Staffordshire Hoard Research Report 19

XRF Study of Silver Objects from the Staffordshire Hoard

Appendix 3

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2015

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Appendix 3. Individual object sheets

K13 and K995

Object Type Hilt-plate
Date range Late 6th - early 7th
Relation to other objects None
Decoration Gilding ✓ Niello
Other

Surface XRF analysis was undertaken on the gilded front and the inside of both fragments of the hilt-plate. Sub-surface analysis was carried out on the inside of both fragments.

Object	Area analysed	No of analyses		Total*	Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Hg (%)
K13	Front	5	Average	99.7	34.1	2.1	0.9	0.0	0.2	49.6	13.1
			StDev		*13.4*	*1.6*	*0.2*	*0.1*	*0.1*	*15.1*	*0.9*
K13	Inside	5	Average	99.0	89.4	5.1	1.5	0.1	1.3	2.2	0.4
			StDev		*0.4*	*0.6*	*0.1*	*0.1*	*0.0*	*0.2*	*0.2*
K995	Front	6	Average	98.9	69.6	3.3	1.2	0.2	0.7	12.3	12.7
			StDev		*15.0*	*1.3*	*0.3*	*0.2*	*0.3*	*13.1*	*7.5*
K995	Inside	5	Average	95.4	85.5	4.2	1.5	0.1	1.1	2.8	4.8
			StDev		*10.3*	*0.6*	*0.2*	*0.1*	*0.3*	*0.8*	*10.1*

The results from the surface XRF analysis carried as part of the silver study. * The value given for the total is the un-normalised sum of the elements, without iron and chlorine. *StDev* equates to standard deviation

Object	No of analyses		Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Total*	Notes
K179	5	Average	91.3	5.1	0.2	0.2	1.3	1.9	99.9	
		StDev	*0.5*	*0.2*	*0.2*	*0.1*	*0.0*	*0.1*		
K552	5	Average	92.5	3.3	0.6	0.2	1.1	2.3	99.9	
		StDev	*0.6*	*0.2*	*0.5*	*0.1*	*0.0*	*0.1*		

The results from the sub-surface XRF analysis carried as part of the silver study, the results have been normalised but the presence of Hg, Fe or Cl noted. *StDev* equates to standard deviation. * The value given for the total is the un-normalised sum of the elements Ag, Cu, Sn, Zn, Pb and Au.

Analysis of the surface of the object confirmed the presence of mercury gilding. The sub-surface analysis suggested an alloy with approximately 91-93 wt% silver and 3-5.5 wt% copper. The analysis also revealed the presence of some tin, zinc, lead and gold in the alloy.

Analysed February 2015

XRF analysis of K63

Object Type Hilt-guard
Date range 630-675AD

Relation to other objects Possibly K136 pommel

Decoration Gilding ✓ Niello ✓
Other

Surface XRF analysis was undertaken on the top gilded surface of the hilt-guard and also the gilded edge. Sub-surface analysis was carried out on the base.

Area analysed	No of analyses		Total*	Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Hg (%)
Gilded top surface	4	Average	98.9	37.5	1.5	1.1	0.1	0.7	44.5	14.6
		StDev		*9.3*	*1.2*	*0.1*	*0.2*	*0.3*	*7.4*	*3.6*
Edge	4	Average	98.0	87.7	5.7	1.7	0.6	1.7	2.5	0.1
		StDev		*0.3*	*0.3*	*0.1*	*0.0*	*0.1*	*0.1*	*0.1*

The results from the surface XRF analysis carried as part of the silver study* The value given for the total is the un-normalised sum of the elements, without iron and chlorine. *StDev* equates to standard deviation

No of analyses		Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Total*	Notes
7	Average	86.3	7.6	1.0	0.5	2.2	2.4	90.4	8-10% Fe
	StDev	*0.6*	*0.4*	*0.3*	*0.1*	*0.0*	*0.0*		

The results from the sub-surface XRF analysis carried as part of the silver study, the results have been normalised but the presence of Hg, Fe or Cl noted. *StDev* equates to standard deviation. * The value given for the total is the un-normalised sum of the elements Ag, Cu, Sn, Zn, Pb and Au.

Analysis of the surface of the object confirmed the presence of mercury gilding. The sub-surface analysis suggested an alloy with approximately 85-87 wt% silver and 7-8 wt% copper. The analysis also revealed the presence of some tin, zinc, lead and gold in the alloy. The presence of traces of iron in the sub-surface results, even after successive scrapes, suggests that the prepared area may still be influenced by some corrosion products.

Analysed May 2015

XRF analysis of K64

Object Type Niello mount
Date range 600-650 AD

Relation to other objects None

Decoration Gilding ✓ Niello ✓
Other

Surface XRF analysis was undertaken on the front of the niello mount and also on four pins. Sub-surface analysis was carried out on the back.

Area analysed	No of analyses		Total*	Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Hg (%)
Front	4	Average	100.0	96.2	1.6	0.0	0.0	0.5	1.7	0.0
		StDev		*0.2*	*0.1*	*0.0*	*0.0*	*0.1*	*0.1*	*0.0*
Pins	4	Average	99.8	85.1	0.9	0.0	0.0	0.5	10.8	2.7
		StDev		*4.4*	*0.1*	*0.0*	*0.0*	*0.1*	*3.4*	*1.0*

The results from the surface XRF analysis carried as part of the silver study. * The value given for the total is the un-normalised sum of the elements, without iron and chlorine. *StDev* equates to standard deviation

No of analyses		Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Total*	Notes
4	Average	96.8	1.2	0.0	0.0	0.4	1.6	99.4	0.3-1% Hg
	StDev	*0.2*	*0.1*	*0.0*	*0.0*	*0.1*	*0.0*		

The results from the sub-surface XRF analysis carried as part of the silver study, the results have been normalised but the presence of Hg, Fe or Cl noted. *StDev* equates to standard deviation. * The value given for the total is the un-normalised sum of the elements Ag, Cu, Sn, Zn, Pb and Au.

Analysis of the surface of the object confirmed the presence of mercury gilding on the pins, and border. The sub-surface analysis suggested an alloy with approximately 96-97 wt% silver and 1-1.5 wt% copper. The analysis also revealed the presence of some lead and gold in the alloy. Mercury was also detected in the subsurface area, and this is likely to have been absorbed during the gilding process rather than a deliberate addition to the alloy.

Analysed June 2015

XRF analysis of K138 and K593

Object Type Hilt-plate
Date range Late 6th - early 7th
Relation to other objects None
Decoration Gilding ✓ Niello
Other

Surface XRF analysis was undertaken on the front of the hilt-plate in areas of gilding and areas with no observable gilding present, as well as the inside. Sub-surface analysis was carried out on the inside of both fragments.

Object	Area analysed	No of analyses		Total*	Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Hg (%)
K138	Front gilding	3	Average	99.5	26.5	1.1	0.9	0.0	0.2	58.3	13.0
			StDev		*3.4*	*0.3*	*0.1*	*0.0*	*0.1*	*3.6*	*0.4*
K138	Front	3	Average	97.0	68.3	9.9	1.6	0.8	1.5	14.3	3.6
			StDev		*13.1*	*4.3*	*0.3*	*0.4*	*0.4*	*14.5*	*4.1*
K138	Inside	4	Average	96.4	65.5	29.0	1.3	0.9	1.3	1.7	0.3
			StDev		*10.2*	*11.0*	*0.2*	*0.3*	*0.1*	*0.7*	*0.1*
K593	Front gilding	3	Average	100.0	27.1	0.7	0.9	0.0	0.1	58.7	12.6
			StDev		*6.3*	*0.2*	*0.1*	*0.0*	*0.1*	*6.0*	*0.6*
K593	Front	3	Average	96.9	79.2	13.9	1.6	0.9	1.8	2.4	0.2
			StDev		*4.3*	*4.6*	*0.2*	*0.1*	*0.2*	*0.3*	*0.1*
K593	Inside	4	Average	98.3	80.4	13.2	1.5	0.7	1.4	2.5	0.3
			StDev		*5.6*	*5.8*	*0.1*	*0.0*	*0.1*	*0.2*	*0.1*

The results from the surface XRF analysis carried as part of the silver study. * The value given for the total is the un-normalised sum of the elements, without iron and chlorine. *StDev* equates to standard deviation

Object	No of analyses		Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Total*	Notes
K138	4	Average	78.1	17.1	0.4	1.0	1.3	2.1	97.6	2-3% Fe
		StDev	*0.5*	*0.8*	*0.3*	*0.0*	*0.0*	*0.2*		
K593	5	Average	86.7	7.2	1.3	0.7	1.6	2.5	100.0	
		StDev	*0.4*	*0.3*	*0.3*	*0.0*	*0.0*	*0.0*		

The results from the sub-surface XRF analysis carried as part of the silver study, the results have been normalised but the presence of Hg, Fe or Cl noted. *StDev* equates to standard deviation. * The value given for the total is the un-normalised sum of the elements Ag, Cu, Sn, Zn, Pb and Au.

Analysis of the surface of the object confirmed the presence of mercury gilding. The sub-surface analysis suggested an alloy with approximately 78-87 wt% silver and 7-18 wt% copper, with a clear difference between the two fragments. The analysis also revealed the presence of some tin, zinc, lead and gold in the alloy. The iron in the sub-surface results, even after successive scrapes, suggests that the prepared area may still be influenced by some corrosion products.

Analysed February 2015

XRF analysis of K176

Object Type C-tubing
Date range

Relation to other objects

Decoration Gilding ✓ Niello
Other

Surface XRF analysis was undertaken on the gilded front of the c-tubing. Sub-surface analysis was carried out on the back.

Area analysed	No of analyses		Total*	Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Hg (%)
Front	5	Average	100.0	17.0	0.3	0.2	0.0	0.0	71.4	11.1
		StDev		*8.1*	*0.1*	*0.2*	*0.0*	*0.0*	*6.4*	*2.5*

The results from the surface XRF analysis carried as part of the silver study. * The value given for the total is the un-normalised sum of the elements, without iron and chlorine. *StDev* equates to standard deviation

No of analyses		Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Total*	Notes
5	Average	93.5	5.2	0.0	0.0	0.4	0.9	99.9	
	StDev	*0.4*	*0.2*	*0.0*	*0.0*	*0.2*	*0.0*		

The results from the sub-surface XRF analysis carried as part of the silver study, the results have been normalised but the presence of Hg, Fe or Cl noted. *StDev* equates to standard deviation. * The value given for the total is the un-normalised sum of the elements Ag, Cu, Sn, Zn, Pb and Au.

Analysis of the surface of the object confirmed the presence of mercury gilding. The sub-surface analysis suggested an alloy with approximately 93-94 wt% silver and 5-6 wt% copper. The analysis also revealed the presence of some lead and gold in the alloy.

Analysed June 2015

XRF analysis of K179 and K552

Object Type Hilt-plate
Date range Late 6th - early 7th

Relation to other objects None

Decoration Gilding ✓ Niello
Other

Surface XRF analysis was undertaken on the front and the inside of both fragments of hilt-plate. Sub-surface analysis was carried out on the inside.

Object	Area analysed	No of analyses		Total*	Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Hg (%)
K179	Front	4	Average	99.1	87.5	6.8	1.2	0.9	1.5	2.1	0.0
			StDev		*2.0*	*2.1*	*0.0*	*0.1*	*0.1*	*0.3*	*0.0*
K179	Inside	5	Average	97.0	86.5	8.4	1.0	0.9	1.3	1.9	0.0
			StDev		*2.5*	*2.5*	*0.2*	*0.1*	*0.1*	*0.2*	*0.0*
K552	Front	5	Average	93.5	89.1	5.6	1.2	0.8	1.2	2.1	0.0
			StDev		*1.5*	*1.3*	*0.1*	*0.1*	*0.1*	*0.1*	*0.0*
K552	Inside	5	Average	96.4	85.7	8.2	1.5	1.0	1.5	2.1	0.0
			StDev		*1.6*	*1.6*	*0.1*	*0.1*	*0.1*	*0.1*	*0.0*

The results from the surface XRF analysis carried as part of the silver study. * The value given for the total is the un-normalised sum of the elements, without iron and chlorine. *StDev* equates to standard deviation

Object	No of analyses		Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Total*	Notes
K179	5	Average	87.9	8.4	0.0	1.0	1.2	1.5	100.0	
		StDev	*0.1*	*0.1*	*0.0*	*0.0*	*0.0*	*0.0*		
K552	4	Average	85.9	8.8	0.2	1.3	1.8	2.0	100.0	
		StDev	*1.8*	*1.1*	*0.3*	*0.1*	*0.2*	*0.1*		

The results from the sub-surface XRF analysis carried as part of the silver study, the results have been normalised but the presence of Hg, Fe or Cl noted. *StDev* equates to standard deviation. * The value given for the total is the un-normalised sum of the elements Ag, Cu, Sn, Zn, Pb and Au.

Analysis of the surface of the object suggested that the hilt-plate had not been gilded. The sub-surface analysis suggested an alloy with approximately 84-88 wt% silver and 7-9 wt% copper. The analysis also revealed the presence of some tin, zinc, lead and gold in the alloy.

