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CHEMICAL DATA OF ROMAN POTTERY IN *GERMANIA INFERIOR* AND BEYOND

This paper aims at presenting an overview on archaeometric analyses of Roman pottery from sites in *Germania Inferior* and neighbouring Roman provinces carried out since 1975 at the Free University of Berlin (FUB). All pottery samples have been analysed using wavelength-dispersive X-ray fluorescence (WD-XRF). Many samples have also been studied in thin-section and by MGR-analysis[1]. All data from these chemical analyses are recorded in the same format and collected in a database which is currently being prepared as a web-portal. There are two reasons to do this now. Firstly, many of the data available in Berlin have not been published with the detailed data of all sherds analysed, or they are less easy to find than it is now made possible using the internet. Secondly, the rapidly growing use of portable X-ray fluorescence (pXRF) as a tool for limited but fast chemical analysis of ceramics needs accurate data for comparison when the chemical compositions will be used to determine provenances of pottery samples.

Reference groups, accuracy and precision

Laboratory analysis is a powerful tool for classifying archaeological ceramic finds according to their material and technology. Chemical analysis certainly plays a major role in defining the composition and properties of a ceramic material, even when it does not always provide a complete picture[2]. Nevertheless, the following discussion will be limited to chemical analysis by WD-XRF. The first preconditions for using chemical data are precise and accurate analyses. Data from different labs by other techniques (e.g. by NAA or by ICP-MS) can be compared if precision and accuracy for every individual chemical element is known. Using this information and, if a sufficient number of significant elements is determined, the interpretation of the data will lead to the same result[3].

The determination of provenances, besides reliable data, requires comparison with analysed samples of known provenances (reference groups). The significance of reference groups determines the security of attributions to a workshop or manufacturing area, to a geological region or to archaeologically defined groups e.g. of local or imported pottery[4]. Reference groups could be:

- workshop finds such as kilns, potter's tools, moulds, true wasters[5], unfired vessels,
- geological clay samples (thin-sections and firing tests are essential),
- local groups based on archaeological arguments, e.g. on typology, frequencies,
- chemically homogeneous groups with hypothesized geographical attribution.

Example 1: Attribution of finds of Italian sigillata to their places of origin

Among the first pottery analysed by WD-XRF was Italian sigillata from Arezzo, Pisa and Lyon found in *Germania Inferior*[6]. The composition of sigillata from Arezzo as a reference group and the attribution of finds were discussed in various labs[7]. This was continued with the aim of attributing varieties of stamps on vessels to specific workshops[8]. The calcium content of the typically calcareous sigillata in Arezzo differs in the workshops of Ateius and those of most of the other potters due to different recipes (**fig. 1**). From the variation of other elements, it can be concluded that this must stem from variation of the calcium content in the local clay, of which, however, the present author only received one non-calcareous sample for analysis in 1978. Interestingly, the analysed clay sampl,e as well as the fakes of Arretine moulds found in many museums around the world, can be attributed to a production in Arezzo, and can be identified by their lower calcium levels, which are inconsistent with the antique technological tradition of using calcareous clay for gloss pottery[9].

Of the chemically analysed finds of Italian sigillata in *Germania Inferior* – Vechten (H. Kars), Velsen (S. van Lith), Nijmegen (J. K. Haalebos), Haltern and Oberaden (B. Rudnick), and Anreppen (B. Tremmel) – only some results have been published[10]. Various papers discuss the altera-

1 Daszkiewicz/Schneider 2001.
2 Daszkiewicz et al. 2009; 2012.
3 Schneider/Mommsen 2009.
4 Schneider et al. 1979.
5 Daszkiewicz/Bobryk 1998.
6 Lasfarques/Picon 1982.
7 e.g. Picon et al. 1971; Maggetti/Galetti 1986; Schneider/Hoffmann 1990.
8 e.g. Schneider/Daszkiewicz 2006a; b.
9 Hoffmann 1990.
10 Schneider 2006.

