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Examination and analysis of some crucibles from Birka

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Seven crucible fragments from excavations at Birka were kindly loaned by the Statens Historiska Museum, Stockholm. All were examined microscopically, x-radiographed and analysed by energy dispersive x-ray fluorescence (XRF).

One piece (I C1 697/981) was found not to be from a crucible but from a plano-convex glass object, possibly a gaming piece. The major element found was lead. This, when taken together with its density (5.0 g/cc), indicated that the glass contained about 70 % by weight lead oxide. The glass was translucent green and now has a thin weathered outside layer which appears pale grey. Other elements detected by XRF included iron, copper, zinc and a trace of tin. The colour is probably due to the presence of the iron and/or copper. The zinc and tin probably entered the glass with the copper, suggesting the metal added was brass not pure copper; the small amount of iron could have got into the glass as an impurity in glass-making raw materials. This type of glass is known on several English sites dating to about the tenth century (Biek and Bayley 1979,13).

The other six fragments were all parts of dish or disc-shaped crucibles rather than the normal thimble-shaped ones (see figure 1). The analytical results obtained are given in the table. In addition to the elements listed the following were also detected in all cases: potassium, calcium, strontium, titanium, zirconium and manganese. These elements, which were present in fairly small amounts, and also the iron were probably in the crucible fabric or the fuel ash from the hearth in which the crucible was heated. (Note: sodium and silicon, which were not detectable under the analytical conditions used, were almost certainly also present.) The rest of the elements detected are not likely to have been incorporated in the crucibles by accident; they were deliberate additions which must relate to the uses that were made of them.

Figure 2 shows the radiographs of the crucible fragments. The paler an area appears the more opaque to x-rays it is. This can indicate two things, either a greater thickness of crucible fabric or a metal-rich deposit, often droplets of metal trapped in the vitrified surface of the crucible. Careful examination of figure 2 allows a number of conclusions to be drawn, especially when the visual information is combined with that provided by the analyses. All the crucibles are of a fairly fine-grained fabric, that of no. 3 probably being the coarsest. The large, roundish, darker areas, especially well seen in no. 4 and near the rim of no. 5, are bubbles formed by gases trapped in the vitrified surface of the crucible. The small, circular, intense white spots represent droplets of metal.

Catalogue

Fragment no. 1:

The radiograph is a side view of this piece, the upper surface of the crucible being upmost in figure 2. The crucible has been heated from above as the upper surface is far more deeply vitrified than the underside (far more bubbles are visible on the radiograph). The widespread radio-opacity (the pale area) is mainly due to relatively large amounts of lead in the glassy surface layer; the white spots are metal droplets. As copper, zinc and silver have been detected by XRF these droplets may be copper, brass (copper + zinc) or silver. The presence of bismuth is unexpected though the deposits on both this and crucible no. 6 contain significant amounts of it. Bismuth ores are found in association with lead ores so the bismuth was probably incorporated into the crucible deposit together with the lead.

Fragment no. 2:

This radiograph is also a side view with the upper surface of the crucible uppermost. The deeply vitrified layer again contains considerable amounts of lead and has many trapped metal droplets. The metals detected were copper, zinc, silver and gold so the droplets may be of any or all of these, either alone or alloyed. The red colour of the vitreous layer, like that of no. 1, is due to copper colouring the accidentally formed glass as it does in deliberately made red glass or enamel.

Fragment no. 3:

This is a far larger fragment than either no. 1 or 2 and has a quite different character. The vitrification is restricted to a thin surface layer rather than penetrating several millimeters into the crucible and is a transparent green rather than opaque red/brown/black. The metal droplets are far smaller, only the largest being visible on the radiograph without magnification. The metal is gold (it can be seen with a binoccular microscope) and the copper, zinc and lead are present at far lower levels than in nos. 1 and 2.

Fragment no. 4:

This is similar to no. 3, having very many extremely tiny metal droplets trapped in the vitreous surface. The analysis is also very similar, gold giving strong signals, copper and zinc weak ones and lead is no longer detectable.