Analysed February 2015

XRF analysis of K235

Object Type Helmet tray
Date range 600-650 AD

Relation to other objects Helmet fittings

Decoration Gilding ✓ Niello
Other

Surface XRF analysis was undertaken on the inside of the tray. Sub-surface analysis was carried out on the back of K1734 part of K235.

Area analysed	No of analyses		Total*	Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Hg (%)
Front	6	Average	99.6	92.3	4.4	0.6	0.0	0.5	1.9	0.3
		StDev		*1.5*	*1.3*	*0.1*	*0.0*	*0.2*	*0.1*	*0.1*

The results from the surface XRF analysis carried as part of the silver study. * The value given for the total is the un-normalised sum of the elements, without iron and chlorine. *StDev* equates to standard deviation

No of analyses		Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Total*	Notes
10	Average	92.9	4.3	0.3	0.0	0.5	2.0	99.7	0.2-0.3% Hg
	StDev	*0.3*	*0.3*	*0.2*	*0.0*	*0.0*	*0.1*		

The results from the sub-surface XRF analysis carried as part of the silver study, the results have been normalised but the presence of Hg, Fe or Cl noted. *StDev* equates to standard deviation. * The value given for the total is the un-normalised sum of the elements Ag, Cu, Sn, Zn, Pb and Au.

Analysis of the surface of the object confirmed the presence of mercury gilding. The sub-surface analysis suggested an alloy with approximately 92-94 wt% silver and 4-5 wt% copper. The analysis also revealed the presence of some tin, lead and gold in the alloy. Mercury was also detected in the subsurface area, and this is likely to have been absorbed during the gilding process rather than a deliberate addition to the alloy.

Analysed June 2015

XRF analysis of K239 and K1029

Object Type Hilt-plate
Date range 620-650

Relation to other objects None

Decoration Gilding ☐ Niello ☐
Other ☐

Surface XRF analysis was undertaken on the front and the inside of the hilt-plate. Sub-surface analysis was carried out on the inside of both fragments.

Object	Area analysed	No of analyses		Total*	Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Hg (%)
K239	Front	5	Average	92.4	83.1	5.2	2.9	0.8	1.8	6.2	0.0
			StDev		*1.3*	*0.7*	*0.2*	*0.1*	*0.1*	*0.8*	*0.0*
K239	Inside	5	Average	93.8	77.1	13.7	2.3	0.8	1.9	4.2	0.0
			StDev		*6.7*	*8.4*	*0.3*	*0.2*	*0.2*	*1.2*	*0.0*
K1029	Front	5	Average	87.7	78.5	11.4	2.4	0.6	1.7	5.4	0.0
			StDev		*4.0*	*3.0*	*0.2*	*0.2*	*0.2*	*1.0*	*0.0*
K1029	Inside	5	Average	94.3	61.5	32.1	1.8	1.1	1.4	2.1	0.0
			StDev		*2.7*	*3.8*	*0.3*	*0.3*	*0.1*	*1.0*	*0.0*

The results from the surface XRF analysis carried as part of the silver study. * The value given for the total is the un-normalised sum of the elements, without iron and chlorine. *StDev* equates to standard deviation

Object	No of analyses		Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Total*	Notes
K239	5	Average	80.6	12.2	0.7	0.8	1.6	4.0	99.2	0.7-0.8% Fe
		StDev	*0.2*	*0.2*	*0.5*	*0.0*	*0.1*	*0.0*		
K1029	3	Average	78.8	13.8	1.1	0.8	1.5	4.0	98.9	0.9-1.3% Fe
		StDev	*0.5*	*0.3*	*0.4*	*0.0*	*0.1*	*0.1*		

The results from the sub-surface XRF analysis carried as part of the silver study, the results have been normalised but the presence of Hg, Fe or Cl noted. *StDev* equates to standard deviation. * The value given for the total is the un-normalised sum of the elements Ag, Cu, Sn, Zn, Pb and Au.

The sub-surface analysis suggested an alloy with approximately78-81 wt% silver and 12-14 wt% copper. The analysis also revealed the presence of some zinc, lead and gold, and traces of tin in the alloy. The presence of of iron in the sub-surface results, even after successive scrapes, suggests that the prepared area may still be influenced by some corrosion products.

Analysed February 2015

XRF analysis of K241

Object Type Niello mount
Date range 600-650 AD

Relation to other objects None

Decoration Gilding ✓ Niello ✓
Other

Surface XRF analysis was undertaken on the front and the gilded border of the niello mount. Sub-surface analysis was carried out on the back.

Area analysed	No of analyses		Total*	Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Hg (%)
Front	5	Average	99.3	95.6	1.1	0.0	0.0	0.5	2.6	0.2
		StDev		*0.2*	*0.2*	*0.0*	*0.0*	*0.1*	*0.2*	*0.0*
Gilded border	5	Average	100.0	6.2	0.1	0.2	0.0	0.0	82.3	11.2
		StDev		*2.4*	*0.1*	*0.2*	*0.0*	*0.0*	*2.6*	*0.1*

The results from the surface XRF analysis carried as part of the silver study. * The value given for the total is the un-normalised sum of the elements, without iron and chlorine. *StDev* equates to standard deviation

No of analyses		Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Total*	Notes
8	Average	96.9	0.8	0.0	0.0	0.2	2.1	99.9	
	StDev	*0.2*	*0.1*	*0.0*	*0.0*	*0.1*	*0.1*		

The results from the sub-surface XRF analysis carried as part of the silver study, the results have been normalised but the presence of Hg, Fe or Cl noted. *StDev* equates to standard deviation. * The value given for the total is the un-normalised sum of the elements Ag, Cu, Sn, Zn, Pb and Au.

Analysis of the surface of the object confirmed the presence of mercury gilding on the border. The sub-surface analysis suggested an alloy with approximately 96-97 wt% silver. The analysis also revealed the presence of some copper and gold, with traces of lead, in the alloy.

Analysed June 2015

XRF analysis of K248 for the silver project

Object Type Hilt-plate
Date range Late 6th - early 7th

Relation to other objects None

Decoration Gilding ✓ Niello
Other

Surface XRF analysis was undertaken on the front of the hilt-plate in areas of gilding and areas with no observable gilding present, as well as the inside. Sub-surface analysis was carried out on the inside of the fragment.

Object	Area analysed	No of analyses		Total*	Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Hg (%)
K248	Front gilding	3	Average	98.1	27.6	1.0	0.8	0.0	0.2	58.9	11.5
			StDev		*36.3*	*1.5*	*0.8*	*0.0*	*0.3*	*44.8*	*5.9*
K248	Front	3	Average	57.7	36.0	6.8	1.2	0.1	0.7	49.6	5.6
			StDev		*31.4*	*8.3*	*1.2*	*0.2*	*0.9*	*38.9*	*3.3*
K248	Inside	5	Average	99.1	88.4	2.4	1.4	0.0	0.5	2.0	5.3
			StDev		*1.3*	*0.7*	*0.1*	*0.0*	*0.1*	*0.8*	*1.3*

The results from the surface XRF analysis carried as part of the silver study. * The value given for the total is the un-normalised sum of the elements, without iron and chlorine. *StDev* equates to standard deviation

Object	No of analyses		Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Total*	Notes
K248	5	Average	90.2	6.2	1.0	0.0	1.2	1.4	99.3	0.5-0.9% Hg
		StDev	*0.3*	*0.2*	*0.4*	*0.0*	*0.0*	*0.0*		

The results from the sub-surface XRF analysis carried as part of the silver study, the results have been normalised but the presence of Hg, Fe or Cl noted. *StDev* equates to standard deviation. * The value given for the total is the un-normalised sum of the elements Ag, Cu, Sn, Zn, Pb and Au.

Analysis of the surface of the object confirmed the presence of mercury gilding. The inside of the hilt-plate fragments had elevated gold and some mercury present suggesting contamination from the gilding process. The sub-surface analysis suggested an alloy with approximately 90-91 wt% silver and 6-7 wt% copper. The analysis also revealed the presence of some tin, lead and gold in the alloy. Mercury was also detected in the subsurface area, and this is likely to have been absorbed during the gilding process rather than a deliberate addition to the alloy.

Analysed February 2015

XRF analysis of K274

Object Type Unknown
Date range

Relation to other objects None

Decoration Gilding ☐ Niello ☐
Other ☐

Surface XRF analysis was undertaken on the front of the object. Sub-surface analysis was carried out on the base.

Area analysed	No of analyses		Total*	Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Hg (%)
Front	6	Average	95.5	95.3	3.4	0.1	0.0	0.7	0.5	0.0
		StDev		*0.2*	*0.1*	*0.1*	*0.0*	*0.0*	*0.1*	*0.0*

The results from the surface XRF analysis carried as part of the silver study. * The value given for the total is the un-normalised sum of the elements, without iron and chlorine. *StDev* equates to standard deviation

No of analyses		Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Total*	Notes
3	Average	98.9	0.4	0.2	0.0	0.2	0.3	99.1	0.6-1.4% Fe
	StDev	*0.6*	*0.4*	*0.1*	*0.0*	*0.1*	*0.1*		

The results from the sub-surface XRF analysis carried as part of the silver study, the results have been normalised but the presence of Hg, Fe or Cl noted. *StDev* equates to standard deviation. * The value given for the total is the un-normalised sum of the elements Ag, Cu, Sn, Zn, Pb and Au.

The sub-surface analysis suggested an alloy with approximately 98-99.5 wt% silver with only small quantities of copper, tin, lead and gold in the alloy. The presence of iron in the sub-surface results, even after successive scrapes, suggests that the prepared area may still be influenced by some corrosion products.

Analysed May 2015

XRF analysis of K286

Object Type Pommel
Date range Late 6th - early 7th

Relation to other objects None

Decoration Gilding ✓ Niello
Other Garnet

Surface XRF analysis was undertaken on the front gilding, the border around the garnet and the beaded wire on the pommel. Sub-surface analysis was carried out on the base.

Area analysed	No of analyses		Total*	Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Hg (%)
Front gilding	4	Average	91.9	75.3	6.7	0.6	0.5	0.8	10.7	5.4
		StDev		*19.2*	*2.1*	*0.2*	*0.2*	*0.3*	*16.0*	*5.4*
Border around garnet	3	Average	96.1	47.8	3.1	0.2	0.0	0.1	48.3	0.5
		StDev		*5.9*	*1.6*	*0.0*	*0.0*	*0.2*	*8.1*	*0.4*
Beaded wire	3	Average	94.8	51.7	4.7	0.4	0.2	0.3	37.2	5.5
		StDev		*28.0*	*4.5*	*0.4*	*0.3*	*0.5*	*29.3*	*4.8*

The results from the surface XRF analysis carried as part of the silver study. * The value given for the total is the un-normalised sum of the elements, without iron and chlorine. *StDev* equates to standard deviation

No of analyses		Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Total*	Notes
5	Average	84.8	11.3	0.4	0.8	1.1	1.6	99.5	0-0.6% Fe
	StDev	*0.6*	*0.4*	*0.2*	*0.0*	*0.0*	*0.0*		

The results from the sub-surface XRF analysis carried as part of the silver study, the results have been normalised but the presence of Hg, Fe or Cl noted. *StDev* equates to standard deviation. * The value given for the total is the un-normalised sum of the elements Ag, Cu, Sn, Zn, Pb and Au.

Analysis of the surface of the object confirmed the presence of mercury gilding. The border around the garnet was a gold alloy whereas the beaded wire had high quantities of mercury so may have been a silver alloy that has been gilded. The sub-surface analysis suggested an alloy with approximately 84-86 wt% silver and 11-12 wt% copper. The analysis also revealed the presence of some tin, zinc, lead and gold in the alloy. Traces of iron in the sub-surface results, even after successive scrapes, suggests that the prepared area may still be influenced by some corrosion products.