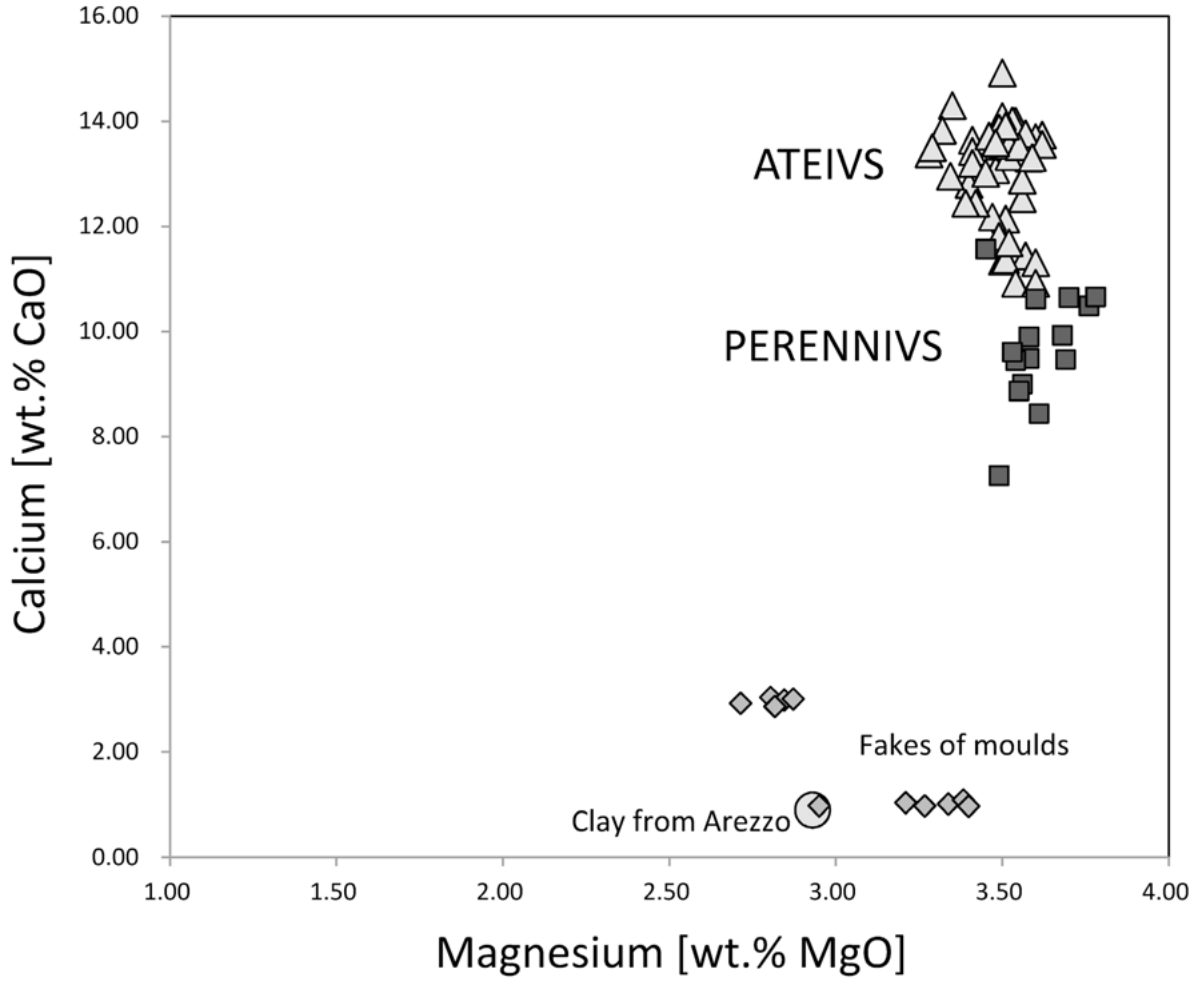

Fig. 1. Arezzo reference group: calcium and magnesium contents in sigillata from Ateius and Perennius (finds in Arezzo), and in fakes of moulds in the Loeb Collection (Antikensammlung Munich) compared to modern Arezzo clay.

tion effects (caused by the burial of sherds in soil) which make attributions of analysed sherds more difficult[11]. The composition of sigillata from Arezzo found in the Northern Roman provinces may differ by absorption of phosphorus and barium and leaching of alkaline elements and calcium[12]. Another problem is distinguishing between products from Arezzo and those from Pisa which differ mainly in a tendency to higher potassium values[13], not sufficient for a secure distinction of all analysed samples. Puteolana, too, is mainly distinguishable from Arezzo by somewhat lower titanium and magnesium values. In such cases, fast analysis by pXRF certainly is not sufficient for secure attributions of all samples.

Example 2: Reference groups of Terra Sigillata made in *Germania Inferior*, *Germania Superior* and *Belgica*

A list of the sites of sigillata manufacture which have been confirmed by chemical analyses is given in **figure 2**. For most of these workshops, the late Maurice Picon had already analysed reference samples by WD-XRF in the 1970s in Lyon, though at the time he was, unfortunately, only able to determine eight major elements. We are indebted to him for making available to us many of his unpublished data for comparative purposes. For some sites these data are still the only ones. After our first detailed study of the ceramic production in Rheinzabern[14] we collected data through the years also for other manufacturing centres (e.g. for Sinzig)[15]. A joint project with a group of archaeologists needed reference groups to establish where the Roman potter Cintugnatus had worked and if the workshops are connected with the type and size of stamps[16]. Rheinzabern, Sinzig, Haute-Yutz or Metz and Lavoye have now been identified as possible production centres, with a further two as yet unknown locations. Heiligenberg[17] could not be confirmed until now by chemical analysis. A sherd found in Colchester was attributed to Haute-Yutz or Metz. It was not locally made because analysed sigillata from Colchester differs significantly in composition.