Fragment no. 5:

This again is similar to nos. 3 and 4 though only very few metal droplets are visible on the radiograph. Copper and zinc were detected at low levels but no precious metals were detected, probably because the overall amount present is so low (see figure 2).

Fragment no. 6:

This piece is more like no. 1 than any of the others; there is a high -lead vitreous area furthest from the rim of the sherd which is coloured red by the relatively large amounts of copper present. Bismuth and zinc were the other metals detected. The metal droplets are neither as numerous or frequent as in nos. 1 and 2 and so may not have been detected by XRF, or they may be of copper or brass.

One further general point must be made before possible uses are considered. All these crucible fragments have been heated under reducing conditions as the fabrics are all grey or black in colour, and further confirmation of this is provided by the red, copper coloured vitreous deposits; this colour only develops under reducing conditions.

It will be apparent from the catalogue that there are two different types of use for these disc-shaped crucibles. The first produces high-lead vitreous deposits with relatively large trapped metal droplets. Nos. 1, 2 and 6 are examples of this type which can be parallelled from a number of sites in both Scandinavia and England. These include Fyrkat, where they are described as 'heating trays' (Roesdahl 1977, 51ff), Hedeby, Kaupang, York, Lincoln,Thetford and Northampton.

The second use for these disc-shaped crucibles produces a fuel ash 'glaze' containing low levels of metals and little or no lead. The metal droplets are more finely divided than in the first type and are usually of gold. Similar crucibles are known from Helgö (where some contain silver as well as or instead of gold) and York.

All the sites where disc-shaped crucibles with high-lead deposits have been found have also produced deep, metal melting crucibles, mainly thimble-shaped in Scandinavia and bag-shaped in England. This supports the suggestion that the 'heating trays' were connected with non-ferrous metalworking but were not used for metal melting. Roesdahl (1977) suggests they may have been used to hold metalwork while e.g. filigree or granulation was applied. This immediately appears an attractive idea but on closer examination there are points that do not fit in. The 'heating trays' have high-lead surfaces - but soft solders were not usually used in the early mediaeval period and certainly not for joining noble metals (gold and silver), yet the metal droplets on the 'heating trays' suggest that at least some of them were used with noble metals. A process that does involve noble metals and lead is assaying or cupellation, the refining of the metal by removing base impurities by heating it with lead. This must be carried out under oxidising conditions as the base metals dissolve in litharge (lead oxide) which is then separated from the noble metal by skimming it off or by absorbing it in a porous cupel (crucible). As the 'heating trays' are universally reduced fired, cupellation must be completely ruled out as a possible use though in other ways (shape, fabric etc.) they are not too unsuitable. Excavations on Helgö have produced a number of cupels(?) which were described by Lamm (1973, 1) as "plates of clay with upward-turned rims..." They are strongly oxidised fired.

At present there are no further suggestions as to possible uses for the 'heating trays' but it is hoped that detailed consideration of the finds from more of the sites mentioned above will throw some further light on the subject.

The low-lead disc crucibles are less of a problem as one possible use can be suggested straight away. This is holding objects while decoration is applied as suggested by Roesdahl for the high-lead disc crucibles (1977, 54ff). The metal droplets are mainly gold which suggests the objects concerned were of gold. The small amounts of copper and zinc could well be part of a lower melting point gold alloy used to 'solder' the applied decoration into place.

References

Biek, L and Bayley, J (1979) Glass and other vitreous materials. World Archaeology 11(1), 1-25.

Lamm, K (1973) The manufacture of jewellery during the migration period at Helgö in Sweden. Bulletin Historical Metallurgy Group 7(2), 1-6.

Roesdahl, E (1977) Fyrkat: En jysk vikingeborg. II Oldsagerne og gravpladsen.