Analysed May 2015

XRF analysis of K290, K744, K904, K1112 and K1185

Object Type Pommel
Date range 630-675 AD
Relation to other objects None
Decoration Gilding ✓ Niello ✓
Other Glass, gold panels

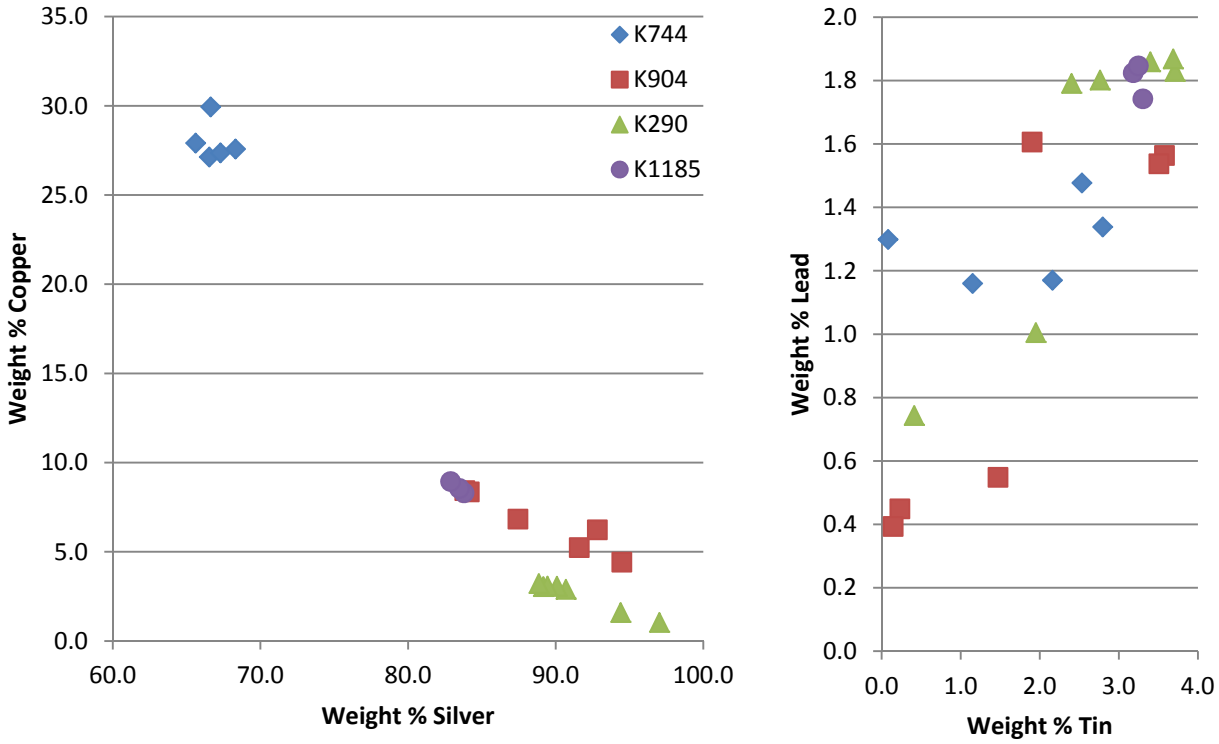
Surface XRF analysis was undertaken on a range of components on this pommel, particularly on the surface of the sword ring, shoulder and main body. Sub-surface analysis was also carried out on the inside of the different components.

Object	Area analysed	No of analyses		Total*	Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Hg (%)
K744	Decorative panel	4	Average	97.3	29.5	2.9	0.9	0.0	0.2	56.9	9.6
			StDev		*4.7*	*2.6*	*0.2*	*0.0*	*0.0*	*3.2*	*0.5*
K904	Shoulder gilding	4	Average	99.6	22.4	0.6	0.7	0.0	0.1	66.2	10.0
			StDev		*5.9*	*0.2*	*0.2*	*0.0*	*0.1*	*6.6*	*0.2*
K1185	Body gilding	4	Average	99.1	26.9	1.4	0.9	0.0	0.2	59.6	11.0
			StDev		*4.0*	*0.7*	*0.1*	*0.0*	*0.1*	*5.2*	*0.6*
K1112	Triangle silver	6	Average	94.4	90.9	6.4	0.7	0.1	0.5	1.1	0.3
			StDev		*4.9*	*4.0*	*0.4*	*0.2*	*0.1*	*1.1*	*0.4*
K1112	Twisted wire	4	Average	97.0	77.8	5.8	4.2	0.1	1.8	3.4	6.9
			StDev		*12.4*	*0.9*	*2.6*	*0.1*	*0.3*	*3.1*	*6.1*
K290	Gilding sword ring	6	Average	100.0	25.1	0.6	1.3	0.0	0.1	60.7	12.2
			StDev		*2.2*	*0.4*	*0.2*	*0.0*	*0.0*	*2.5*	*0.9*
K290	Front sword ring	4	Average	73.5	81.5	5.6	1.8	0.2	1.2	7.9	1.8
			StDev		*12.2*	*5.4*	*1.5*	*0.2*	*0.9*	*11.0*	*2.2*

The results from the surface XRF analysis carried as part of the silver study. * The value given for the total is the un-normalised sum of the elements, without iron and chlorine. *StDev* equates to standard deviation

Object	No of analyses		Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Total*	Notes
K744 Decorative panel	5	Average	66.9	28.0	1.7	0.8	1.3	1.3	99.5	0.5-0.9% Fe
		StDev	*1.0*	*1.1*	*1.1*	*0.1*	*0.1*	*0.2*		
K904 Shoulder	6	Average	87.0	7.5	2.3	0.6	1.3	1.3	95.7	3-4% Fe
		StDev	*4.2*	*1.1*	*1.6*	*0.4*	*0.6*	*0.6*		
K1185 Main body	3	Average	83.4	8.6	3.2	0.9	1.8	2.1	97.6	1.2-1.5% Fe
		StDev	*0.5*	*0.3*	*0.1*	*0.1*	*0.1*	*0.1*		
K290 Sword ring	7	Average	91.4	2.6	2.6	0.3	1.6	1.5	99.6	0-0.5% Fe
		StDev	*3.1*	*0.9*	*1.2*	*0.2*	*0.5*	*0.4*		

The results from the sub-surface XRF analysis carried as part of the silver study, the results have been normalised but the presence of Hg, Fe or Cl noted. *StDev* equates to standard deviation. * The value given for the total is the un-normalised sum of the elements Ag, Cu, Sn, Zn, Pb and Au.



Plots of copper *vs* silver and lead *vs* tin contents, based on XRF analysis, showing the differences between the sub-surface analyses.

Analysis of the surface of the object confirmed the presence of mercury gilding. The internal decorative panel of the pommel appears to have been constructed from a different, copper rich, alloy to that of the main body, shoulder and sword ring. The sub-surface analysis of the main body, shoulder and ring suggested an alloy with approximately 83-92 wt% silver and 2-9 wt% copper. Whereas the decorative panel had a silver content of c. 66-68 wt% and a copper content of c. 27-29 wt% The analysis also revealed the presence of some tin, zinc, lead and gold in the alloy. Traces of iron in the sub-surface results, even after successive scrapes, suggests that the prepared area may still be influenced by some corrosion products.

Analysed May 2015

XRF analysis of K242, K1385 and K1623

Object Type Pommel
Date range 630-675 AD

Relation to other objects None

Decoration Gilding ✓ Niello ✓
Other Glass, garnet, gold panels

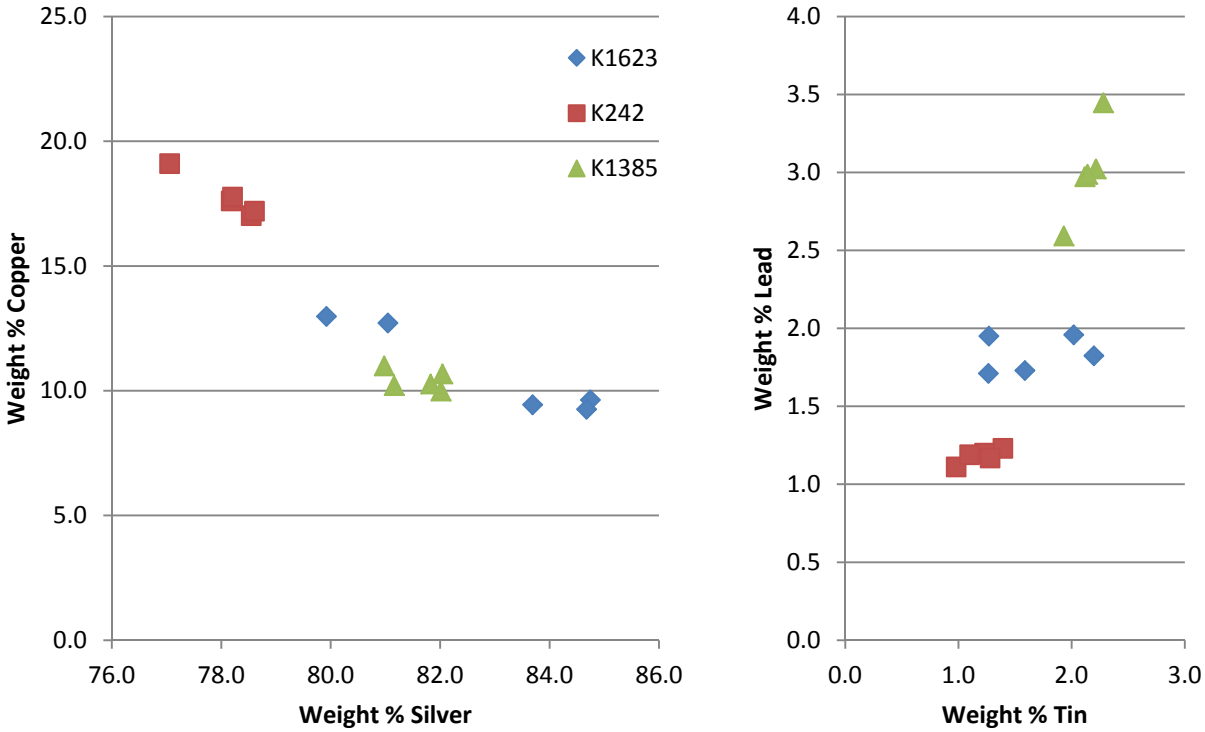
Surface XRF analysis was undertaken on the gilded front of the sword ring, shoulder and main body. Analysis was also undertaken on the inside of the shoulder and the main body. Sub-surface analysis was carried out on the inside of the different components.

Object	Area analysed	No of analyses		Total*	Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Hg (%)
K1623	Sword ring base	4	Average	98.9	10.3	0.8	0.8	0.0	0.2	74.4	13.5
			StDev		*3.2*	*0.3*	*0.3*	*0.0*	*0.1*	*4.8*	*3.0*
K242	Shoulder outside	4	Average	98.3	81.1	9.5	2.1	0.4	1.8	2.5	2.6
			StDev		*2.1*	*2.4*	*0.1*	*0.0*	*0.1*	*0.5*	*1.6*
K242	Shoulder inside	4	Average	99.6	71.7	9.5	1.3	0.3	1.1	2.0	14.1
			StDev		*3.2*	*2.9*	*0.1*	*0.0*	*0.1*	*0.4*	*1.2*
K1385	Gilding main body	4	Average	94.9	14.4	0.8	0.7	0.0	0.1	72.5	11.5
			StDev		*8.0*	*0.5*	*0.3*	*0.0*	*0.1*	*8.5*	*0.4*
K1385	Inside main body	4	Average	99.4	81.8	8.1	2.0	0.5	2.1	2.4	3.1
			StDev		*2.7*	*1.8*	*0.2*	*0.1*	*0.2*	*0.2*	*2.1*

The results from the surface XRF analysis carried as part of the silver study. * The value given for the total is the un-normalised sum of the elements, without iron and chlorine. *StDev* equates to standard deviation

Object	No of analyses		Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Total*	Notes
K1623 Sword ring	5	Average	82.8	10.8	1.7	0.6	1.8	2.3	98.8	0.5-1.3% Fe
		StDev	*2.2*	*1.9*	*0.4*	*0.1*	*0.1*	*0.1*		
K242 Shoulder	5	Average	78.2	17.7	1.2	0.3	1.2	1.4	99.1	0.8-1% Fe
		StDev	*0.6*	*0.8*	*0.2*	*0.0*	*0.0*	*0.0*		
K1385 Main body	5	Average	81.6	10.4	2.1	0.6	3.0	2.3	98.1	0.2-0.3% Hg, 1.4-1.9% Fe
		StDev	*0.5*	*0.4*	*0.1*	*0.0*	*0.3*	*0.1*		

The results from the sub-surface XRF analysis carried as part of the silver study, the results have been normalised but the presence of Hg, Fe or Cl noted. *StDev* equates to standard deviation. * The value given for the total is the un-normalised sum of the elements Ag, Cu, Sn, Zn, Pb and Au.



Plots of copper *vs* silver and lead *vs* tin contents, based on XRF analysis, showing the differences between the sub-surface and surface analyses.

Analysis of the surface of the object confirmed the presence of mercury gilding. The inside of the shoulder and main body had elevated gold and some mercury present suggesting contamination from the gilding process. Mercury was also detected in the subsurface area, and this is likely to have been absorbed during the gilding process rather than a deliberate addition to the alloy.

The shoulder of the pommel appeared to have been constructed from a different alloy to that of the main body and sword ring. The sub-surface analysis of the main body and ring suggested an alloy with approximately 81-83 wt% silver and 10-11 wt% copper. Whereas the shoulder had a silver content of c. 78 wt% and a copper content of c. 17.7 wt% The analysis also revealed the presence of some tin, lead and gold, and traces of zinc in the alloy.

Traces of iron in the sub-surface results, even after successive scrapes, suggests that the prepared area may still be influenced by some corrosion products.

Analysed May 2015

XRF analysis of K294

Object Type Pommel
Date range 630-675 AD

Relation to other objects None

Decoration Gilding ✓ Niello

Other: Gold panel, garnet and punched decoration

Surface XRF analysis was undertaken on the front of the pommel. Sub-surface analysis was carried out on the base.

