

# Cupel and crucible: the refining of debased silver in the Colonia Ulpia Traiana, Xanten

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Excavations in the Colonia Ulpia Traiana in the Archaeological Park Xanten (NW Germany) produced a group of finds related to the refining of silver: cupellation hearth material, crucible fragments and crucible slags. Chemical and mineralogical analysis of these finds has led to the reconstruction of a hitherto unknown process of silver refining involving the re-use of litharge or cupellation hearth material from a previous cupellation. It was fused with sand in crucibles to form a lead oxide slag, to which debased silver scrap was added. Tin as the most deleterious impurity in debased silver, together with zinc, went to the slag, while copper, silver and probably lead formed a 'bullion' regulus underneath the slag at the bottom of the crucible. The possible use of the slag produced in this operation as an enamel material will be discussed, based on a few finds from elsewhere. The archaeological context demonstrates that this refining took place in a private workshop located in a craft quarter of the settlement.

## Introduction

The Roman Empire saw several periods of significant debasement of its silver coinage, followed by various attempts to re-establish a reliable silver-based currency. Silver debasement was also a matter of concern for local craftsmen working the metal. While the monetary silver stock was allowed to drop to ever lower levels, though still being closely controlled,<sup>1</sup> silver used in tableware remained at a rather high degree of fineness even during the later Roman period.<sup>2</sup> Smaller items of jewellery, by contrast, exhibited a wide range of compositions, though still mostly at a higher level than the more heavily debased coinage.<sup>3</sup> It is generally assumed that the refining of debased silver was done by cupellation, resulting in a silver with as little as 1% copper and lead, though to increase the mechanical properties of the silver it was usually alloyed with c.5% copper by weight.

Recent excavations in the Colonia Ulpia Traiana have produced archaeological evidence for how a silversmith far from primary sources of metal dealt with the problem of debased silver, namely by immersing it in a lead-silica bath prior to cupellation. The first step, carried out in a crucible, served to reduce the content of deleterious elements present, notably tin, while collecting the silver in a ternary copper-silver-lead alloy. During cupellation this alloy is then remelted under a draft of ambient air. The lead and copper oxidize to cupriferous litharge, while the silver becomes more and more enriched, unaffected by the attack of oxygen. Cupellation is typically conducted on a hearth lined with porous materials such as marl or bone ash which readily absorb the metal oxides. The silver metal, having a much higher surface tension than the oxides, stays on top of the hearth, from where it is collected once the process is completed. The ease and success with which the cupellation could be performed depend greatly on the composition of the bullion used. Both tin and copper are deleterious elements when present in too high concentrations relative to lead. Severe debasement of the silver, in particular if bronze is used instead of pure copper, therefore increases the difficulties experienced later in refining the metal. The hearth material, soaked with the oxides of lead, copper, and any further base metals from the charge, is discarded and may eventually make its

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- 1 L. Cope, "The metallurgical analysis of Roman imperial silver and aes coinage," in E. Hall and D. Metcalf (edd.), *Methods of chemical and metallurgical investigation of ancient coinage* (London 1972) 3-47; C. King and P. Northover, "The analyses" in *Der Münzhort aus dem Gutshof in Neftenbach* (Zürich 1993) 101-17.
  - 2 E.g., A. Bennett, "Technical examination and conservation," in *The Sevso treasure, Part 1* (JRA Suppl. 12.1, 1994), 21-35.
  - 3 C. Mortimer, "Early use of brass in silver alloys," *OJA* 5 (1986) 233-42.