*Staffordshire Hoard Research Report 7*

# Analysis of a Multi-Component Garnet, Gold and Millefiori Object from the Staffordshire Hoard

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*The Staffordshire Hoard: an Anglo-Saxon Treasure*
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## 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. In the final publication these three items are part of catalogue no. 541 which is described as a roundel with disc in gold, with garnet cloisonné, animal art ornamented panels and a glass gem setting. This was found partially intact and brought together from nine fragments.

The British Museum

**DEPARTMENT OF CONSERVATION AND SCIENTIFIC RESEARCH**

# Analysis of a multi-component garnet, gold and millefiori object from the Staffordshire Hoard (K130, K545, K1055)

**Science Report PR07444-11**

E. S. Blakelock

## Abstract:

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, clearly showed that in many cases there is significant but not consistent enrichment of the gold content at the surface of the alloy due to the depletion of both copper and silver (Blakelock 2013).

The surface and sub-surface analysis of three gold pieces (K130, K545 and K1055) making up the 'mystery object', so-called as its purpose has not been established at the time of writing, not only expands the dataset for the enrichment study but also allows for a comparison between the separate components that form the object.

Sub-surface analysis revealed that most of the components of the mystery object were made of a similar gold alloy, most likely from a similar stock of gold alloy (88.1–88.8 wt% Au, 7.6–8.8 wt% Ag, 3.1–3.6 wt% Cu). The only exception was the wire used in the construction of the stud. This had higher silver and a slightly lower copper content than the other components (*c.*69.9 wt% Au, 27.9 wt% Ag, 2.2 wt% Cu). Analysis revealed no deliberate enrichment of gold at the surface, but did demonstrate a significant increase in silver which is most likely due to a natural deposition from contact with corroding silver objects.

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External Registration Numbers: Staffordshire Hoard K130, K545, K1055

## 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] The results from the pilot study of 16 gold objects, mostly sword fittings, from the Staffordshire Hoard undertaken to determine whether there was evidence of any surface enrichment of the gold alloy (Blakelock 2013), clearly showed that in many cases there is significant but not consistent surface enrichment of the gold 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 objects suggest that some form of deliberately induced depletion gilding took place to remove both silver and copper from the surface, perhaps to improve the colour at the manufacturing stage. Therefore a larger study of more objects from the Staffordshire Hoard is being undertaken, including the analysis of three garnet-inlaid pieces (K130, K545 and K1055) that fit together. The purpose of this composite and richly decorated object is not known and it will be termed here the 'mystery object' (Figure 1).


**Figure 1.** The three pieces reconstructed to make up the mystery object, from the top right K545, K1055 and K130.

The analysis of the three gold pieces making up the 'mystery object' not only expands the dataset for the enrichment study but also allows for a comparison between the separate components that form the object (Blakelock 2014).

[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 analysis by SEM-EDX, using a Hitachi S-3700N Variable Pressure SEM, used at high vacuum, set at an acceleration voltage of 20 kV and at 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

### *K545*

The main body of the stud (K545) from the mystery object is constructed from two sheets of gold. One forms the back of the stud, the other is the front rim into which the decorative elements are set. These have been soldered on to a wire that runs around the circumference of the stud (Figure 2). SEM-EDX surface and sub-surface analyses were undertaken on the two sheets and the wire on the edge of the circular stud (Figure 2). A repeat analysis was carried out on the sheet on the back of the stud. In addition, analysis was also carried out on one of the garnet cell walls on the front of the stud.


**Figure 2.** Left) stud K545, the orange arrow indicates the location of the area pictured on the right. Right) Arrows a) and b) indicate the front and back sheets respectively. Arrows c) point to the central wire (which runs around the circumference of the stud), to which the front and back sheets appear to have been soldered.