Area analysed	No of analyses		Total*	Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Hg (%)
Front	5	Average	99.9	23.0	0.4	0.6	0.0	0.2	63.3	12.5
		StDev		*17.9*	*0.5*	*0.2*	*0.0*	*0.2*	*17.8*	*1.2*

The results from the surface XRF analysis carried as part of the silver study. * The value given for the total is the un-normalised sum of the elements, without iron and chlorine. *StDev* equates to standard deviation

No of analyses		Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Total*	Notes
5	Average	90.4	4.8	0.6	0.6	1.7	1.9	99.8	0.1-0.2% Hg
	StDev	*0.8*	*0.3*	*0.4*	*0.0*	*0.1*	*0.1*		

The results from the sub-surface XRF analysis carried as part of the silver study, the results have been normalised but the presence of Hg, Fe or Cl noted. *StDev* equates to standard deviation. * The value given for the total is the un-normalised sum of the elements Ag, Cu, Sn, Zn, Pb and Au.

Analysis of the surface of the object confirmed the presence of mercury gilding. The sub-surface analysis suggested an alloy with approximately 90-91 wt% silver and 4-5 wt% copper. The analysis also revealed the presence of some tin, zinc, lead and gold in the alloy. Mercury was also detected in the subsurface area, and this is likely to have been absorbed during the gilding process rather than a deliberate addition to the alloy.

Analysed June 2015

XRF analysis of K298

Object Type Hilt-collar
Date range

Relation to other objects None

Decoration Gilding ✓ Niello ?
Other

Surface XRF analysis was undertaken on the front of the gilded hilt-collar. Sub-surface analysis was carried out on the back.

Area analysed	No of analyses		Total*	Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Hg (%)
Front	6	Average	69.7	51.9	3.1	0.5	0.0	0.2	37.5	6.8
		StDev		*15.9*	*1.3*	*0.1*	*0.0*	*0.1*	*13.6*	*2.3*

The results from the surface XRF analysis carried as part of the silver study* The value given for the total is the un-normalised sum of the elements, without iron and chlorine. *StDev* equates to standard deviation

No of analyses		Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Total*	Notes
4	Average	96.7	1.3	0.3	0.5	0.5	0.7	100.0	
	StDev	*0.7*	*0.3*	*0.2*	*0.1*	*0.1*	*0.2*		

The results from the sub-surface XRF analysis carried as part of the silver study, the results have been normalised but the presence of Hg, Fe or Cl noted. *StDev* equates to standard deviation. * The value given for the total is the un-normalised sum of the elements Ag, Cu, Sn, Zn, Pb and Au.

Analysis of the surface of the object confirmed the presence of mercury gilding. The sub-surface analysis suggested an alloy with approximately 96-98 wt% silver and 1-2 wt% copper. The analysis also revealed the presence of traces of tin, zinc, lead and gold in the alloy.

Analysed May 2015

XRF analysis of K302

Object Type Sword pyramid
Date range

Relation to other objects None

Decoration Gilding [ ] Niello [ ]
Other [Gold panels, garnet]

Surface XRF analysis was undertaken on the front beaded wires of the sword pyramid. Sub-surface analysis was carried out on the base.

Area analysed	No of analyses		Total*	Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Hg (%)
Body beaded wire	5	Average	83.0	82.3	6.5	3.3	0.6	2.6	4.7	0.0
		StDev		*3.2*	*2.2*	*0.5*	*0.1*	*0.4*	*0.8*	*0.0*
Small beaded wire	5	Average	87.8	29.8	3.0	0.2	0.0	0.1	66.9	0.0
		StDev		*5.9*	*0.8*	*0.2*	*0.0*	*0.1*	*6.8*	*0.1*

The results from the surface XRF analysis carried as part of the silver study * The value given for the total is the un-normalised sum of the elements, without iron and chlorine. *StDev* equates to standard deviation

No of analyses		Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Total*	Notes
5	Average	86.6	7.2	1.2	0.5	2.1	2.4	100.0	
	StDev	*1.0*	*0.7*	*0.7*	*0.0*	*0.0*	*0.0*		

The results from the sub-surface XRF analysis carried as part of the silver study, the results have been normalised but the presence of Hg, Fe or Cl noted. *StDev* equates to standard deviation. * The value given for the total is the un-normalised sum of the elements Ag, Cu, Sn, Zn, Pb and Au.

Analysis of the surface of the object suggests that the main body was not gilded. The sub-surface analysis suggested an alloy with approximately 85-88 wt% silver and 6-8 wt% copper. The analysis also revealed the presence of some tin, zinc, lead and gold in the alloy.

Analysed June 2015

XRF analysis of K304 and K160

Object Type Hilt-collar
Date range Late 6th - early 7th
Relation to other objects Pommel K39/K1007
Decoration Gilding ✓ Niello ✓
Other

Surface XRF analysis was undertaken on the gilded front and base of each of the hilt-collars. Sub-surface analysis was carried out on the base of K304.

Object	Area analysed	No of analyses		Total*	Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Hg (%)
K304	Front	4	Average	98.4	40.7	2.0	0.6	0.1	0.3	46.5	9.8
			StDev		*11.7*	*0.9*	*0.1*	*0.1*	*0.1*	*10.9*	*1.2*
K304	Base	3	Average	80.1	84.4	11.1	1.0	0.7	0.9	1.4	0.5
			StDev		*6.1*	*5.5*	*0.0*	*0.1*	*0.1*	*0.4*	*0.3*
K160	Front	4	Average	99.5	19.9	0.7	0.3	0.0	0.1	65.7	13.3
			StDev		*7.4*	*0.4*	*0.2*	*0.0*	*0.1*	*6.9*	*1.1*
K160	Base	4	Average	63.2	93.2	4.2	0.9	0.3	0.4	0.8	0.2
			StDev		*6.7*	*6.6*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*

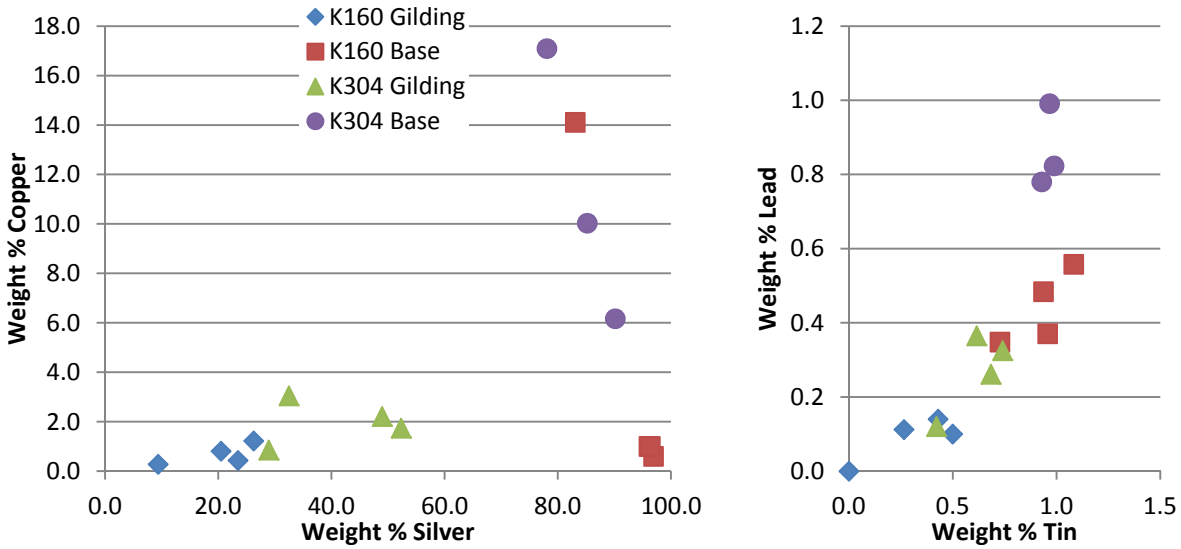
The results from the surface XRF analysis carried as part of the silver study. * The value given for the total is the un-normalised sum of the elements, without iron and chlorine. *StDev* equates to standard deviation

No of analyses		Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Total*	Notes
5	Average	91.5	5.5	0.6	0.7	0.7	1.0	98.6	0.1-0.2% Hg, 0.4-0.7% Fe
	StDev	*1.0*	*0.7*	*0.2*	*0.0*	*0.1*	*0.0*		

The results from the sub-surface XRF analysis carried as part of the silver study, the results have been normalised but the presence of Hg, Fe or Cl noted. *StDev* equates to standard deviation. * The value given for the total is the un-normalised sum of the elements Ag, Cu, Sn, Zn, Pb and Au.

Analysis of the surface of the object confirmed the presence of mercury gilding. When the surface analyses results for K160 and K304 are compared there are some clear differences in the alloys used. Particularly when lead and tin are plotted. However the surface results are likely to be influenced by corrosion products present on the surface. Both the un-gilded base results had large quantities of chlorine and iron on the surface.

The sub-surface analysis suggested an alloy with approximately 91-92 wt% silver and 5-6 wt% copper. The analysis also revealed the presence of some tin, zinc, lead and gold in the alloy. The presence of traces of iron in the sub-surface results, even after successive scrapes, suggests that the prepared area may still be influenced by some corrosion products. Some mercury was also detected in the subsurface area, and this is likely to have been absorbed during the gilding process or contamination from the corrosion products rather than a deliberate addition to the alloy.



Plots of copper *vs* silver and lead *vs* tin contents, based on XRF analysis, showing the differences between K160 and K304 surface analyses.

Analysed June 2015

XRF analysis of K306

Object Type Pommel
Date range Late 6th - early 7th

Relation to other objects None

Decoration Gilding [ ] Niello [ ]
Other [ ]

Surface XRF analysis was undertaken on the front base sheet, cap and the wires of the pommel. Sub-surface analysis was carried out on the base.

Area analysed	No of analyses		Total*	Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Hg (%)
Base sheet	5	Average	99.6	93.5	4.8	0.0	0.0	0.9	0.8	0.0
		StDev		*0.4*	*0.4*	*0.1*	*0.0*	*0.1*	*0.0*	*0.0*
Cap	5	Average	92.8	93.4	4.7	0.0	0.0	0.9	1.0	0.0
		StDev		*1.9*	*1.8*	*0.1*	*0.0*	*0.1*	*0.1*	*0.0*
Wires	6	Average	97.3	94.8	3.6	0.0	0.0	0.6	1.0	0.0
		StDev		*0.8*	*0.7*	*0.0*	*0.0*	*0.2*	*0.1*	*0.1*

The results from the surface XRF analysis carried as part of the silver study. * The value given for the total is the un-normalised sum of the elements, without iron and chlorine. *StDev* equates to standard deviation

No of analyses		Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Total*	Notes
5	Average	94.6	3.8	0.0	0.0	0.9	0.7	100.0	
	StDev	*0.1*	*0.1*	*0.0*	*0.0*	*0.0*	*0.0*		

The results from the sub-surface XRF analysis carried as part of the silver study, the results have been normalised but the presence of Hg, Fe or Cl noted. *StDev* equates to standard deviation. * The value given for the total is the un-normalised sum of the elements Ag, Cu, Sn, Zn, Pb and Au.

No mercury gilding was present on the surface of the pommel. The sub-surface analysis suggested an alloy with approximately 94-95 wt% silver and 3-4 wt% copper. The analysis also revealed the presence of some lead and gold in the alloy. The copper alloy core is a leaded tin-bronze.

Analysed May 2015

XRF analysis of K310 and K620

Object Type Niello mount
Date range 600-650 AD

Relation to other objects None

Decoration Gilding ✓ Niello ✓
Other

Surface XRF analysis was undertaken on the front, back and on the gilded beaded wire of K310. Analysis was also undertaken on the back of K620 which is most likely a fragment from the other part of an object that makes up the pair of mounts. Sub-surface analysis was carried out on the back of K310.

Object	Area analysed	No of analyses		Total*	Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Hg (%)
K310	Front	5	Average	99.9	96.3	1.0	0.0	0.0	0.6	2.1	0.0
			StDev		*0.2*	*0.1*	*0.0*	*0.0*	*0.1*	*0.1*	*0.0*
K310	Beaded wire	5	Average	99.2	26.8	0.3	0.2	0.0	0.0	60.6	12.1
			StDev		*11.3*	*0.1*	*0.1*	*0.0*	*0.0*	*9.7*	*1.6*
K310	Back	4	Average	84.3	96.3	0.8	0.2	0.0	0.2	2.3	0.2
			StDev		*0.2*	*0.1*	*0.1*	*0.0*	*0.0*	*0.1*	*0.0*
K620	Back	4	Average	97.9	95.8	0.8	0.0	0.0	0.5	2.9	0.0
			StDev		*0.3*	*0.2*	*0.1*	*0.0*	*0.1*	*0.4*	*0.1*

The results from the surface XRF analysis carried as part of the silver study. * The value given for the total is the un-normalised sum of the elements, without iron and chlorine. *StDev* equates to standard deviation

No of analyses		Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Total*	Notes
5	Average	97.3	0.6	0.0	0.0	0.3	1.8	100.0	
	StDev	*0.3*	*0.3*	*0.0*	*0.0*	*0.1*	*0.1*		

The results from the sub-surface XRF analysis of K310 carried as part of the silver study, the results have been normalised but the presence of Hg, Fe or Cl noted. *StDev* equates to standard deviation. * The value given for the total is the un-normalised sum of the elements Ag, Cu, Sn, Zn, Pb and Au.

