

Evaluation of handheld X-ray fluorescence spectroscopy results of Roman copper alloy brooches by using archaeological typology

Vince Van Thienen^(1,3), Sylvia Lycke^(1,2) and Peter Vandenaabeele⁽¹⁾

GHENT UNIVERSITY

FACULTY OF ARTS AND PHILOSOPHY

FACULTY OF SCIENCES

Ram Spec

ARCHAOMETRY GHENT

Historical Archaeology Research group

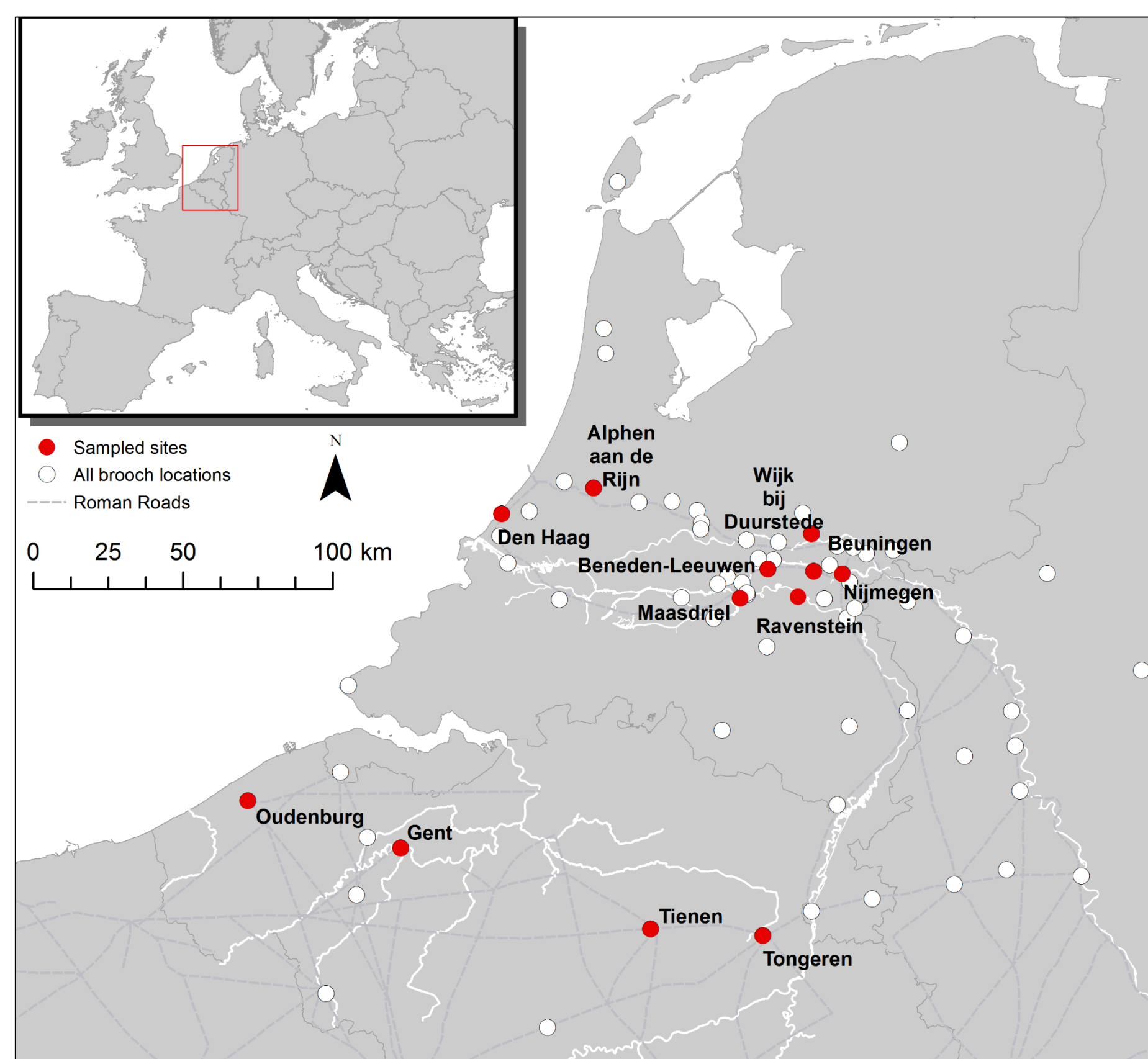
(1) Department of Archaeology, Ghent University, Sint-Pietersnieuwstraat 35, UFO, Ghent, Belgium
(2) Department of Analytical Chemistry, Ghent University, Krijgslaan 281, S12, Ghent, Belgium
(3) Department of Anthropology, Yale University, 51 Hillhouse Avenue, New Haven, CT, USA

