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From the Fabricae of Augustus and the Workshops of Charlemagne: A compositional study of corroded copper-alloy artifacts using hand-held portable XRF
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Cover Page



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Summary

This thesis, presents six peer reviewed articles and an editor reviewed book chapter that discuss the relationship between the composition and typology of a large number of brooches and other personal items, dating between the end of the Iron-Age and the end of the early middle ages. The main study area is The Netherlands, but for comparative purposes, objects are also drawn from the Baltic states of Estonia and Latvia, and also from the east coast of England. The compositional focus explores the use of portable X-ray fluorescence spectrometry (HHpXRF) as a surface measurement tool, on corroded objects. This socially embedded approach explores the relationship through the intentional actions of the crafts people who made them. This approach is more meaningful than traditional provenance studies because it explores the socio-technological context of production. As well as identifying indicators for social complexity and economic change, personal artefacts from this period also play a role in the study of human mobility and identity construction.

The research engages with the important debate surrounding the transformation of the western Roman world into the modern nation states we know today. The processes that led to the medieval 'recovery' in the west cannot be fully understood without a better understanding of the role of craft production during this time. The more specific aim is to investigate variability in the control of composition and to identify regional or chronological differences. Subsequently the intention is to gain new insights into the way production was organised, including the supply of raw materials, then to identify differing cultural associations through these differing choices of alloy. The primary research goal is to analyse the degree of variability (or standardisation) of the ratios of base metals used in production, which will shed light on both technical and raw material choices. The social organisation of production and the various (exchange) mechanisms that resulted in the artefact distribution patterns we see today are also explored.

Subsequently a number of research questions were formulated, starting by addressing the traditional problems associated with the use of HHpXRF in the study of corroded objects, to establish a valid methodological approach. Then questions could be asked concerning the nature of compositional and chronological variation, seen in the measurement of large numbers of artefacts. Questions surrounding the evidence for deliberate compositional control, pertaining to regional differences and the sourcing of raw materials, are then posed. Lastly where compositional variation across geographical and temporal distributions exists, questions are formulated regarding the social organisation of production, and the identity of those wearing the finished objects.

Brooches (also known as fibulae) are the main artefact type analysed in this study. They were used extensively by ancient communities during the Roman and early medieval periods with their forms and types changing significantly over time and geographic region. Roman period bow brooches are included from The Netherlands, dating between the last half of the first century BC to the late second century AD. Then an assemblage of middle to late Roman period disc brooches from

the eastern Baltic, dating between the 2nd and 5th centuries is also included. For the early bow brooches, the main question is whether regional, or civilian production could be identified versus production at military centres. A 'Roman' alloy if it existed could be compared to alloys more confined to local or 'tribal' typologies. The questions asked of the later Roman disc brooches relate to the organisation of production and variation in regional culture, engaging in particular with the debate over the nature of long distance contact with Lithuania and the distant Roman provinces. The next group of brooches are early medieval in date, returning once again to The Netherlands. A great many Carolingian/Ottonian period disc brooches bear what are thought to be Christian motifs and were mostly popular during the late 8th to 10th centuries, but with a few types staying in use as late as the 11th to 12th centuries. The earliest type of brooch included in the study is the Saints brooch, popular during the 9th century. But the bulk of the brooches are of the enamelled cross type dating between the 9th and 10th centuries. The organisation of production is considered once more then the exchange system in which they circulated is explored with particular emphasis on the Christian nature of their motifs. Both disc and equal-arm brooches (dating between the 7th to 10th centuries) from the island of Walcheren are then explored regionally, in comparison to those found from other areas of The Netherlands. Hypotheses regarding the organisation of production are then proposed against Walcheren's historical past. This in turn leads to discussions surrounding cultural identity within an interconnected North Sea world. For the equal-arm brooches an earlier hypothesis is tested; that the more northerly Fresian brooches are regionally different to those from those found at Walcheren.

The next type of artefact to be included is a group of zoomorphic mounts tentatively dated between the 9th and 11th centuries. The origin, their original function and their relationship in terms of expressions of identity are subsequently discussed in detail. A number of Stirrup-strap mounts were also found on Walcheren and are considered to have an equestrian function. The subsequent analysis enables a discussion to take place regarding local versus non-local origins. The choice of alloy could also be compared with the other find types in the study. Ring and dress pins are presented last, but additionally with a more detailed comparison to a similar assemblage from 2009. The Walcheren examples above are thought to date from the 7th to 11th centuries. A discussion takes place regarding mercantile contact between the two coastlines as well as local or centralised production in an interconnected North Sea world.

The approach selected for the compositional analysis is a very important part of this thesis and is discussed in some detail. There is a particular focus on the published debate surrounding the reliability and validity of HHpXRF use in archaeology, as it is still causing objection from some parts of the scientific community. The main objection is that highly accurate quantitative data is not obtainable from the measurement of corroded copper-alloy surfaces. Furthermore that gaining a 'true' measurement (by the destructive removal of the patina) of an objects composition is key to solving archaeological questions. The second objection was that the technology was being misused, that it was not appropriate for archaeologists to

just simply purchase an HHPXRF machine and go out and measure anything they wanted, without having adequate training or years of experience behind them. This debate has subsequently led to a divided community with one side believing that it is an unacceptable side of science, and the other calling for a break away from limited laboratory based paradigms so that appropriate methodologies can be applied to archaeological use. Past studies (elsewhere) have demonstrated that it is not possible to achieve highly accurate quantitative data on corroded copper-alloy surfaces, but an alternative qualitative route has been proposed, that these devices are suitable analytical tools to sort objects into classifications, therefore able to answer questions regarding the basic choices made in terms of copper-alloy production (e.g. brass or bronze).

