Chemical composition of Firmalampen and other Roman lamps

Abstract
Firmalampen were the most common type of Roman lamps from 1st to 3rd century AD in the provinces north of Rome. Analysis results of 1180 samples of such lamps and their moulds analysed by WD-XRF since 1976 are listed. A minor series of analyses of other types of Roman lamps is also included. Generally, samples of 0.1 g were taken predominantly by drilling. Most data has not been published or is only discussed in overview articles. This project was possible thanks to the generous support of the German Volkswagenstiftung and the cooperation of various archaeologists and museums in Germany, Switzerland, Austria, Hungary, Slovenia, and Italy.

Description
A research project supported by the German Volkswagenstiftung was launched in 1976 to obtain information about the production and distribution of Roman lamps. Mould-made Firmalampen were chosen because they bear name-stamps and thus can shed light on the Roman economy of production and distribution of everyday items. Beginning from the second half of the 1st century AD, Firmalampen (Loeschcke types IX and X) were the most common variety of Roman lamps. They were widely used, mainly by the Roman military. Most lamps have been found in graves. The first series of samples to be analysed (up to and including Lab.-no. L711) was selected, documented and sampled using a tungsten carbide drill by Erwin Wirz, who also initiated the project. It initially comprised samples from Vindonissa, Frankfurt, and Regensburg as well as from various other sites in Bavaria kept in the museum in München. The later series of samples from Frankfurt were selected by Ingeborg Huld-Zetsche, while those from Trier were chosen by Karin Goethert-Polaschek, both of whom greatly assisted the project with their ideas. Most of these later samples were taken by the staffs of the museums in Frankfurt and Trier, also using a tungsten carbide drill. Bernd Liesen selected and sampled the lamps from Xanten and Bonn, Andreas Hensen the lamps from Heidelberg. The later series, including samples from Poetovio, Aquincum, and Aquileia, was assembled during various independent campaigns undertaken together with Malgorzata Daszkiewicz. The analysed samples from the region of Modena were sampled in cooperation with Nicoletta Giordani, those from Rome with Carlo Pavolini.
The starting point of the project was the hypothesis of Siegfried Loeschcke (1912), who studied the finds in Vindonissa (Brugg, Switzerland). He distinguished four "techniques" A, B, C, and D of Firmalampen and attributed them to four different production sites/regions. The grouping of the chemical composition confirmed his idea for three groups (A, C, D). He believed that lamps of group B, mainly lamps of lower quality, had been locally made at Vindonissa. They, however, turned out to belong to group A representing the good quality lamps believed to be Italian. The non-calcareous group A and B lamps were produced somewhere in the region of Modena, while the calcareous group C lamps (like the lamps from Modena mostly without handles but in contrary to the Modena lamps always covered with a slip) were made in Lyon or to a lesser part probably in Switzerland (groups C2, C3). Group D lamps, which were mould-pressed complete with handles (but also some without handles), represent products from Trier. These results for the first century AD in Vindonissa led to a revision of the idea that the names on lamps are proof of "surmoulage", in other words of unauthorised copies being made at many places. However, no locally produced lamps found in Vindonissa and imports produced almost exclusively at only three production centres, indicate the existence of branch workshops of the lamp-making firms.

Further analyses included other types of lamps but the focus remained on Firmalampen, especially those made by the most prolific firm of FORTIS, which according to dated finds must have been existed for over 150 years supplying the Roman provinces north of Rome. At most sites more than half of the lamps bear his stamp. Analysis revealed that most of the good quality Firmalampen found between Rome and the North Sea came from one of only three central production centres. At all sites studied they are clearly distinguishable from locally produced lamps only having a limited local market. None of the large manufacturing centres for Firmalampen as Modena, Trier or Lyon, however, has been identified to date with secure workshop finds, kilns or gypsum moulds.