INTRODUCTION

- This study is part of the research on the northern periphery of the Late Roman Empire that studied the developments between the 3rd to 5th century in this region¹
- The crossbow brooch is a well-known artifact, frequently found in Late Roman archaeology and art-historical sources.
- Not much was known about its production organization, nor its connection to the changes in the Roman world²
- The aim was to investigate the composition of these brooches to explore how this could inform us on changes in metal production that reflect the larger socio-cultural changes in the Late Roman world

MATERIALS

- The crossbow brooch has its origin in the 3rd century as a military item, gains status with the rise of the military elites in the 4th century, and becomes a symbol of Roman power and state authority in the 5th century³
- A total of 187 brooches were collected from 12 different sites in Belgium and the Netherlands
- The sample population covers the complete typological and stylistic variability between ca. AD 250 and 450 in this region



METHODOLOGY

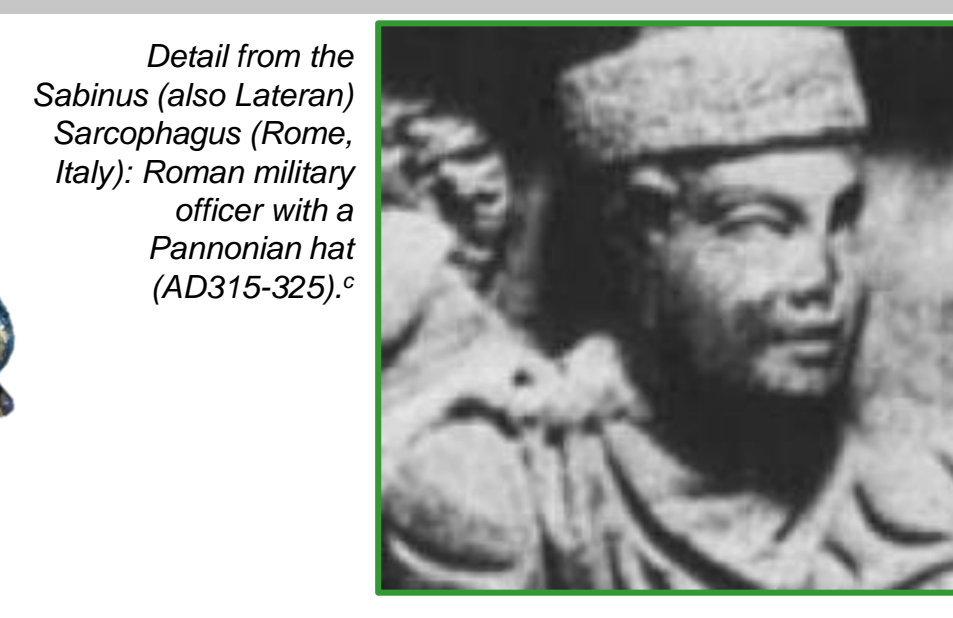
- Handheld XRF was chosen because the artifacts belong to invaluable collections and a non-destructive, fast, and mobile technique was required
 - Olympus InnovX Delta handheld X-Ray Fluorescence instrument, spot size 5x5 mm², Rh-anode, silicon-drift detector, air in shielded chamber, 40kV, 79mA, 300 sec live time.
- There are known issues with surface XRF on copper alloy artefacts, including positioning difficulties due to multidimensionality:
 - Measurements with noticeable effects from corrosion, surface enrichments, and soil contaminations were discarded;
 - Flat surfaces were located on the underside of the foot (catch) and arms (crossbar with hinge mechanism) and sides of the bow (arch);
 - Multiple measurements per brooch (2-5, depending on fragmentation) to account for the heterogeneity.
- Semi-quantitative method⁴:
 - No focus on exact compositional information: uncertain how reliable that information would be and uncertain what the actual value is in reconstructing choices made in Antiquity;
 - Questions are not about exact technological differences, techniques or skills, but about how changes in production relate to changes in the social transformations of Roman life.