[2] The report PR07444-10 (Blakelock 2013) details the methodology and standards applied 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 |
|---|---|---|---|---|---|
| Sheet (back) surface | 6 | Average | 85.5 | 11.8 | 2.7 |
| | | *Standard Deviation* | *0.70* | *0.64* | *0.07* |
| Sheet (back) sub-surface | 10 | Average | 88.6 | 8.2 | 3.2 |
| | | *Standard Deviation* | *0.29* | *0.30* | *0.09* |
| Sheet (back repeat) surface | 4 | Average | 85.7 | 11.7 | 2.6 |
| | | *Standard Deviation* | *0.52* | *2.45* | *0.36* |
| Sheet (back repeat) sub-surface | 6 | Average | 88.2 | 8.7 | 3.1 |
| | | *Standard Deviation* | *0.25* | *0.77* | *0.10* |
| Centre wire surface | 6 | Average | 68.3 | 30.7 | 1.0 |
| | | *Standard Deviation* | *1.33* | *1.36* | *0.10* |
| Centre wire sub-surface | 9 | Average | 69.9 | 27.9 | 2.2 |
| | | *Standard Deviation* | *1.11* | *1.10* | *0.09* |
| Sheet (front) surface | 6 | Average | 86.4 | 10.9 | 2.7 |
| | | *Standard Deviation* | *0.35* | *0.44* | *0.09* |
| Sheet (front) sub-surface | 10 | Average | 88.9 | 8.0 | 3.1 |
| | | *Standard Deviation* | *0.22* | *0.17* | *0.11* |
| Cell wall surface | 6 | Average | 85.1 | 12.0 | 2.9 |
| | | *Standard Deviation* | *0.21* | *0.19* | *0.05* |
| Cell wall sub-surface | 6 | Average | 88.1 | 8.8 | 3.1 |
| | | *Standard Deviation* | *0.26* | *0.31* | *0.08* |

**Table 1.** SEM-EDX surface and sub-surface compositions for each component of K545 analysed (the results are normalised)

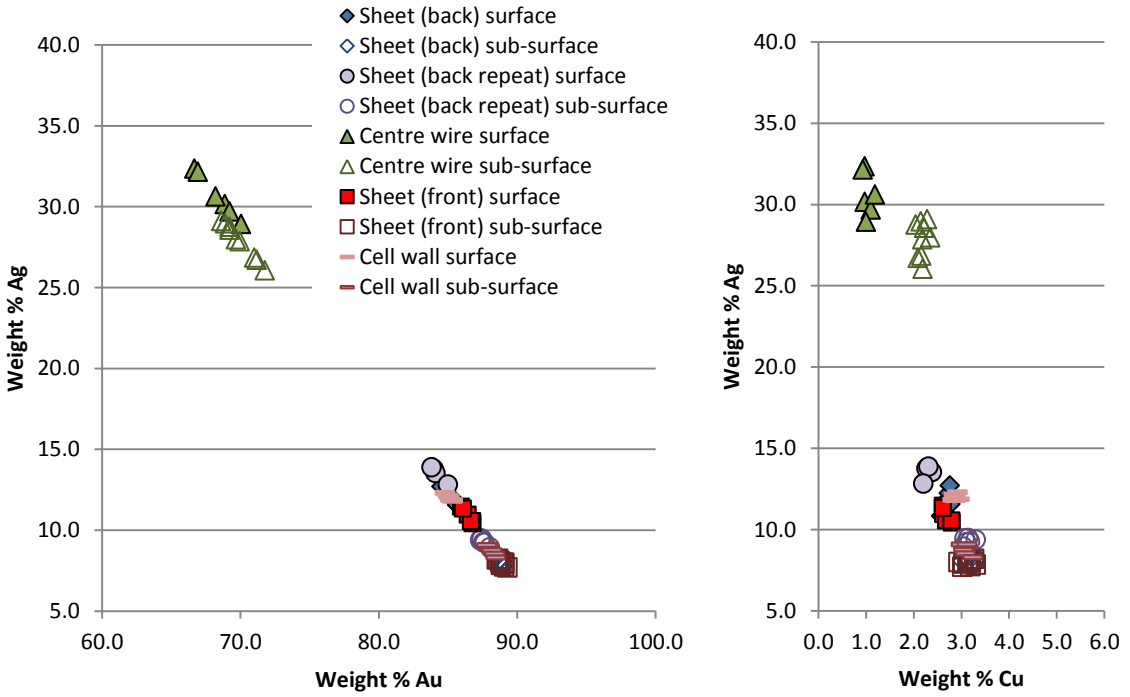


**Figure 3.** Plots of gold *vs* silver and copper *vs* silver contents, from SEM-EDX analysis, showing the differences between the sub-surface and surface analyses of the components of K545.

Comparison of the sub-surface compositions (i.e. the original alloy composition) of the components (Figure 3) suggests that the gold alloy used for the central wire in the construction of this piece was of a different composition to that of the sheet gold used for the front and back, and the cell walls (Table 1). The analysis indicated a loss of copper and

higher silver at the surface compared to the sub-surface alloy of all components, including the back of the stud, which was analysed away from soldered joins.