Analysis of the front surface of the object confirmed the absence of mercury gilding except for on the beaded wire. The sub-surface analysis suggested an alloy with approximately 97-98 wt% silver. The analysis also revealed the presence of some copper, lead and gold in the alloy. Fragment K620 had a very similar composition so was most likely made in the same workshop with the same or similar alloy.

Analysed June 2015

XRF analysis of K363 and K397

Object Type Helmet fitting
Date range 600-650 AD

Relation to other objects Helmet fittings

Decoration Gilding ✓ Niello
Other

Surface XRF analysis was undertaken on the front of K363. Sub-surface analysis was carried out on two parts of the same object K363 and K397.

Area analysed	No of analyses		Total*	Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Hg (%)
Front	5	Average	99.6	16.9	0.3	0.3	0.0	0.1	73.7	8.7
		StDev		*7.1*	*0.0*	*0.1*	*0.0*	*0.1*	*6.4*	*0.7*

The results from the surface XRF analysis carried as part of the silver study. * The value given for the total is the un-normalised sum of the elements, without iron and chlorine. *StDev* equates to standard deviation

Object	No of analyses		Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Total*	Notes
K363	4	Average	93.9	4.4	0.0	0.0	0.2	1.5	98.9	0.8-1.3% Hg
		StDev	*0.4*	*0.3*	*0.0*	*0.0*	*0.0*	*0.2*		
K397	5	Average	94.5	3.5	0.0	0.0	0.4	1.6	99.3	0.2-1.4% Hg
		StDev	*0.6*	*0.8*	*0.1*	*0.0*	*0.1*	*0.1*		

The results from the sub-surface XRF analysis carried as part of the silver study, the results have been normalised but the presence of Hg, Fe or Cl noted. *StDev* equates to standard deviation. * The value given for the total is the un-normalised sum of the elements Ag, Cu, Sn, Zn, Pb and Au.

Analysis of the surface of the object confirmed the presence of mercury gilding. The sub-surface analysis suggested an alloy with approximately 93-95 wt% silver and 3-5 wt% copper. The analysis also revealed the presence of some lead and gold in the alloy. Mercury was also detected in the subsurface area, and this is likely to have been absorbed during the gilding process rather than a deliberate addition to the alloy.

Analysed June 2015

XRF analysis of K369

Object Type Hilt-collar
Date range

Relation to other objects None

Decoration Gilding ✓ Niello ✓
Other

Surface XRF analysis was undertaken on the gilding on the front of the hilt-collar. Sub-surface analysis was carried out on the base.

Area analysed	No of analyses		Total*	Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Hg (%)
Gilded front	5	Average	88.3	59.3	2.9	0.0	0.6	0.4	32.2	4.6
		StDev		*15.1*	*3.1*	*0.1*	*0.3*	*0.1*	*16.1*	*2.2*

The results from the surface XRF analysis carried as part of the silver study. * The value given for the total is the un-normalised sum of the elements, without iron and chlorine. *StDev* equates to standard deviation

No of analyses		Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Total*	Notes
3	Average	95.2	2.1	0.1	1.0	0.3	1.3	99.7	
	StDev	*0.2*	*0.1*	*0.1*	*0.0*	*0.0*	*0.0*		

The results from the sub-surface XRF analysis carried as part of the silver study, the results have been normalised but the presence of Hg, Fe or Cl noted. *StDev* equates to standard deviation. * The value given for the total is the un-normalised sum of the elements Ag, Cu, Sn, Zn, Pb and Au.

Analysis of the surface of the object confirmed the presence of mercury gilding. The sub-surface analysis suggested an alloy with approximately 95-96 wt% silver and 2-2.5 wt% copper. The analysis also revealed the presence of some zinc, lead and gold in the alloy. Analysis of the copper alloy core revealed a leaded tin-bronze.

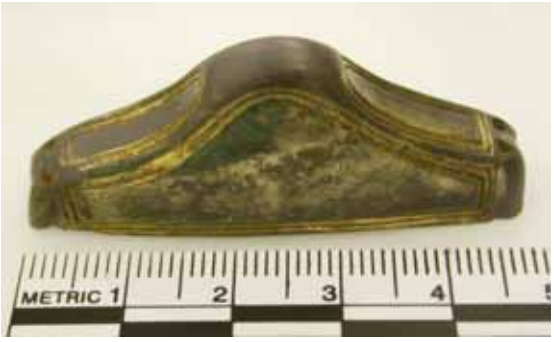
Analysed May 2015

XRF analysis of K456

Object Type Pommel
Date range Late 6th - early 7th

Relation to other objects None

Decoration Gilding Some Niello
Other



Surface XRF analysis was undertaken on the incised lines and the front of the pommel. Sub-surface analysis was carried out on the base.

Area analysed	No of analyses		Total*	Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Hg (%)
Front	4	Average	96.7	94.8	3.2	0.3	0.0	0.6	1.1	0.0
		StDev		*0.5*	*0.5*	*0.1*	*0.0*	*0.1*	*0.1*	*0.1*
Incised gilding	4	Average	99.9	27.3	1.1	0.2	0.0	0.2	61.8	9.4
		StDev		*4.8*	*0.3*	*0.1*	*0.0*	*0.0*	*4.0*	*0.9*

The results from the surface XRF analysis carried as part of the silver study. * The value given for the total is the un-normalised sum of the elements, without iron and chlorine. *StDev* equates to standard deviation

No of analyses		Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Total*	Notes
4	Average	98.3	0.3	0.0	0.0	0.4	1.0	99.6	
	StDev	*0.1*	*0.0*	*0.1*	*0.0*	*0.0*	*0.1*		

The results from the sub-surface XRF analysis carried as part of the silver study, the results have been normalised but the presence of Hg, Fe or Cl noted. *StDev* equates to standard deviation. *The value given for the total is the un-normalised sum of the elements Ag, Cu, Sn, Zn, Pb and Au.

Analysis of the surface of the object suggests that the main body of the pommel was not mercury gilded, but that the incised decoration was gilded. The sub-surface analysis suggested an alloy with approximately 98-99 wt% silver. The analysis also revealed the presence of some copper, lead and gold in the alloy.

Analysed May 2015

XRF analysis of K543

Object Type Sword ring
Date range

Relation to other objects Possibly K711

Decoration Gilding ☐ Niello ☐
Other ☐

Surface XRF analysis was undertaken on the front of the base and ring. Sub-surface analysis was carried out on the base.

Area analysed	No of analyses		Total*	Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Hg (%)
Ring	4	Average	96.0	70.3	16.1	2.8	0.7	5.0	5.1	0.0
		StDev		*5.5*	*7.2*	*0.3*	*0.2*	*1.2*	*0.5*	*0.0*
Base	4	Average	97.7	68.5	16.0	2.9	0.8	6.4	5.4	0.0
		StDev		*1.5*	*1.4*	*0.2*	*0.0*	*1.0*	*0.3*	*0.0*

The results from the surface XRF analysis carried as part of the silver study. * The value given for the total is the un-normalised sum of the elements, without iron and chlorine. *StDev* equates to standard deviation

No of analyses		Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Total*	Notes
5	Average	71.9	15.5	2.3	0.8	3.9	5.6	99.1	0.7-0.9 Fe
	StDev	*0.4*	*0.4*	*0.2*	*0.0*	*0.1*	*0.1*		

The results from the sub-surface XRF analysis carried as part of the silver study, the results have been normalised but the presence of Hg, Fe or Cl noted. *StDev* equates to standard deviation. * The value given for the total is the un-normalised sum of the elements Ag, Cu, Sn, Zn, Pb and Au.

The sub-surface analysis suggested an alloy with approximately 71-73 wt% silver and 15-16 wt% copper. The analysis also revealed the presence of some tin, zinc, lead and gold in the alloy. The presence of traces of iron in the sub-surface results, even after successive scrapes, suggests that the prepared area may still be influenced by some corrosion products.

Analysed May 2015

XRF analysis of K546

Object Type Helmet crest
Date range 600-650 AD

Relation to other objects Helmet fittings

Decoration Gilding ✓ Niello
Other

Surface XRF analysis was undertaken on the gilded front of the crest. Sub-surface analysis was carried out on the back.

Area analysed	No of analyses		Total*	Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Hg (%)
Front	4	Average	100.0	14.0	0.0	0.3	0.0	0.0	73.1	12.6
		StDev		*3.5*	*0.0*	*0.1*	*0.0*	*0.0*	*2.6*	*1.0*

The results from the surface XRF analysis carried as part of the silver study. * The value given for the total is the un-normalised sum of the elements, without iron and chlorine. *StDev* equates to standard deviation

No of analyses		Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Total*	Notes
4	Average	95.8	2.7	0.0	0.0	0.5	1.0	100.0	
	StDev	*0.2*	*0.2*	*0.0*	*0.0*	*0.0*	*0.0*		

The results from the sub-surface XRF analysis carried as part of the silver study, the results have been normalised but the presence of Hg, Fe or Cl noted. *StDev* equates to standard deviation. * The value given for the total is the un-normalised sum of the elements Ag, Cu, Sn, Zn, Pb and Au.

Analysis of the surface of the object confirmed the presence of mercury gilding. The sub-surface analysis suggested an alloy with approximately 95-96 wt% silver and 2-3 wt% copper. The analysis also revealed the presence of some lead and gold in the alloy.

Analysed June 2015

XRF analysis of K559

Object Type Pommel
Date range Late 6th - early 7th

Relation to other objects None

Decoration Gilding ☐ Niello ☐
Other ☐

Surface XRF analysis was undertaken on the front of the pommel. Sub-surface analysis was carried out on the base.

Area analysed	No of analyses		Total*	Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Hg (%)
Front	5	Average	98.3	84.9	9.9	0.6	0.3	1.0	3.3	0.0
		StDev		*5.4*	*5.4*	*0.1*	*0.0*	*0.3*	*0.3*	*0.0*

The results from the surface XRF analysis carried as part of the silver study. * The value given for the total is the un-normalised sum of the elements, without iron and chlorine. *StDev* equates to standard deviation

No of analyses		Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Total*	Notes
5	Average	83.5	10.9	0.5	0.4	1.3	3.4	99.6	0-0.5% Fe
	StDev	*0.7*	*0.7*	*0.2*	*0.0*	*0.1*	*0.0*		

The results from the sub-surface XRF analysis carried as part of the silver study, the results have been normalised but the presence of Hg, Fe or Cl noted. *StDev* equates to standard deviation. * The value given for the total is the un-normalised sum of the elements Ag, Cu, Sn, Zn, Pb and Au.

Analysis of the surface of the object confirms that the pommel was not mercury gilded. The sub-surface analysis suggested an alloy with approximately 83-84 wt% silver and 10-12 wt% copper. The analysis also revealed the presence of some tin, zinc, lead and gold in the alloy. Traces of iron in the sub-surface results, even after successive scrapes, suggests that the prepared area may still be influenced by some corrosion products.

Analysed June 2015

XRF analysis of K577

Object Type Hilt-fitting
Date range

Relation to other objects None

Decoration Gilding ✓ Niello ✓
Other

Surface XRF analysis was undertaken on the front of the hilt-fitting. Sub-surface analysis was carried out on the back.

Area analysed	No of analyses		Total*	Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Hg (%)
Front	5	Average	99.0	75.5	3.3	0.2	0.0	0.7	16.7	3.6
		StDev		*8.2*	*0.5*	*0.1*	*0.0*	*0.1*	*7.2*	*1.4*

The results from the surface XRF analysis carried as part of the silver study. * The value given for the total is the un-normalised sum of the elements, without iron and chlorine. *StDev* equates to standard deviation

No of analyses		Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Total*	Notes
4	Average	88.1	5.3	0.0	0.0	0.8	5.8	96.0	3-4% Hg
	StDev	*0.4*	*0.2*	*0.0*	*0.0*	*0.0*	*0.4*		

The results from the sub-surface XRF analysis carried as part of the silver study, the results have been normalised but the presence of Hg, Fe or Cl noted. *StDev* equates to standard deviation. * The value given for the total is the un-normalised sum of the elements Ag, Cu, Sn, Zn, Pb and Au.

Analysis of the surface of the object confirmed the presence of mercury gilding. The sub-surface analysis suggested an alloy with approximately 87-89 wt% silver and 5-6 wt% copper. The analysis also revealed the presence of some lead and gold in the alloy. Mercury was also detected in the subsurface area, and this is likely to have been absorbed during the gilding process rather than a deliberate addition to the alloy.