Type '0'



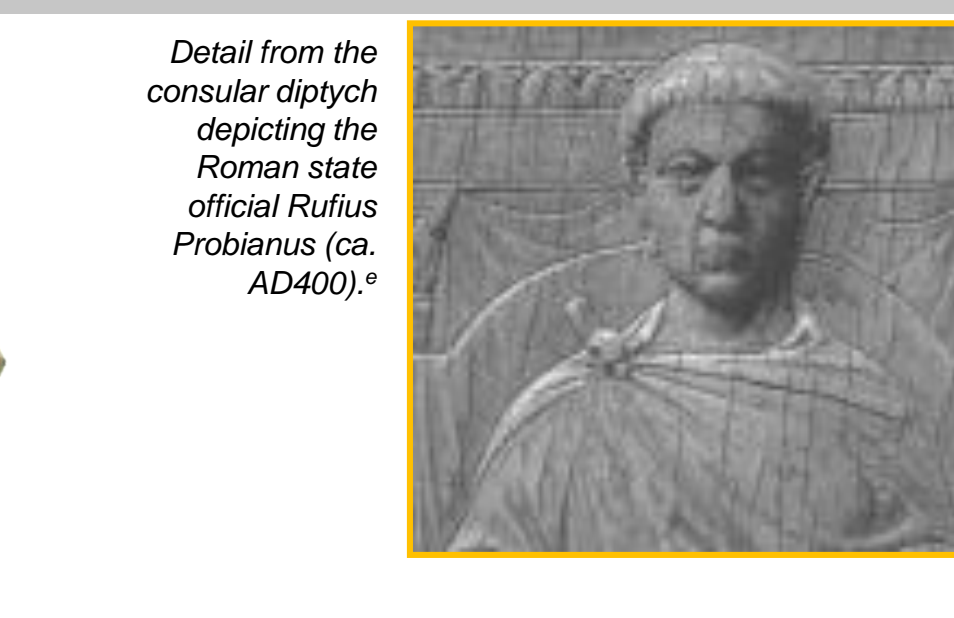
- 3rd century
- Cast in mold, possible batch production
- Little decoration and dimensional variation
- Part of soldier's uniform

Type 2



- Ca. AD 300-365
- Combination casting and working
- Further increase in decoration and dimensional variation
- Military officer's brooches and civilian imitations

Type 5



- Ca. AD 350-415
- Mainly working of sheet metal
- Continuity of standardized dimensionality, appearance of new decoration types
- Production on commission
- Symbol for military elite and administrative state officials

Type 1



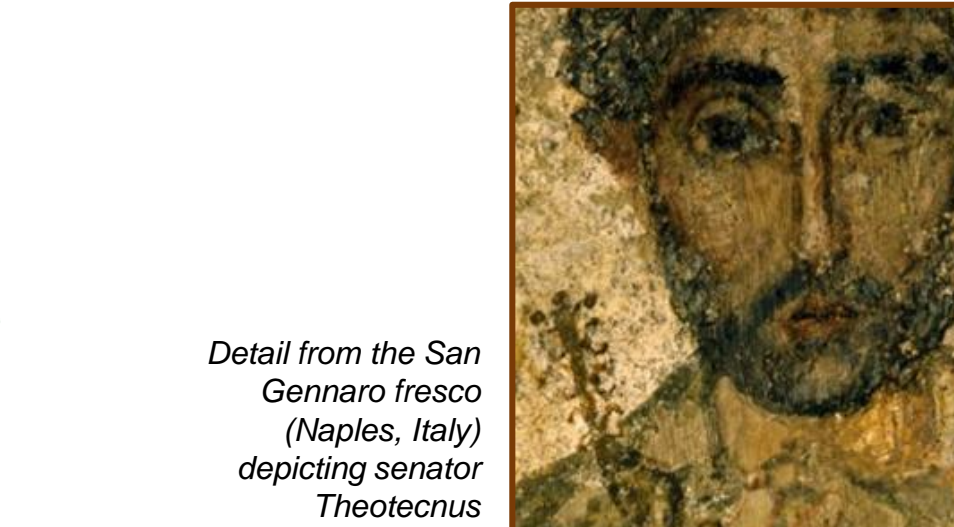
- Ca. AD 280-320
- Casting, working or a combination that was assembled
- Increase in decoration and dimensional variation
- Common military brooch