11 e.g. Lasfarques/Picon 1982; Schneider/Daszkiewicz 2006a.
12 Schneider 2015.
13 Thilhard 1998.
14 Schneider 1978; Daszkiewicz et al. 2001.
15 Daszkiewicz et al. 2003.
16 Zetsche 2012.
17 Biegert 1999b.

Avocourt	Heiligenberg	Mittelbronn
Blickweiler	Ittenweiler	Nürtingen
Boucheporn	Kräherwald	Rheinzabern
Chemery	La Madeleine	Sinzig
Eschweiler Hof	Lavoye	Trier (Werkstatt I, II, II)
Haute-Yutz	Metz	Waiblingen

Fig. 2. Available reference groups of sigillata manufacturing centres in *Germania Inferior, Germania Superior* and *Belgica*.

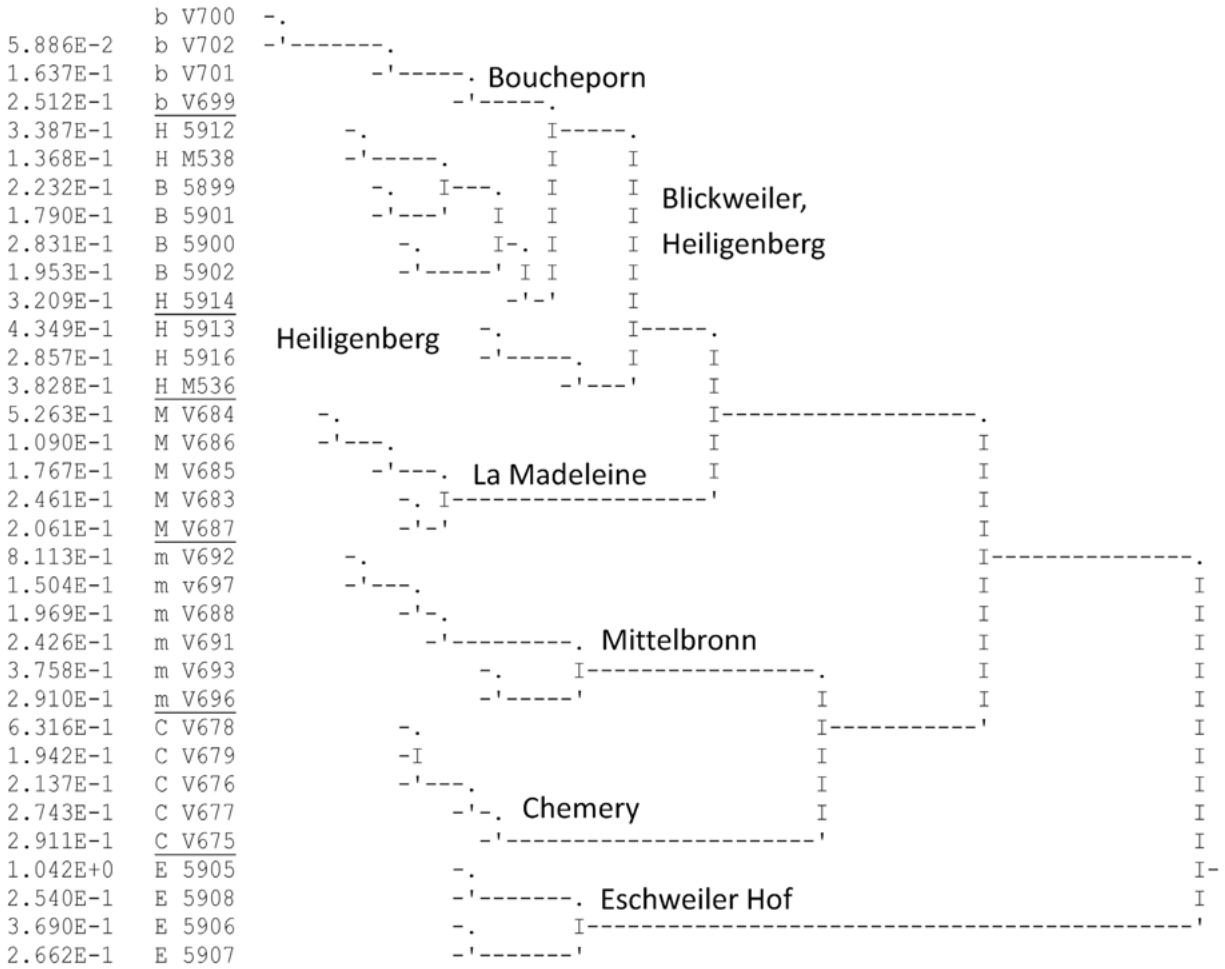

Fig. 3. Dendrogram of analyses by non-destructive pXRF of gloss surfaces of sherds from seven reference groups of sigillata (logged data, average linkage, elements used Ti, Fe, Mn, Ca, K, V, Cr, Zn, Rb, Sr, Zr).