Analysed June 2015

XRF analysis of K711

Object Type Pommel
Date range Last 3rd of 6th Century

Relation to other objects None

Decoration Gilding ✓ Niello ✓
Other

Surface XRF analysis was undertaken on the front of the pommel. Sub-surface analysis was carried out on the base.

Area analysed	No of analyses		Total*	Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Hg (%)
Front	4	Average	99.4	38.2	1.0	0.4	0.0	0.2	50.4	9.8
		StDev		*4.8*	*0.6*	*0.1*	*0.0*	*0.1*	*5.7*	*0.5*

The results from the surface XRF analysis carried as part of the silver study. * The value given for the total is the un-normalised sum of the elements, without iron and chlorine. *StDev* equates to standard deviation

No of analyses		Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Total*	Notes
5	Average	94.7	3.1	0.5	0.0	0.9	0.8	95.5	1.5-3.5% Fe
	StDev	*0.6*	*0.5*	*0.2*	*0.1*	*0.1*	*0.0*		

The results from the sub-surface XRF analysis carried as part of the silver study, the results have been normalised but the presence of Hg, Fe or Cl noted. *StDev* equates to standard deviation. * The value given for the total is the un-normalised sum of the elements Ag, Cu, Sn, Zn, Pb and Au.

Analysis of the surface of the object confirmed the presence of mercury gilding. The sub-surface analysis suggested an alloy with approximately 94-96 wt% silver and 2-4 wt% copper. The analysis also revealed the presence of some tin, lead and gold in the alloy. The presence of iron in the sub-surface results, even after successive scrapes, suggests that the prepared area may still be influenced by some corrosion products.

Analysed June 2015

XRF analysis of K776

Object Type 14mm ribbed strip
Date range 600-650

Relation to other objects Helmet fittings?

Decoration Gilding ✓ Niello
Other

Surface XRF analysis was undertaken on the gilded front of the strip. Sub-surface analysis was carried out on the back.

Area analysed	No of analyses		Total*	Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Hg (%)
Front	4	Average	99.8	12.7	0.3	0.2	0.0	0.0	76.3	10.5
		StDev		*1.6*	*0.0*	*0.0*	*0.0*	*0.0*	*1.8*	*1.0*

The results from the surface XRF analysis carried as part of the silver study. * The value given for the total is the un-normalised sum of the elements, without iron and chlorine. *StDev* equates to standard deviation

No of analyses		Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Total*	Notes
5	Average	94.1	4.3	0.0	0.0	0.3	1.3	99.4	0.5-0.7% Hg
	StDev	*0.2*	*0.2*	*0.0*	*0.0*	*0.0*	*0.1*		

The results from the sub-surface XRF analysis carried as part of the silver study, the results have been normalised but the presence of Hg, Fe or Cl noted. *StDev* equates to standard deviation. * The value given for the total is the un-normalised sum of the elements Ag, Cu, Sn, Zn, Pb and Au.

Analysis of the surface of the object confirmed the presence of mercury gilding. The sub-surface analysis suggested an alloy with approximately 94 wt% silver and 4-5 wt% copper. The analysis also revealed the presence of some lead and gold in the alloy. Mercury was also detected in the subsurface area, and this is likely to have been absorbed during the gilding process rather than a deliberate addition to the alloy.

Analysed June 2015

XRF analysis of K787

Object Type Silver bracket
Date range

Relation to other objects None

Decoration Gilding [ ] Niello [ ]
Other [ ]

Surface XRF analysis was undertaken on the front of the bracket. Sub-surface analysis was carried out on the base.

Area analysed	No of analyses		Total*	Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Hg (%)
Front	5	Average	87.9	93.3	2.1	2.0	0.0	1.2	1.4	0.0
		StDev		*0.5*	*0.5*	*0.2*	*0.0*	*0.1*	*0.1*	*0.0*

The results from the surface XRF analysis carried as part of the silver study. * The value given for the total is the un-normalised sum of the elements, without iron and chlorine. *StDev* equates to standard deviation

No of analyses		Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Total*	Notes
6	Average	95.2	1.3	1.4	0.0	1.0	1.1	100.0	
	StDev	*0.4*	*0.1*	*0.3*	*0.0*	*0.0*	*0.1*		

The results from the sub-surface XRF analysis carried as part of the silver study, the results have been normalised but the presence of Hg, Fe or Cl noted. *StDev* equates to standard deviation. * The value given for the total is the un-normalised sum of the elements Ag, Cu, Sn, Zn, Pb and Au.

Analysis of the surface of the object suggests that the bracket was not mercury gilded. The sub-surface analysis suggested an alloy with approximately 95-96 wt% silver and 1-1.5 wt% copper. The analysis also revealed the presence of some tin, lead and gold in the alloy.

Analysed June 2015

XRF analysis of K791

Object Type Hilt-fitting
Date range

Relation to other objects None

Decoration Gilding ✓ Niello
Other

Surface XRF analysis was undertaken on the front and back of the hilt-fitting, and also on the pins. Sub-surface analysis was carried out on the back.

Area analysed	No of analyses		Total*	Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Hg (%)
Front	5	Average	98.2	31.3	1.3	0.5	0.0	0.4	54.9	11.6
		StDev		*17.7*	*0.5*	*0.3*	*0.0*	*0.2*	*17.3*	*1.5*
Pins	3	Average	81.0	79.1	1.8	0.9	0.2	1.0	13.6	3.4
		StDev		*21.5*	*0.3*	*0.1*	*0.3*	*0.5*	*17.6*	*4.5*
Back	5	Average	98.6	73.6	2.6	0.5	0.0	0.7	9.5	13.1
		StDev		*4.8*	*0.7*	*0.1*	*0.0*	*0.2*	*4.1*	*1.9*

The results from the surface XRF analysis carried as part of the silver study. * The value given for the total is the un-normalised sum of the elements, without iron and chlorine. *StDev* equates to standard deviation

No of analyses		Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Total*	Notes
4	Average	88.1	6.2	0.3	0.3	1.5	3.6	95.2	0-0.5% Fe, 3-5.5%Hg
	StDev	*0.3*	*0.3*	*0.2*	*0.0*	*0.1*	*0.3*		

The results from the sub-surface XRF analysis carried as part of the silver study, the results have been normalised but the presence of Hg, Fe or Cl noted. *StDev* equates to standard deviation. * The value given for the total is the un-normalised sum of the elements Ag, Cu, Sn, Zn, Pb and Au.

Analysis of the surface of the object confirmed the presence of mercury gilding. The back of the hilt-fitting had elevated gold and mercury present suggesting contamination from the gilding process. The sub-surface analysis suggested an alloy with approximately 87-89 wt% silver and 6-7 wt% copper. The analysis also revealed the presence of some tin, zinc, lead and gold in the alloy. Mercury was also detected in the subsurface area, and this is likely to have been absorbed during the gilding process rather than a deliberate addition to the alloy. The presence of traces of iron in the sub-surface results, even after successive scrapes, suggests that the prepared area may still be influenced by some corrosion products.

Analysed June 2015

XRF analysis of K827

Object Type Pommel
Date range Late 6th - early 7th

Relation to other objects None

Decoration Gilding ☐ Niello ☐
Other ☐

Surface XRF analysis was undertaken on the front of the pommel. Sub-surface analysis was carried out on the base.

Area analysed	No of analyses		Total*	Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Hg (%)
Base sheet	5	Average	99.2	75.2	8.9	9.2	0.5	3.7	2.5	0.0
		StDev		*0.6*	*0.9*	*0.2*	*0.0*	*0.2*	*0.1*	*0.0*

The results from the surface XRF analysis carried as part of the silver study. * The value given for the total is the un-normalised sum of the elements, without iron and chlorine. *StDev* equates to standard deviation

No of analyses		Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Total*	Notes
5	Average	82.1	5.4	7.5	0.4	2.7	1.9	100.0	
	StDev	*0.3*	*0.1*	*0.1*	*0.0*	*0.1*	*0.1*		

The results from the sub-surface XRF analysis carried as part of the silver study, the results have been normalised but the presence of Hg, Fe or Cl noted. *StDev* equates to standard deviation. * The value given for the total is the un-normalised sum of the elements Ag, Cu, Sn, Zn, Pb and Au.

Analysis of the surface of the object suggested that the pommel had not been mercury gilded. The sub-surface analysis suggested an alloy with approximately 81.5-82.5 wt% silver and 5-6 wt% copper. The analysis also revealed the presence of tin, lead, gold and some zinc in the alloy.

Analysed June 2015

XRF analysis of K959

Object Type Buckle
Date range

Relation to other objects None

Decoration Gilding Niello
Other

Surface XRF analysis was undertaken on the front of the buckle and also the twisted wires. Sub-surface analysis was carried out on the base.

Area analysed	No of analyses		Total*	Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Hg (%)
Front	4	Average	93.7	86.0	2.0	0.0	0.0	0.2	11.8	0.0
		StDev		*13.4*	*0.4*	*0.0*	*0.0*	*0.0*	*13.2*	*0.0*
Twisted wire	4	Average	98.6	29.6	3.5	0.3	0.0	0.0	66.4	0.2
		StDev		*3.5*	*0.3*	*0.1*	*0.0*	*0.0*	*3.4*	*0.1*

The results from the surface XRF analysis carried as part of the silver study. * The value given for the total is the un-normalised sum of the elements, without iron and chlorine. *StDev* equates to standard deviation

No of analyses		Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Total*	Notes
5	Average	96.7	2.4	0.0	0.0	0.2	0.7	100.0	
	StDev	*0.1*	*0.1*	*0.0*	*0.0*	*0.0*	*0.0*		

The results from the sub-surface XRF analysis carried as part of the silver study, the results have been normalised but the presence of Hg, Fe or Cl noted. *StDev* equates to standard deviation. * The value given for the total is the un-normalised sum of the elements Ag, Cu, Sn, Zn, Pb and Au.

Analysis of the surface of the object showed that there was no mercury gilding present, the inlaid wires on the buckle are a gold alloy. The sub-surface analysis suggested an alloy with approximately 96-97 wt% silver and 2-3 wt% copper. The analysis also revealed the presence of traces of lead and gold in the alloy.

Analysed June 2015

XRF analysis of K1007 and K39

Object Type Pommel
Date range Late 6th - early 7th
Relation to other objects None
Decoration Gilding ✓ Niello ✓
Other

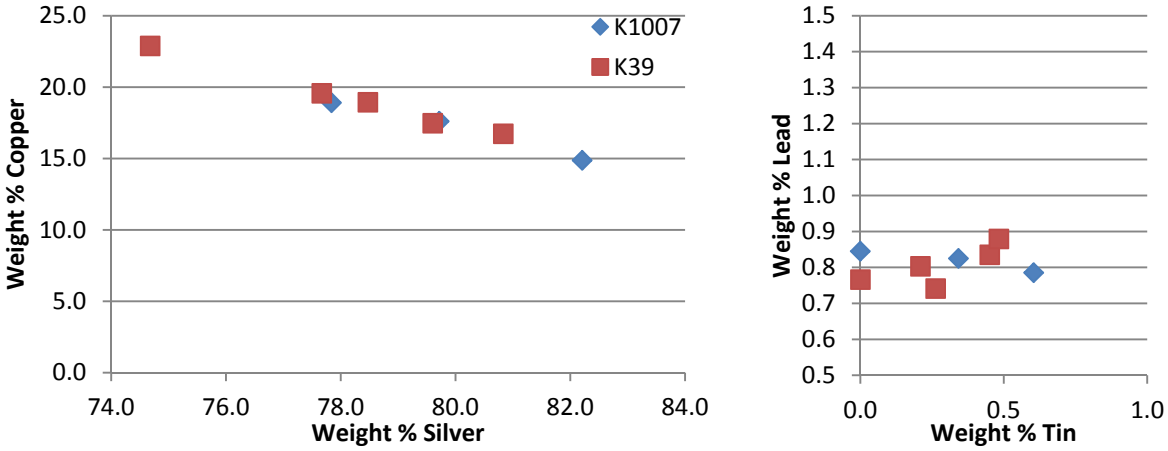
Surface XRF analysis was undertaken on the front of the pommel. Sub-surface analysis was carried out on the base of K39 and K1007.

Area analysed	No of analyses		Total*	Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Hg (%)
Front	5	Average	84.7	81.6	6.5	1.0	0.7	1.0	7.1	2.1
		StDev		*6.9*	*3.8*	*0.2*	*0.2*	*0.2*	*4.2*	*1.3*

The results from the surface XRF analysis carried as part of the silver study. * The value given for the total is the un-normalised sum of the elements, without iron and chlorine. *StDev* equates to standard deviation

No of analyses		Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Total*	Notes
5	Average	78.3	19.1	0.3	0.7	0.8	0.8	91.4	6-12% Hg
	StDev	*2.3*	*2.4*	*0.2*	*0.1*	*0.1*	*0.0*		
3	Average	80.0	17.1	0.3	0.9	0.8	0.9	99.4	0.3-0.6% Hg
	StDev	*2.2*	*2.1*	*0.3*	*0.1*	*0.0*	*0.0*		

The results from the sub-surface XRF analysis carried as part of the silver study, the results have been normalised but the presence of Hg, Fe or Cl noted. *StDev* equates to standard deviation. * The value given for the total is the un-normalised sum of the elements Ag, Cu, Sn, Zn, Pb and Au.