Table: Analytical results for the crucible fragments

Fragment no.	Excavator's no.	Fe	Cu	Zn	Au	Pb	Bi	Ag	Sn
		Elements detected							
1	C^1 702/978	x	xx	x		x	x	x	
2	C^1 700/979	x	xx	x	x	xx		x	
3	D^3 704/974	x	(x)	x	x	(x)			
4	5208:2489 large	x	(x)	x	x				
5	medium	x	(x)	x					
6	small	x	x	x		x	x		

(x) weak signal

x medium signal

xx strong signal

A blank means that the element was not detected

Figure 1 : Sketch plans and sections of the crucible fragments

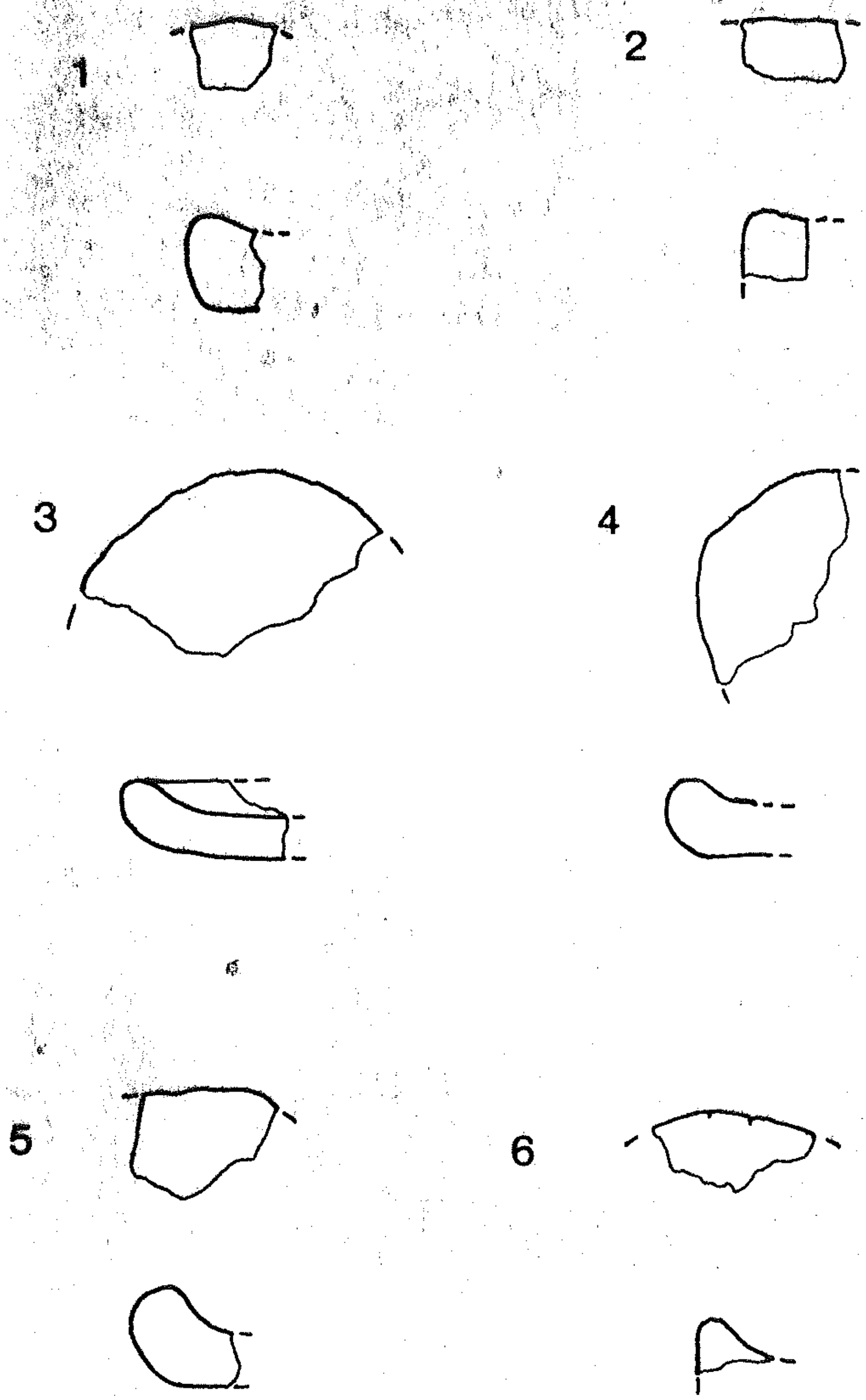
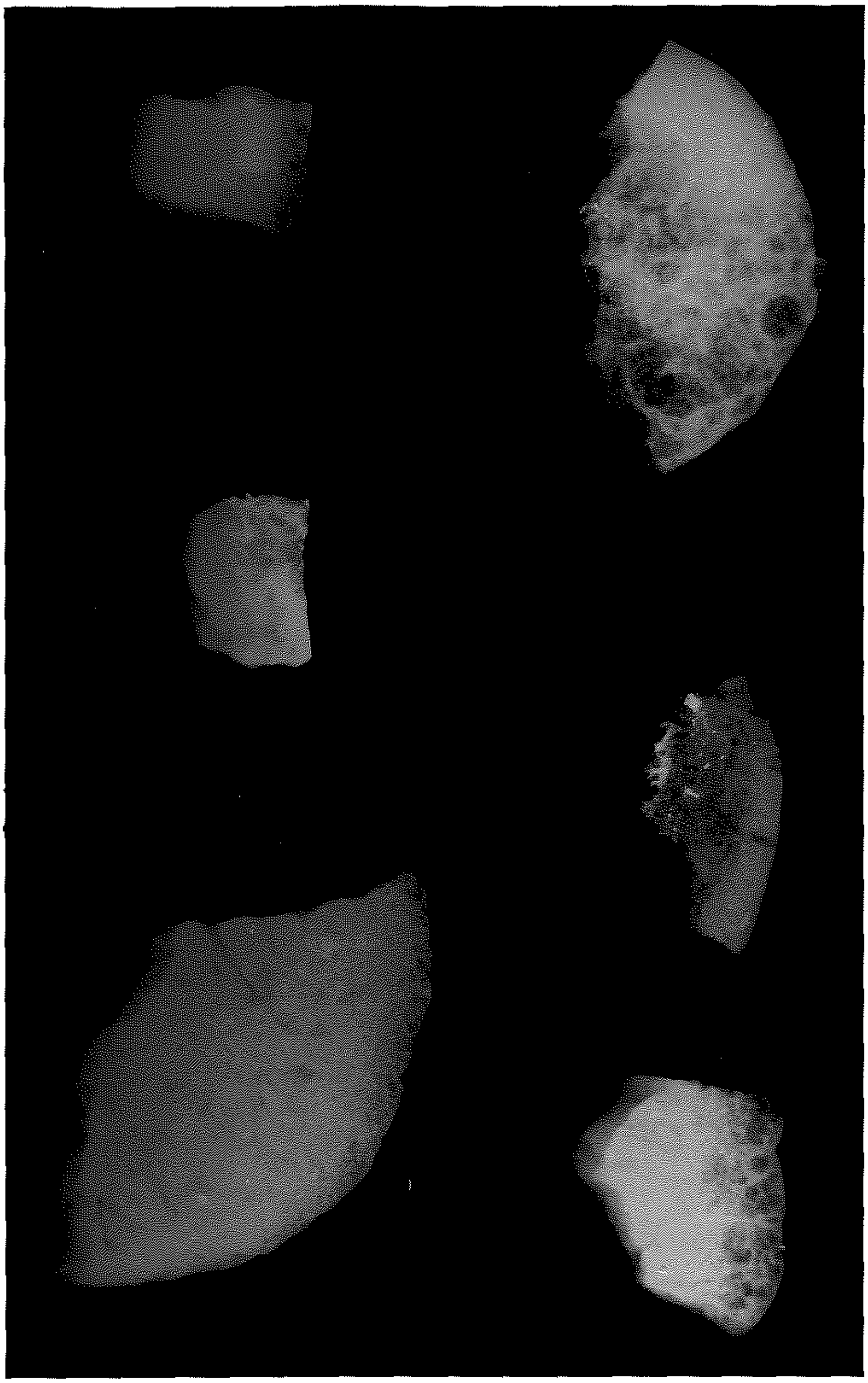


Figure 2 : Radiographs of the crucible fragments



Scale: nearly twice life size

Top row (left to right) Fragments 1 and 4
Middle row Fragments 2 and 6
Bottom row Fragments 3 and 5

Fragments 1 and 2 are viewed sideways on, upper surface to the right. The rest are viewed from above.