To address the second issue that inexperienced archaeologists can just pick up these devices and misinterpret the data (e.g. by mistakenly interpreting qualitative corroded measurements as quantitative 'true' measurements), a protocol is called for, one that includes experimental reproducibility based on appropriate scientific standards. This call for a protocol is subsequently addressed in the methodology article presented in chapter 2. This article argues that HHPXRF is a suitable measurement technique to study the production of ancient copper-alloy artefacts. Rather than try to match techniques developed within laboratory paradigms, it suggests that it is more beneficial to deploy it in a survey role, one that attempts to model chronological and geographical changes within large quantities of artefacts. To achieve this, it investigates to what extent corrosion and the issues surrounding surface measurements affect the potential of this approach. A combined typological/compositional analysis of early Roman period brooches from the Nijmegen region of the Netherlands was compared with published data.

Following on, chapters 3 to 8 present the results of a series of case studies employing the approach developed in chapter 2. These articles not only engage with the debate, but also demonstrate appropriate lines of archaeological questioning and offer some intriguing new insights into the organisation behind ancient copper-alloy craft production. Chapters 3 and 4 present research on early and late Roman brooches respectively. For comparative reasons they take their measurements from brooches found in two separate geographic regions (The Netherlands and Estonia/Latvia), from two HHPXRF machines, and from two different manufacturers (Niton and Bruker). Chapter 3 identifies a shift away from bronze to brass between pre-Roman and early Roman bow brooch types. This allows for discussions to take place regarding the appearance and use of brass in military camps and civilian centres. The hypothesis of Roman military production fits well with notions of Roman industrialisation, but bronze also continues to be used for some brooch types as well. Various hypotheses are put forward, firstly that the craftsmen had a high degree of control over the alloy choice, secondly that the choice of alloy relates to the mode of production, i.e. that if choice was not just determined by the production method, it could be that civilian workshops maintained their production in bronze, whilst brass was reserved for production in the military centres. Chapter 4 moves location to the eastern Baltic to explore the typological and compositional relationships between middle to late

Roman period disc brooches. Regionality was explored together with the nature of contact and influence from other areas. The alloy composition was also compared with published results from other countries leading to the conclusion that the choice for these brooches was not as strictly controlled as that for the bow brooches of the previous chapter. Alternatively the HHpXRF analysis combined with visual inspection revealed evidence for tinning, a silvery coloured surface treatment, which may also have influenced the compositional results. The combined analysis contributed to the identification of two regionally distinctive groups. The brooches from one area were found to be silvery in appearance (created by a surface treatment). The brooches from the other area were golden coloured (by leaving them untreated).

Chapter 5 then returns to The Netherlands to explore the typological and compositional relationship of Carolingian/Ottonian period disc brooches. Several aspects of production and exchange are examined. The compositional results show a marked change in alloy use from the end of the Merovingian period. They also revealed a high degree of alloy consistency allowing hypotheses to be formed that production may have been organised on a regional or super-regional scale. The most likely source for these items was the great monastic estates, perhaps creating long lasting production traditions capable of applying a high degree of control over several centuries. This hypothesis when supported by the Christian nature of the motifs on these brooches also enabled discussions surrounding an exchange system imbued with Christian meaning, one where the brooches served to reinforce the social hierarchy between the ecclesiastical elite and the ordinary individual.

The next three chapters concentrate in detail on one particular assemblage, the early medieval artefacts found on Walcheren, The Netherlands. The artefact types include disc fibulae, equal arm fibulae, dress pins, ring pins, stirrup-strap mounts, and zoomorphic mounts. A detailed study of zoomorphic mounts is considered first in chapter 6. The results shed light on the character of the technology of the time and also allow a new hypothesis to be formulated regarding their purpose and cultural associations within a Viking-Age, North Sea world. Although exact dating remains elusive, the styles suggest that close ties existed between the Frisian, Viking and Anglo-Scandinavian worlds between the 9th and 11th centuries. Chapter 7 considers the wider assemblage found in Walcheren and is published as an editor reviewed book chapter. The results suggested that copper-alloy crafting on Walcheren was probably organised along the lines of a permanently administered urban production site, with items being made for market. Differences in local versus traded items are also discussed, followed by a hypothesis being put forward proposing the existence of a multicultural group of inhabitants drawn together by the presence of an inter-regional trading site. Lastly, Chapter 8 draws a comparison between the dress pins found in proximity to the coastal town of Domburg on Walcheren and those found at a comparable coastal site in England. Pins such as these are found in large quantities on both sides of the North Sea, therefore the nature of cross-cultural contact is explored in terms of style, composition and manufacture. Our results suggest that pin production may have been focused around major mercantile, ecclesiastical or royal centres, but also that it was also localised in terms of production methods and material

supply, the latter favouring more accessible scrap metal for production than the former more centralised locations where access to fresh metals would be easier.