Plots of copper *vs* silver and lead *vs* tin contents, based on XRF analysis, showing the differences between the sub-surface analyses.

Analysis of the surface of the object confirmed the presence of mercury gilding. The sub-surface analysis suggested an alloy with approximately 75-82 wt% silver and 15-22 wt% copper. The analysis also revealed the presence of some tin, zinc, lead and gold in the alloy. Mercury was also detected in the subsurface area, and this is likely to have been absorbed during the gilding process rather than a deliberate addition to the alloy.

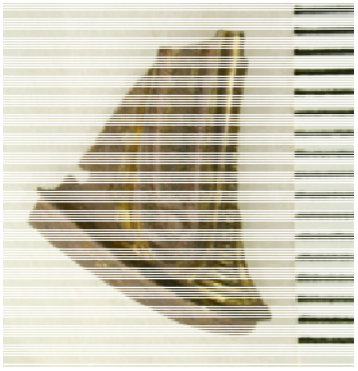
Analysed June 2015

XRF analysis of K1026

Object Type Hilt-collar
Date range

Relation to other objects None

Decoration Gilding ✓ Niello ✓
Other



Surface XRF analysis was undertaken on the gilding on the front of the hilt-collar. Sub-surface analysis was carried out on the back.

Area analysed	No of analyses		Total*	Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Hg (%)
Gilded front	5	Average	99.8	59.7	2.3	1.2	0.3	0.4	20.2	15.9
		StDev		*8.5*	*0.6*	*0.1*	*0.2*	*0.1*	*9.7*	*3.3*

The results from the surface XRF analysis carried as part of the silver study. * The value given for the total is the un-normalised sum of the elements, without iron and chlorine. *StDev* equates to standard deviation

No of analyses		Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Total*	Notes
5	Average	88.6	4.5	1.9	0.6	1.7	2.7	99.7	
	StDev	*0.7*	*0.5*	*0.1*	*0.0*	*0.1*	*0.1*		

The results from the sub-surface XRF analysis carried as part of the silver study, the results have been normalised but the presence of Hg, Fe or Cl noted. *StDev* equates to standard deviation. * The value given for the total is the un-normalised sum of the elements Ag, Cu, Sn, Zn, Pb and Au.

Analysis of the surface of the object confirmed the presence of mercury gilding. The sub-surface analysis suggested an alloy with approximately 88-90 wt% silver and 4-5 wt% copper. The analysis also revealed the presence of some tin, zinc, lead and gold in the alloy.

Analysed May 2015

XRF analysis of K1132

Object Type C-tubing
Date range

Relation to other objects

Decoration Gilding ☐ Niello ☐
Other ☐

Surface XRF analysis was undertaken on the front of the c-tubing. Sub-surface analysis was carried out on the back.

Area analysed	No of analyses		Total*	Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Hg (%)
Front	4	Average	99.2	96.0	1.6	0.0	0.0	0.5	1.9	0.0
		StDev		*0.4*	*0.2*	*0.0*	*0.0*	*0.1*	*0.1*	*0.0*

The results from the surface XRF analysis carried as part of the silver study. * The value given for the total is the un-normalised sum of the elements, without iron and chlorine. *StDev* equates to standard deviation

No of analyses		Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Total*	Notes
5	Average	95.8	1.8	0.0	0.0	0.6	1.8	100.0	
	StDev	*0.1*	*0.1*	*0.0*	*0.0*	*0.1*	*0.1*		

The results from the sub-surface XRF analysis carried as part of the silver study, the results have been normalised but the presence of Hg, Fe or Cl noted. * The value given for the total is the un-normalised sum of the elements Ag, Cu, Sn, Zn, Pb and Au.

Analysis of the surface of the object confirmed the absence of mercury gilding. The sub-surface analysis suggested an alloy with approximately 95-96 wt% silver and 1-2 wt% copper. The analysis also revealed the presence of some lead and gold in the alloy.

Analysed June 2015

XRF analysis of K1169

Object Type Fragment of hilt-collar
Date range Late 6th - early 7th

Relation to other objects K63 hilt-guard?

Decoration Gilding ✓ Niello
Other

Surface XRF analysis was undertaken on the gilded front of the fragment. Sub-surface analysis was carried out on the inside.

Area analysed	No of analyses		Total*	Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Hg (%)
Gilded front	4	Average	96.3	78.3	1.7	1.6	0.2	0.8	7.8	9.6
		StDev		*5.4*	*0.4*	*0.1*	*0.1*	*0.1*	*4.3*	*1.9*

The results from the surface XRF analysis carried as part of the silver study. * The value given for the total is the un-normalised sum of the elements, without iron and chlorine. *StDev* equates to standard deviation

No of analyses		Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Total*	Notes
8	Average	86.8	6.6	1.7	0.6	1.6	2.7	97.3	1.5-3% Fe
	StDev	*3.6*	*4.0*	*0.1*	*0.1*	*0.1*	*0.2*		

The results from the sub-surface XRF analysis carried as part of the silver study, the results have been normalised but the presence of Hg, Fe or Cl noted. *StDev* equates to standard deviation. * The value given for the total is the un-normalised sum of the elements Ag, Cu, Sn, Zn, Pb and Au.

Analysis of the surface of the object confirmed the presence of mercury gilding. The sub-surface analysis suggested an alloy with approximately 83-91 wt% silver and 2-10 wt% copper. The analysis also revealed the presence of some tin, zinc, lead and gold in the alloy. The presence of traces of iron in the sub-surface results, even after successive scrapes, suggests that the prepared area may still be influenced by some corrosion products.

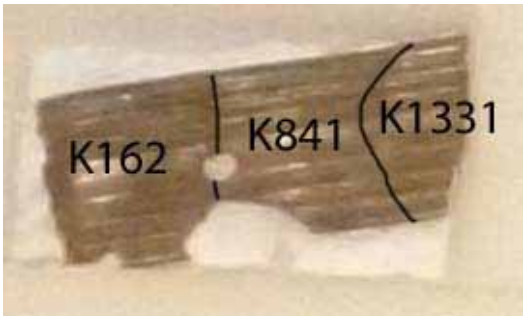
Analysed May 2015

XRF analysis of K1331

Object Type 5mm ribbed strip
Date range 600-650

Relation to other objects Helmet fittings?

Decoration Gilding ✓ Niello
Other



Surface XRF analysis was undertaken on the gilded front of the strip. Sub-surface analysis was carried out on the back.

Area analysed	No of analyses		Total*	Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Hg (%)
Front	4	Average	98.5	48.3	0.6	0.2	0.0	0.1	37.8	12.8
		StDev		*6.0*	*0.1*	*0.1*	*0.0*	*0.0*	*5.1*	*1.1*

The results from the surface XRF analysis carried as part of the silver study. * The value given for the total is the un-normalised sum of the elements, without iron and chlorine. *StDev* equates to standard deviation

No of analyses		Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Total*	Notes
6	Average	94.2	3.6	0.0	0.0	0.5	1.7	99.8	
	StDev	*0.1*	*0.1*	*0.0*	*0.0*	*0.0*	*0.0*		

The results from the sub-surface XRF analysis carried as part of the silver study, the results have been normalised but the presence of Hg, Fe or Cl noted. *StDev* equates to standard deviation. * The value given for the total is the un-normalised sum of the elements Ag, Cu, Sn, Zn, Pb and Au.

Analysis of the surface of the object confirmed the presence of mercury gilding. The sub-surface analysis suggested an alloy with approximately 94-94.5 wt% silver and 3-4 wt% copper. The analysis also revealed the presence of some lead and gold in the alloy.

Analysed June 2015

XRF analysis of K1447

Object Type Pommel
Date range

Relation to other objects None

Decoration Gilding ☐ Niello ☐
Other ☐

Surface XRF analysis was undertaken on the front of the pommel. Sub-surface analysis was carried out on the base.

Area analysed	No of analyses		Total*	Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Hg (%)
Front	5	Average	99.9	82.2	7.3	2.5	0.9	1.6	5.5	0.0
		StDev		*2.1*	*1.8*	*0.1*	*0.1*	*0.1*	*0.2*	*0.0*

The results from the surface XRF analysis carried as part of the silver study. * The value given for the total is the un-normalised sum of the elements, without iron and chlorine. *StDev* equates to standard deviation

No of analyses		Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Total*	Notes
5	Average	83.6	6.3	2.4	0.8	1.6	5.3	100.0	
	StDev	*0.3*	*0.1*	*0.2*	*0.0*	*0.0*	*0.1*		

The results from the sub-surface XRF analysis carried as part of the silver study, the results have been normalised but the presence of Hg, Fe or Cl noted. *StDev* equates to standard deviation. * The value given for the total is the un-normalised sum of the elements Ag, Cu, Sn, Zn, Pb and Au.

The sub-surface analysis suggested an alloy with approximately 83-84 wt% silver and 6-7 wt% copper. The analysis also revealed the presence of some tin, zinc, lead and gold in the alloy.

Analysed May 2015

XRF analysis of K1448 and K762

Object Type Pommel
Date range 630-675 AD

Relation to other objects None

Decoration Gilding ✓ Niello
Other Glass, gold panels

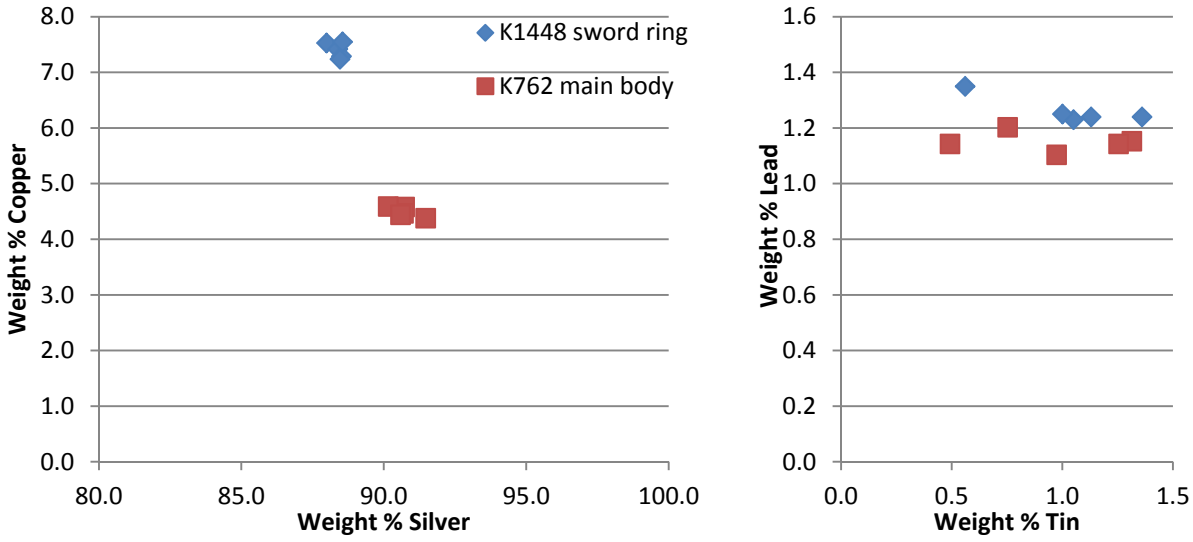
Surface XRF analysis was undertaken on the gilded front of the sword ring and main body. Sub-surface analysis was carried out on the inside of the sword ring and main body.

Object	Area analysed	No of analyses		Total*	Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Hg (%)
K1448	Sword ring	4	Average	100.0	32.9	1.9	0.7	0.0	0.3	55.4	8.8
			StDev		*7.9*	*0.9*	*0.0*	*0.0*	*0.3*	*8.3*	*0.9*
K762	Main body	4	Average	99.3	29.7	1.5	0.7	0.0	0.3	57.0	10.8
			StDev		*14.9*	*0.2*	*0.2*	*0.0*	*0.2*	*14.2*	*1.2*

The results from the surface XRF analysis carried as part of the silver study. * The value given for the total is the un-normalised sum of the elements, without iron and chlorine. *StDev* equates to standard deviation

Object	No of analyses		Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Total*	Notes
K1623 Sword ring	5	Average	88.4	7.4	1.0	0.0	1.3	1.9	100.0	
		StDev	*0.2*	*0.1*	*0.3*	*0.0*	*0.0*	*0.0*		
K1385 Main body	5	Average	90.8	4.5	1.0	0.1	1.1	2.5	99.7	
		StDev	*0.5*	*0.1*	*0.3*	*0.1*	*0.0*	*0.0*		

The results from the sub-surface XRF analysis carried as part of the silver study, the results have been normalised but the presence of Hg, Fe or Cl noted. *StDev* equates to standard deviation. * The value given for the total is the un-normalised sum of the elements Ag, Cu, Sn, Zn, Pb and Au.



Plots of copper *vs* silver and lead *vs* tin contents, based on XRF analysis, showing the differences between the sub-surface analyses.