Type 3/4



- Ca. AD 325-410
- Combination casting and working
- Diminished decorative variability and increased dimensional standardization
- High-output craft production
- Marker for military and administrative officers (insignia)

Type 6

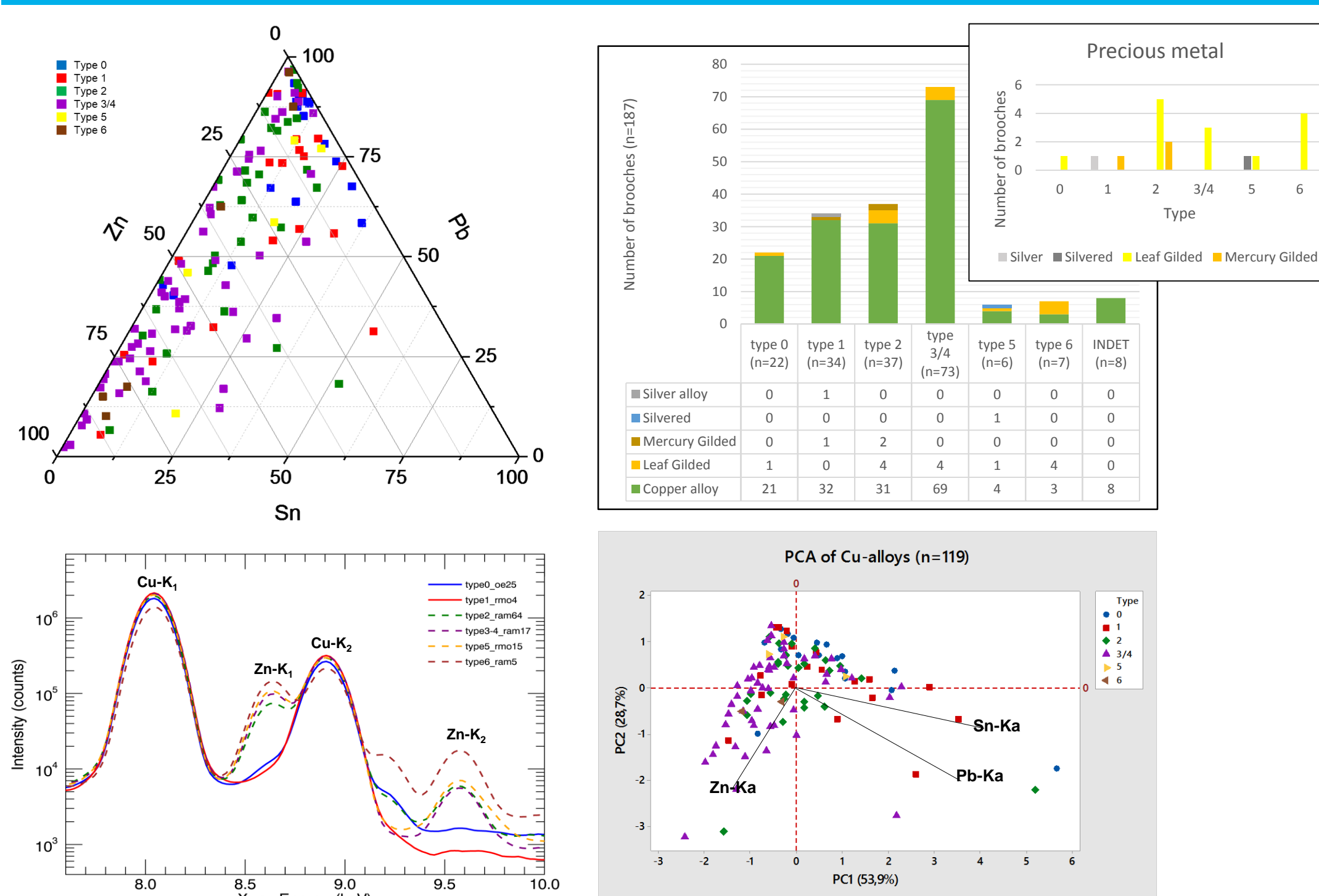


- Ca. AD 390-460
- Working of sheet metal
- Frequent use of precious metal, highly decorated, continuity of standardized dimensionality
- Production on commission
- Symbol of state authority and highest elites

TPOLOGY AS A VARIABLE

- Typological information can be used to move beyond a black box approach of the compositional data:
- Ideally provenance and dating are used to make significant groupings; but often with old finds or museum collections, these are uncertain
- Typology is an archaeological tool that contains information about both regionality and chronology
- A typology is a collection of variables that reflects differences in the material. The distinction between types means that at least one variable is significantly different.
- A single typological variable represents a number of related variables that have a significant meaning about the material.
- Typological models reflect aspects from both the production and consumption of that material.⁵ By using typology to clarify analytical data, we insert a number of variables that are most likely to represent conscious or unconscious choices by the producers.