***K1055***

**Figure 4.** Left) Cylinder K1055 with inset garnets, the arrow indicates the prepared sub-surface area. Right) top of K1055 which fits into the base of K545.

It appears that the gold foils and garnets have been inset into the gold of the cylinder. Analysis undertaken on the side of the cylindrical component K1055 suggested no loss of copper and higher silver at the dark, tarnished surface of the gold compared to the sub-surface alloy composition (surface composition of *c*.75.3 wt% Au, 21.4 wt% Ag and 3.3 wt% Cu with a sub-surface composition of *c*.88.2 wt% Au, 8.5 wt% Ag and 3.3 wt% Cu).

***K130***

**Figure 5.** The prepared sub-surface area on the top side of the circular base sheet is indicated by the arrow in the picture on the left, this would have originally been underneath a gold panel like that seen in the right image.

The roundel K130 is constructed of a circular base sheet with applied cell walls, garnet and gold panel decoration. SEM-EDX analysis was undertaken on the top surface of the base sheet to which the applied decoration is attached. This has a surface composition of *c*.89.2 wt% Au, 7.5 wt% Ag and 3.3 wt% Cu with a sub-surface composition of *c*.88.7 wt% Au, 7.6 wt% Ag and 3.6 wt% Cu.

## Discussion

Analysis revealed that apart from the wire at the circumference of the stud K545, the other components analysed on the three pieces of the 'mystery object' had a similar sub-surface alloy composition (Table 2 and Figure 6). This suggests that all the pieces were made in the same workshop using the same alloy. The choice of a different alloy, with more silver, to form the central wire (Figure 2 right) might have been to provide support for the attached sheets or may have simply reflected what was available in the workshop.

| | | SEM-EDX surface | | | SEM-EDX sub-surface | | |
|---|---|---|---|---|---|---|---|
| **Object** | | **Wt% Au** | **Wt% Ag** | **Wt% Cu** | **Wt% Au** | **Wt% Ag** | **Wt% Cu** |
| K545 Sheets | Average | 85.8 | 11.5 | 2.7 | 88.5 | 8.3 | 3.2 |
| | *Standard Deviation* | *0.5* | *1.2* | *0.2* | *0.3* | *0.4* | *0.1* |
| K545 Wire | Average | 68.3 | 30.7 | 1.0 | 69.9 | 27.9 | 2.2 |
| | *Standard Deviation* | *1.33* | *1.36* | *0.10* | *1.11* | *1.10* | *0.09* |
| K545 Cell wall | Average | 85.1 | 12.0 | 2.9 | 88.1 | 8.8 | 3.1 |
| | *Standard Deviation* | *0.21* | *0.19* | *0.05* | *0.26* | *0.31* | *0.08* |
| K1055 Main Body | Average | 75.3 | 21.4 | 3.3 | 88.2 | 8.5 | 3.3 |
| | *Standard Deviation* | *2.36* | *1.98* | *0.53* | *0.71* | *0.56* | *0.18* |
| K130 Base sheet | Average | 89.2 | 7.5 | 3.3 | 88.8 | 7.6 | 3.6 |
| | *Standard Deviation* | *0.19* | *0.40* | *0.35* | *0.45* | *0.49* | *0.16* |

**Table 2**. SEM-EDX sub-surface alloy compositions of the main components of the three pieces making up the 'mystery object'. The results are normalised.