Analysis of the surface of the object confirmed the presence of mercury gilding. The sub-surface analysis suggested an alloy with approximately 88-92 wt% silver and 4-8 wt% copper. The analysis also revealed the presence of some tin, lead and gold in the alloy. Mercury was also detected in the subsurface area, and this is likely to have been absorbed during the gilding process rather than a deliberate addition to the alloy. The presence of traces of iron in the sub-surface results, even after successive scrapes, suggests that the prepared area may still be influenced by some corrosion products.

Analysed June 2015

XRF analysis of K1493 and K1534

Object Type Hilt-plate
Date range 620-650

Relation to other objects None

Decoration Gilding ☐ Niello ☐
Other ☐

Surface XRF analysis was undertaken on the front and the inside of the hilt-plate. Sub-surface analysis was carried out on the inside of both fragments.

Object	Area analysed	No of analyses		Total*	Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Hg (%)
K1493	Front	4	Average	89.4	86.4	7.3	2.2	0.5	1.5	2.1	0.0
			StDev		*3.2*	*3.4*	*0.1*	*0.1*	*0.1*	*0.1*	*0.0*
K1493	Inside	5	Average	89.1	84.6	8.2	1.8	2.2	1.3	1.9	0.0
			StDev		*1.1*	*1.6*	*0.2*	*1.3*	*0.3*	*0.1*	*0.0*
K1534	Front	5	Average	89.7	86.2	7.9	2.1	0.5	1.4	1.9	0.0
			StDev		*2.2*	*2.0*	*0.3*	*0.1*	*0.1*	*0.2*	*0.0*
K1534	Inside	5	Average	98.1	82.8	12.2	1.4	1.3	1.0	1.3	0.0
			StDev		*5.3*	*5.1*	*0.2*	*0.8*	*0.2*	*0.1*	*0.0*

The results from the surface XRF analysis carried as part of the silver study. * The value given for the total is the un-normalised sum of the elements, without iron and chlorine. *StDev* equates to standard deviation

Object	No of analyses		Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Total*	Notes
K1493	6	Average	87.1	7.4	1.4	1.1	1.2	1.8	99.3	0.5-0.8% Fe
		StDev	*0.7*	*0.5*	*0.6*	*0.3*	*0.1*	*0.1*		
K1534	4	Average	84.4	10.5	1.3	1.0	1.3	1.5	99.9	
		StDev	*0.9*	*0.7*	*0.4*	*0.1*	*0.1*	*0.0*		

The results from the sub-surface XRF analysis carried as part of the silver study, the results have been normalised but the presence of Hg, Fe or Cl noted. *StDev* equates to standard deviation. * The value given for the total is the un-normalised sum of the elements Ag, Cu, Sn, Zn, Pb and Au.

The sub-surface analysis suggested an alloy with approximately 84-88 wt% silver and 7-11 wt% copper. The analysis also revealed the presence of some tin, zinc, lead and gold in the alloy. Traces of iron in the sub-surface results, even after successive scrapes, suggests that the prepared area may still be influenced by some corrosion products.

Analysed February 2015

XRF analysis of K1509 and K453

Object Type Helmet cheek piece
Date range 600-650 AD
Relation to other objects Helmet fittings
Decoration Gilding ✓ Niello ✓
Other

Surface XRF analysis was undertaken on the front of K453. Sub-surface analysis was carried out on the back of K1509 and K453.

Area analysed	No of analyses		Total*	Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Hg (%)
Front	5	Average	99.6	15.7	0.0	0.4	0.0	0.0	74.1	9.8
		StDev		*2.5*	*0.0*	*0.1*	*0.0*	*0.0*	*2.4*	*0.2*

The results from the surface XRF analysis carried as part of the silver study. * The value given for the total is the un-normalised sum of the elements, without iron and chlorine. *StDev* equates to standard deviation

Object	No of analyses		Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Total*	Notes
K453	4	Average	62.6	2.1	0.0	0.0	0.4	34.9	94.3	4-7% Hg
		StDev	*7.8*	*0.5*	*0.0*	*0.0*	*0.1*	*8.4*		
K1509	6	Average	95.6	3.1	0.0	0.0	0.5	0.8	99.3	0.5-0.8% Hg
		StDev	*0.2*	*0.2*	*0.0*	*0.0*	*0.1*	*0.1*		

The results from the sub-surface XRF analysis carried as part of the silver study, the results have been normalised but the presence of Hg, Fe or Cl noted. *StDev* equates to standard deviation. * The value given for the total is the un-normalised sum of the elements Ag, Cu, Sn, Zn, Pb and Au.

Analysis of the surface of the object confirmed the presence of mercury gilding. The sub-surface analysis suggested an alloy with approximately 95-96 wt% silver and 3-4 wt% copper. The analysis also revealed the presence of some lead and gold in the alloy. Mercury was also detected in both subsurface areas, but particularly K453. This is likely to have been absorbed during the gilding process rather than a deliberate addition to the alloy, and may explain the elevated gold result for K453.

Analysed June 2015

XRF analysis of K1566

Object Type 8mm ribbed strip
Date range

Relation to other objects

Decoration Gilding ✓ Niello
Other

Surface XRF analysis was undertaken on the gilded front of the strip. Sub-surface analysis was carried out on the back.

Area analysed	No of analyses		Total*	Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Hg (%)
Front	4	Average	100.0	32.8	0.6	0.5	0.0	0.0	56.2	9.9
		StDev		*0.9*	*0.0*	*0.0*	*0.0*	*0.0*	*0.9*	*0.3*

The results from the surface XRF analysis carried as part of the silver study. * The value given for the total is the un-normalised sum of the elements, without iron and chlorine. *StDev* equates to standard deviation

No of analyses		Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Total*	Notes
5	Average	94.0	3.9	0.2	0.3	0.5	1.1	99.8	0.1-0.2% Hg
	StDev	*0.2*	*0.1*	*0.2*	*0.0*	*0.0*	*0.0*		

The results from the sub-surface XRF analysis carried as part of the silver study, the results have been normalised but the presence of Hg, Fe or Cl noted. *StDev* equates to standard deviation. * The value given for the total is the un-normalised sum of the elements Ag, Cu, Sn, Zn, Pb and Au.

Analysis of the surface of the object confirmed the presence of mercury gilding. The sub-surface analysis suggested an alloy with approximately 93.5-94.5 wt% silver and 3.5-4 wt% copper. The analysis also revealed the presence of some tin, zinc, lead and gold in the alloy. Traces of mercury were also detected in the subsurface area, and this is likely to have been absorbed during the gilding process rather than a deliberate addition to the alloy.

Analysed June 2015

XRF analysis of K1684

Object Type Pommel
Date range 625-650 AD

Relation to other objects None

Decoration Gilding ☐ Niello ☐
Other ☐

Surface XRF analysis was undertaken on the front of the pommel. Sub-surface analysis was carried out on the base.

Area analysed	No of analyses		Total*	Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Hg (%)
Front	5	Average	94.9	63.8	31.2	1.5	0.0	0.9	2.6	0.0
		StDev		*11.3*	*13.1*	*0.3*	*0.0*	*0.3*	*1.6*	*0.0*

The results from the surface XRF analysis carried as part of the silver study. * The value given for the total is the un-normalised sum of the elements, without iron and chlorine. *StDev* equates to standard deviation

No of analyses		Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Total*	Notes
6	Average	76.6	17.8	0.7	0.0	1.3	3.6	100.0	
	StDev	*1.9*	*2.4*	*0.8*	*0.0*	*0.1*	*0.4*		

The results from the sub-surface XRF analysis carried as part of the silver study, the results have been normalised but the presence of Hg, Fe or Cl noted. *StDev* equates to standard deviation. * The value given for the total is the un-normalised sum of the elements Ag, Cu, Sn, Zn, Pb and Au.

Analysis of the surface of the object suggests that the pommel was not mercury gilded. The sub-surface analysis suggested an alloy with approximately 76-78 wt% silver and 15-20 wt% copper. The analysis also revealed the presence of some tin, lead and gold in the alloy.

Analysed June 2015

XRF analysis of K1700

Object Type Niello mount
Date range 600-650 AD

Relation to other objects None

Decoration Gilding ✓ Niello ✓
Other

Surface XRF analysis was undertaken on the front and on the gilded border, as well as three pins. Sub-surface analysis was carried out on the back.

Area analysed	No of analyses		Total*	Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Hg (%)
Front	4	Average	99.1	98.3	0.2	0.0	0.0	0.5	1.0	0.0
		StDev		*0.5*	*0.2*	*0.0*	*0.0*	*0.2*	*0.1*	*0.1*
Gilded border	4	Average	100.0	16.9	0.2	0.3	0.0	0.0	69.8	12.8
		StDev		*4.5*	*0.0*	*0.0*	*0.0*	*0.0*	*4.3*	*0.5*
Pins	3	Average	98.3	77.0	0.7	0.0	0.0	0.4	16.4	5.5
		StDev		*7.8*	*0.3*	*0.0*	*0.0*	*0.1*	*6.2*	*1.9*

The results from the surface XRF analysis carried as part of the silver study. * The value given for the total is the un-normalised sum of the elements, without iron and chlorine. *StDev* equates to standard deviation

No of analyses		Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Total*	Notes
5	Average	98.1	0.1	0.0	0.0	0.9	0.9	99.9	
	StDev	*0.2*	*0.2*	*0.0*	*0.0*	*0.1*	*0.0*		

The results from the sub-surface XRF analysis carried as part of the silver study, the results have been normalised but the presence of Hg, Fe or Cl noted. *StDev* equates to standard deviation. * The value given for the total is the un-normalised sum of the elements Ag, Cu, Sn, Zn, Pb and Au.

Analysis of the front surface of the object confirmed the absence of mercury gilding except for the border and pins. The sub-surface analysis suggested an alloy with approximately 97.5-98.5 wt% silver. The analysis also revealed the presence of some lead and gold, with traces of copper, in the alloy.

Analysed June 2015

XRF analysis of K1823a and K1823b for the silver project

Object Type Hilt-plate
Date range Late 6th - early 7th
Relation to other objects None
Decoration Gilding ✓ Niello
Other

Surface XRF analysis was undertaken on the front of the hilt-plate in areas of gilding and areas with no observable gilding present, as well as the inside. Sub-surface analysis was carried out on the inside of both fragments.

Object	Area analysed	No of analyses		Total*	Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Hg (%)
K1823a	Front	5	Average	99.8	4.0	0.1	0.2	0.0	0.0	87.7	8.0
			StDev		*1.9*	*0.1*	*0.1*	*0.0*	*0.0*	*3.0*	*1.4*
K1823a	Inside	5	Average	99.7	79.9	1.5	1.2	0.0	0.4	6.8	10.2
			StDev		*9.4*	*0.6*	*0.1*	*0.0*	*0.2*	*5.8*	*4.5*
K1823b	Front gilding	3	Average	100.0	9.2	0.2	0.3	0.0	0.0	79.8	10.5
			StDev		*8.8*	*0.3*	*0.3*	*0.0*	*0.0*	*12.5*	*3.3*
K1823b	Front	3	Average	99.9	9.2	0.2	0.5	0.0	0.0	81.4	8.7
			StDev		*5.8*	*0.1*	*0.2*	*0.0*	*0.1*	*7.4*	*1.4*
K1823b	Inside	5	Average	100.0	79.2	1.2	1.3	0.0	0.4	6.8	11.1
			StDev		*7.3*	*0.5*	*0.2*	*0.0*	*0.1*	*4.7*	*3.4*

The results from the surface XRF analysis carried as part of the silver study. * The value given for the total is the un-normalised sum of the elements, without iron and chlorine. *StDev* equates to standard deviation

Object	No of analyses		Ag (%)	Cu (%)	Sn (%)	Zn (%)	Pb (%)	Au (%)	Total*	Notes
K1823a	4	Average	91.5	5.3	0.8	0.0	1.1	1.3	99.6	0.3-0.5% Hg
		StDev	*0.6*	*0.2*	*0.4*	*0.0*	*0.0*	*0.0*		
K1823b	5	Average	91.1	5.6	0.5	0.0	1.2	1.6	99.3	0.5-0.8% Hg
		StDev	*0.3*	*0.2*	*0.3*	*0.0*	*0.0*	*0.2*		

The results from the sub-surface XRF analysis carried as part of the silver study, the results have been normalised but the presence of Hg, Fe or Cl noted. *StDev* equates to standard deviation. * The value given for the total is the un-normalised sum of the elements Ag, Cu, Sn, Zn, Pb and Au.

Analysis of the surface of the object confirmed the presence of mercury gilding. The inside of the hilt-plate fragments had elevated gold and some mercury present suggesting contamination from the gilding process. The sub-surface analysis suggested an alloy with approximately 90.5-92.5 wt% silver and 5-6 wt% copper. The analysis also revealed the presence of some tin, lead and gold in the alloy. Mercury was also detected in the subsurface area, and this is likely to have been absorbed during the gilding process rather than a deliberate addition to the alloy.

Analysed February 2015

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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Historic England

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