RESULTS



- General compositional results:
 - All brooches are made from copper alloys;
 - Minority have precious metal decoration (gilding or silvering);
 - One silver alloy brooch was found;
 - The continuous variation in Zn, Sn, Pb makes it useless to try to allocate modern alloy labels and fails to deliver distinct groupings based on the XRF data alone.
- Trends and patterns visible with the typological separation (use of net peak intensities):
 - XRF-spectra indicate a difference in Zn and Sn between types 0-1 and 2-3/4-5-6;
 - Ternary plot confirms this difference and indicates a general increase in Zn and decrease of Sn between types 0-1 and 2-3/4-5-6. However, a significant overlap remains.
 - PCA illustrates a shared general trend that persists through all types, mainly influenced by fluctuations in Sn and Pb, less so of Zn. Only part of the type 3/4 population deviates from this main pattern by the increased significance of Zn, although this shift is already visible in type 2. Additionally, to few samples of types 5 and 6 are available to make any statements.

DISCUSSION

- The socio-historical changes³ linked to the typological model provides explanations for the compositional data:
 - Type 0 and 1 are local and regional productions, possibly batch-produced and intended for the general military class (soldiers and officers);
 - Type 2 brooches increase in number and variation as the brooch type becomes more frequent and is imitated in non-military productions with larger regional distributions;
 - Type 3/4 is a (state) controlled large-scale production supplying to the entire Roman army. Despite its larger numbers is this type an outlier to the rest of the typological population by the clearly different role of Zn. It has been suggested that brass production was a monopoly of the Roman state⁶;
 - Despite the shift to military elites and high state officials, type 5 and 6 do not appear to have altered in composition, notwithstanding the increased use of gilding and excessive decoration.

CONCLUSION

- Using typology to interpret compositional data:
 - Investigates diachronic change and persistence;
 - Explores regional diversity and similarities;
 - Adds socio-historical information from archaeological, iconographical and historical sources.
- Ideal method when it is not possible to obtain exact compositional data:
 - Focus on patterns and trends;
 - Supported by additional layers of information which are object or context related.
- For the Late Roman crossbow brooches, the compositional analysis informed us on:
 - Production organization;
 - Changes in the producer-consumer relations;
 - Production choices as the result of changes in the Late Roman society.

REFERENCES

- This research is part of the project 'Decline and Fall? Social and cultural dynamics in the Low Countries in the Late Roman Empire (AD270-450)', financed by the Netherlands Organisation for Scientific Research (NWO) and the Research Foundation - Flanders (FWO) (GA04612N).
- Swift E. 2000. *Regionality in Dress Accessories in the Late Roman West*, Editions Monique Mergoil, Montagnac.
- Van Thienen V. 2017. *A social history of the crossbow brooch*. In: Roymans, Heeren, De Clercq (eds.) 2017. *Social dynamics in the northwest frontiers of the Late Roman Empire: beyond decline or transformation*, Amsterdam Archaeological Studies, Amsterdam University Press, Amsterdam.
- Asinelli M. G. and Martinón-Torres M. 2016. *Copper-alloy use in a Tyrrhenian medieval town: The case of Leopoldi-Cencelle (Italy)*. *Journal of Archaeological Science: Reports* 7, 597-608; Orfanou and Rehren 2015. *A (not so) dangerous method: pXRF vs. EPMA-WDS analyses of copper-based artefacts*. *Archaeological and Anthropological Sciences* 7, 387-397.
- Caple C. 2006. *Objects: reluctant witnesses to the past*, Routledge, London/New York.
- Dungworth D., 1997. *Roman Copper Alloys: Analysis of Artefacts from Northern Britain*. *Journal of Archaeological Science* 24, 901-910.
- Van Thienen V. and Lycke S. (in press) *From commodity to singularity: the production of crossbow brooches and the rise of the Late Roman military elite*.