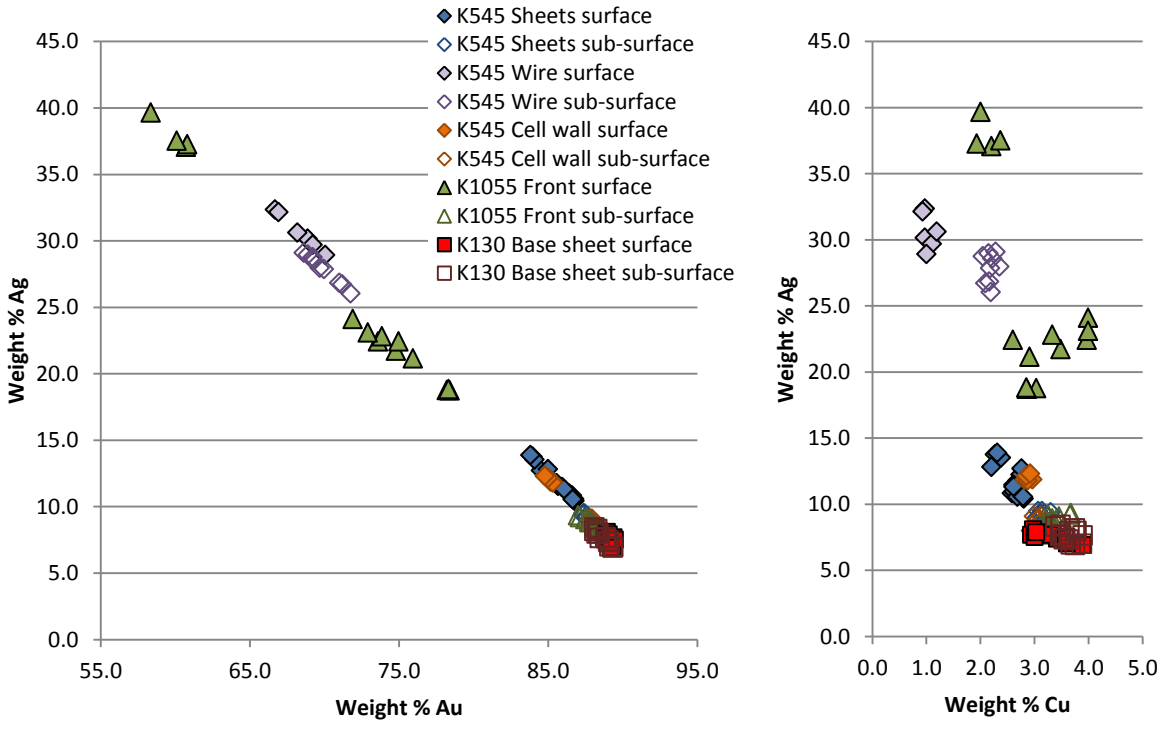


**Figure 6.** Plots of gold *vs* silver and copper *vs* silver contents, from SEM-EDX analysis, showing the differences between the surface and sub-surface compositions of the three gold pieces of the 'mystery object'.

The surface of the main base sheet of K130 revealed a loss of copper and small losses of silver from the surface compared to the core alloy, most likely indicative of corrosion during burial and not necessarily deliberate treatment during manufacture. All of the components of the stud (K545) and the cylinder (K1055) analysed demonstrated a small loss of copper at

the surface, which is indicative of the natural surface corrosion that can occur during burial. On the surface of these components there was a higher proportion of silver than at the core. This enhanced level of surface silver was present on all the components analysed on the stud (K545), including the back where an area likely to be solder-free was analysed. This silver was also present on the surface of the ancient scratch on K1055 which suggests that the silver present on the surface was most likely to have been deposited during burial, rather than during manufacturing processes such as soldering. This phenomenon has also been noted on the gold of the Hoxne Late Roman Treasure, which contained both silver and gold items, buried together in a chest (Cowell and Hook 2010) and is believed to be associated with re-deposition of silver from nearby corroding objects during burial.

The absence of the silver deposit on the top surface of the base sheet surface of K130 may indicate that the gold panel has relatively recently become separated from the roundel; this panel would have covered the sheet, potentially protecting it from the re-deposition of silver. Surface and sub-surface analysis of the inset decorated gold panels on K130, would be required to confirm an increase in silver on exposed surfaces of this piece.

## Conclusion

Sub-surface analysis revealed that most of the components of the 'mystery object' were made of a similar gold alloy, most likely from a similar stock (88.1–88.8 wt% Au, 7.6–8.8 wt% Ag, 3.1–3.6 wt% Cu). The only exception was the wire used in the construction of the stud. This has a higher silver content and a slightly lower copper content than the other components (*c*.69.9 wt% Au, 27.9 wt% Ag, 2.2 wt% Cu). Analysis did not indicate deliberate enrichment of gold at the surface, but did demonstrate a significant increase in silver which is most likely due to a natural deposition from contact with corroding silver objects.

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Cowell, M. and Hook, D.R., 2010. Analysis of the metal artefacts. In Johns, C. (Ed.). *The Hoxne Late Roman Treasure*, British Museum Press, London, pp. 175-184.

# *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.

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