. K354 has a lower copper content than the two hilt-collars and the hilt-ring (K690, K370 and K449). The small difference in composition between the hilt-collars and hilt-ring would not have resulted in an obvious colour difference, but there is a difference in colour between pommel K357 and the

other pieces of the set.

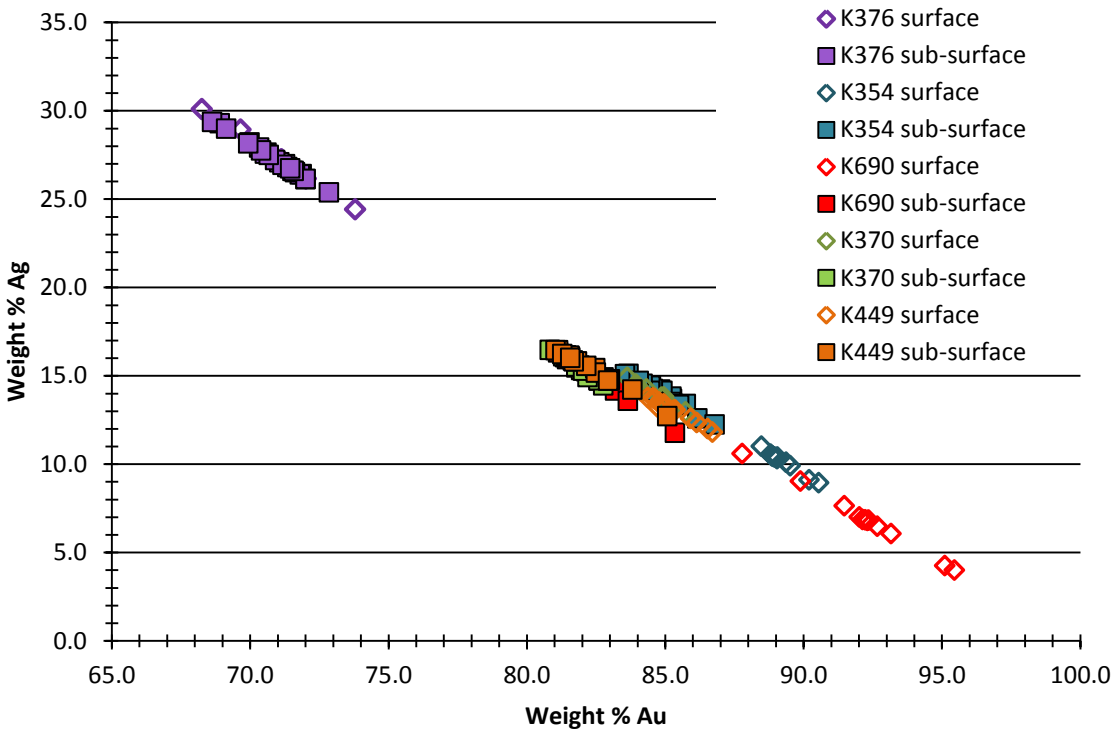

Figure 13. Plots of gold *vs* silver contents, from SEM-EDX analysis, showing the differences between the sub-surface and surface analyses of the five pieces of the seax set.

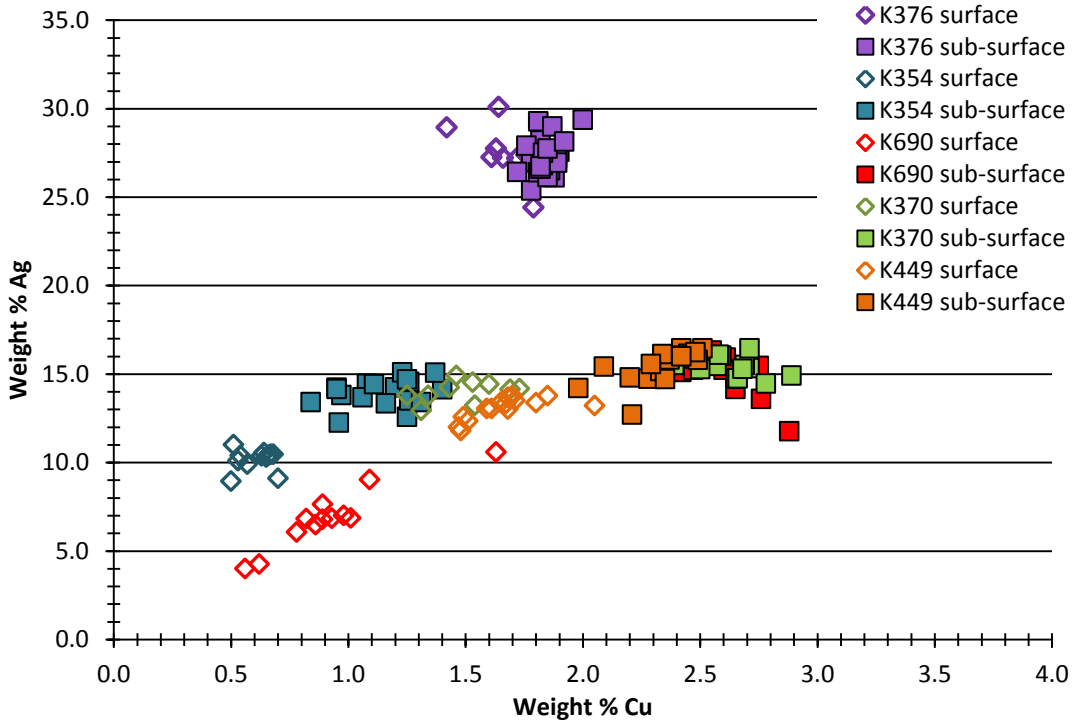

Figure 14. Plots of copper *vs* silver contents, from SEM-EDX analysis, showing the differences between the sub-surface and surface analyses of the five pieces of the seax set.

Conclusion

Analysis of the alloy compositions has shown that two of the garnet cloisonné hilt-collars and the hilt-ring (K370, K449 and K690) used a similar gold alloy, and garnet construction techniques, confirming they are part of the seax set. Hilt-collar (K354) had a similar alloy composition although the copper content was lower than the others from the set so may have been made from a separate batch of gold. Surface and sub-surface analyses indicate that the three hilt-collars and hilt-ring of the seax set may have been deliberately surface treated to create a more golden surface.

Pommel K376 is a clear outlier as it has a different composition, with a higher silver content, to the other pieces and shows no evidence that it was deliberately surface treated. This suggests that this piece may be a later addition or replacement to the seax set.

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21 August 2014

References

Blakelock, E.S., 2013. *Pilot study of surface enrichment in a selection of gold objects from the Staffordshire Hoard*. Staffordshire Hoard Archaeological Report 6, Archaeological Data Service, York.

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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