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Early Roman copper-alloy brooch production: a compositional analysis of 400 brooches from *Germania Inferior*

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We present here a compositional study of a large number of copper-alloy brooches, undertaken in 2014 using Handheld X-ray Fluorescence Spectrometry (HHpXRF). The brooches, which come from the area of Nijmegen, date from the Late Iron Age until the 2nd c. A.D. Our aim is to explore the ways in which artefact production was organized both in the context of Roman centres and in the countryside. The link between alloys and workshop organization will be elucidated before the methodology and results are presented. The results will then be discussed, leading to the formation of several hypotheses regarding the organization of workshops that produced metal artefacts.

Scientific interest in the composition of ancient artefacts has existed for well over two centuries. Roman brooches in particular have been in the forefront of this research both because of their ease of categorization and because they are found in large numbers on archaeological sites. Much work has been done on how they were made and on the technical choices available to the craftsmen. In particular, the choice of alloying agents (tin, lead, zinc) added to copper demonstrated a complex relationship between composition and typology, especially in the debate over Roman or local production.[1] The technological restraints imposed on these artefacts by different alloy ratios have been studied in some detail,[2] especially in terms of casting in liquid form, into a mould, or being wrought through beating with a hammer.

Thanks to the development of X-Ray laboratory-based research since the 1950s, a clearer understanding of the alloying process has been achieved. Until the last decade, however, most of this research has taken place in scientific institutions rather than in museums or places of storage. Not only were there significant cost implications arising from the choice of method or apparatus employed, there was also a hidden cost of safely transporting items to and from their owners and the laboratory. To compound the issue, nearly all methods involved a certain level of damage to the artefact, either by drilling into its centre to remove a sample for testing, or by removing the patina (outer corrosion layer) to gain a clean surface — a requirement plainly at odds with the conservation practices of most museums and other owners, which resulted in a limited availability of objects to study.

X-Ray fluorescence, as a technique for identifying an item's composition, has been available for a number of decades but, thanks to advances driven initially by the mining and

1 D. Dungworth, "Roman copper alloys: analysis of artefacts from northern Britain," *JArchSci* 24 (1997) 902.

2 E.g., J. A. Smythe, "Roman objects of copper and iron from the north of England," *Proc. Univ. Durham Philosoph. Soc.* 9 (1938) 382-405; H. Unglick, "Structure, composition and technology of late Roman copper alloy artifacts from the Canadian excavations at Carthage," *Archaeomaterials* 5 (1991) 91-110; J. Bayley and S. Butcher, "The composition of Roman brooches found in Britain," *Acta of the 12th Congress on Ancient Bronzes* (Nijmegen 1998); iid., *Roman brooches in Britain: a technological and typological study based on the Richborough Collection* (London 2004); P. T. Craddock, "Copper alloys of the Hellenistic and Roman world: new analyses and old authors," in J. Ellis-Jones (ed.), *Aspects of ancient mining and metallurg* (Brit. School Athens Conf. 1986; Bangor 1988) 55-65.