Remarks on the columns in Metadata

All samples are unequivocally identified by their lab.-no. For repeated analyses the averages were calculated. Chemical reference group refers to chemically homogeneous groups mostly well-defined on the basis of the multivariate interpretation of chemical compositions as presented in the publications. For the non-published lamps theses are less secure or even not identified. The abbreviations AB, C, D and R - Z correspond to the publications Schneider/Wirz 1991 and 1992. Some of the others are explained in the respective publications.

The columns headed object, object type, ware, and stamp provide only brief information in German or in English (photographic documentation or drawings were available for part of the lamps). The term Bildlampen was used as a general term for lamps other than Firmalampen. Objects mostly have been fragments. In many cases, the stamps on the fragments were illegible or missing, however, a lamp was classified as unstamped only when no stamp could be observed in the appropriate place. The reading of the stamps was generally up to the responsible archaeologist at the time of sampling. Together with Inv.-No. and Museum their names are indicated. GPS coordinates for the finding sites are presented according the World Geodetic System 1984 (WGS 84). The dating column mostly lists just approximate dates estimated from the lamp type and is not an exact dating. A few samples were also examined in thin-sections (other analyses), but because this method requires fragments and is not possible using powders it is not a suitable method to be used for the classification of lamps. In column source the relevant publications are mentioned.

Remarks on the use and interpretation of the data

For the interpretation of the chemical data in terms of equal or unequal composition (provenance determination), all major elements and all analysed trace elements must be taken into consideration regarding their particular precision. Elevated phosphorus contents indicate concentrations changed due to alteration during burial what then, however, must be considered for all elements (e.g. Ba).

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Applied method of analysis

Most of the analyses were carried out on small powder samples taken by drilling into each lamp sherd with a tungsten carbide drill after prior removal of the sherd's surface layer. A special method was developed to analyse samples of 0.1 g by melting with lithium-tetraborate and using a dilution of

1:19. This reduces the number of trace elements to be determined (empty spaces in the table mean "not determined"). In the first series of analyses not all trace elements were measured, and a first series of the samples also has not been ignited. Generally, in 0.1 g samples V, Cu, Y, Nb, La, Ce and Pb are determined with lower precision and accuracy in comparison to the analysis of 1 g samples made when sufficient material was available. In these instances fragments were pulverised after having first removed their surfaces and cleaned the remaining fragment with distilled water in an ultrasonic device. The resulting powders were dried at 105°C and subsequently ignited at 900°C (heating rate 200°C/h, soaking time 1h), melted 1:19 respectively 1:4 with a flux (Merck Spectromelt A10 respectively A12) and cast into small discs of 25 mm (respectively 30 mm) for measurement. For easier data interpretation the major elements were normalized to a constant sum of 100% (the original sum is indicated; by many tests it was assured that these data were still within the accepted limits of precision when sums have been between 90% and 110%, e.g. when non-ignited samples for the first series of analyses were used). Because of the normalization our data is valid for ignited samples but, with the losses on ignition given (l.o.i.), may be recalculated to a dry basis. Measurements were made using automatic spectrometers: Philips PW1212 (for the first series), PW1400 (after 1980) and PANalytical AXIOS (after 2008 at the GeoForschungsZentrum Potsdam by courtesy of Rudolf Naumann and Anja Schleicher). The precision was tested regularly by repeating analyses over the years. Accuracy was proved by analysing more than fifty certified international standard reference samples and by repeated exchange of samples with other laboratories. Maximum deviations for analysis of 1 g samples for major and trace elements (>100 ppm) generally are between 5 and 10 rel%. Generally, this is also true for the analysis of major elements (except Na) in 0.1 g samples including the five trace elements Cr, Ni, Rb, Sr, Zr. Other trace elements as V and Zn are determined with lower precision, Cu, Y, Nb, La, Ce, and Pb, determined in 0.1 g samples maybe erroneous and are not used for grouping; Th is only determined in 1 g samples with limited precision. The analysis results of the major elements are given in weight per cent oxide in the conventional geochemical order. The results for the trace elements are given in ppm (µg/g) in order of atomic numbers.

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Keywords

chemical analysis, WD-XRF, Roman lamps, Firmalampen, Frankfurt, Modena, Rome, Trier, Vindonissa