The distinction between Haute-Yutz and Metz, however, is still an open question[18].

The quality of the reference groups varies significantly. Whilst at some sites, such as Rheinzabern, sigillata and other pottery, moulds, workshop finds, and local clay sources have been sampled, at other sites a selection of only five to ten purported local sigillata sherds have been analysed. However, if the data show a homogenous group, they provide an initial indication that their composition could be distinguished from the other reference groups. Avocourt and other sigillata production sites in the Argonnen, as well as Rheinzabern and Trier, are important as reference groups for the attribution of late sigillata finds[19].

[18] Weiss-König 2011.

[19] Schneider 1992; 1993; 2005.

Sigillata from Boucheporn, Blickweiler, Heiligenberg, La Madeleine, Chemery, Mittelbronn and Eschweiler Hof can securely be distinguished from each other by WD-XRF (and by MGR-analysis). We therefore took some sherds previously analysed by WD-XRF as examples to test the possibilities of fast analyses by p XRF. Firstly, measurements of fresh breaks were made using the available WD-XRF references for the provenances and own calibration of pXRF. Using the concentrations of thirteen elements determined at the fresh breaks the provenances of 32 sherds were identified with only one misclassified sample. Non-destructive pXRF measurements of the gloss surfaces also securely distinguished the sherds from the seven reference groups with the exception of three samples from Heiligenberg which were attributed to a mixed group with Blickweiler (**fig. 3**). However, these results were only obtained because as examples we had chosen reference groups which according to the already available WD-XRF analyses differ significantly in the elements securely determined by pXRF.

Example 3: Reference groups of Roman common pottery in the lower Rhine valley

The situation for common pottery differs significantly from the situation for sigillata. Here the number of production sites is much larger, the distribution of the products is more limited, and raw material and technology are less standardized. Many of the reference groups have been established in cooperation with Susanne Biegert and Bernd Liesen. The analyses for the seven sites Neuss, Köln, Soller, Bonn, Weißenthurm, Worms, and Speyer were published in 2002 including a short chapter on the technique of analysis[20]. These data will be the first series to be included in a web-based database to be established in Berlin, which will be continuously extended by later unpublished and published data[21]. Larger series of analyses have been collected over the years for other sites. These data have been collated as part of doctoral theses or projects in the lab of the Arbeitsgruppe Archaeometrie FUB and include analyses of local pottery from Xanten[22], Mainz[23], Frankfurt and sites in the Wetterau[24], from Ladenburg[25], and Heidelberg[26]. For various sites also Roman lamps[27] and bricks[28] have been analysed and so additionally support or extend the reference groups for common ware. This overview, however, is not complete at all and merely provides some examples.

The database is being developed by Gerwulf Schneider, Malgorzata Daszkiewicz, Dominik Lukas and Kerstin Brose. Besides the composition of the ten major elements, losses on ignition and up to fifteen trace elements determined by WD-XRF will be completed with relevant archaeological information on the analysed samples (laboratory code, date of sampling, publications, findspot, museum). Further laboratory studies, such as thin-sections and MGR-analysis, will be mentioned and as far as possible linked to external references. Work is underway to transfer already existing analysis data from the last decades into the database, which will reside on the internet, consisting of a PHP-frontend and the PostGreSQL database management system. Within this framework, all data will be addressed via persistent identifiers and stored for long-term accessibility. By using spatial gazetteers like Geonames and Pleiades geospatial referencing of the datasets is made possible. The administration of new analysis, the integration with further external data as well as the actual development of the system is organised by the Excellence Cluster Topoi of FUB and HUB.

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[20] Biegert et al. 2002.

[21] e.g. Köln: Schneider et al. 2004; Schneider 2009.
[22] Liesen 1994.
[23] Heising 2007.
[24] Schneider 1988; Biegert 1999; Biegert/Schneider 2003.
[25] Schneider 2002.
[26] Biegert 1999a; Biegert et al. 2005; 2009.
[27] Schneider 2014.
[28] e.g. Dolata 2007.

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