Scientific Investigations on Roman Silver Coins of the Emperor Trajan (AD 98–117)

K Uhlir¹,², B Woytek³, M Alram³,⁵, M Schreiner¹,⁴, M Grießer²

1 Institute of Science and Technology in Art, Academy of Fine Arts Vienna, Schillerplatz 3, A-1010 Vienna, Austria
   k.uhlir@akbild.ac.at m.schreiner@akbild.ac.at
2 Conservation Science Department, Kunsthistorisches Museum, Burgring 5, A-1010 Vienna, Austria
   martina.griesser@khm.at katharina.uhlir@khm.at
3 Numismatic Commission, Austrian Academy of Sciences, Dr. Ignaz Seipel-Platz 2, A-1010 Vienna, Austria
   bernhard.woytek@oeaw.ac.at
4 Institute of Chemical Technologies and Analytics, Vienna University of Technology, Getreidemarkt 9/163, A-1060 Vienna, Austria
5 Coin Cabinet, Kunsthistorisches Museum, Burgring 5, A-1010 Vienna, Austria
   michael.alram@khm.at

The rule of the Roman emperor Trajan (AD 98–117) has always attracted specific interest among financial historians, since written sources provide us with several important pieces of information concerning the finances of the state during his reign. Therefore, the Trajanic period may be regarded as one of the key periods for the modern understanding of the economy of the Roman principate in general. In order to evaluate the financial policy of an ancient state, it is necessary to study the composition of the alloys of the precious metal coinages issued under the control of the state’s government. In the past, this has often been carried out using energy dispersive x-ray fluorescence analysis (ED–XRF) – also in the case of Trajan’s silver coins (Walker 1977). However, such investigations had to be performed on the surfaces of the coins, as the analyses had to be carried out on pieces of museums’ collections. This means, however, that the results obtained are not reliable at all, since corrosion usually occurs on ancient excavated objects, as has already been documented repeatedly: e.g. Linke et al. 2002 and 2004. Because of this phenomenon the determination of the chemical composition of the coin’s core is essential, which means that either sample material has to be taken or the coin has to be cross-sectioned. In the few cases in which this has been done, no representative number of coins of all the consulates of Trajan could be investigated (Butcher & Ponting 1998).

Within an interdisciplinary project a group of 68 silver coins of Trajan evenly distributed over the entire period of his reign (2nd to 6th consulates) as well as 3 coins from the reign of his predecessor, the emperor Nerva (AD 96–98), were acquired on the coin market (Table 1). All the coins were dissected in the upper third (Fig. 1) and the smaller part was embedded in synthetic resin, ground and polished with SiC-paper up to 4000 mesh. This enabled measurements using μ-XRF (micro x-ray fluorescence spectroscopy) in the coin’s core, as the μ-XRF instrument used (COPRA¹) is equipped with a polycapillary focussing optic (Fig. 2) for collimating the primary x-ray beam (Bichlmeier et al. 2001, Vittiglio et al. 2004). Hence a high spatial resolution of approximately 120 µm (FWHM) in diameter can be achieved on the coin’s cross-section (Fig. 3). Applying the COPRA-instrument the precise

¹ μ-XRF instrument built in the EU-Project COPRA, Project Nr. SMT4-CT98-2237, Prof Dr K Janssens, G Vittiglio, University of Antwerp/Belgium; Dr J Heckel, Dr P Klinger, Spectro Analytical Instruments, Kleve/Germany; Prof Dr M Schreiner, Academy of Fine Arts, Vienna/Austria
positioning of the samples is done by using an electronically controlled xyz-sample stage and a CCD-camera in combination with a microscope (magnification up to 10x). Due to the additional application of a rotary stage a high reproducibility of the analysis can be achieved because all measurements can be performed under the same geometry. The measurement conditions are listed in table 2; the evaluation of the x-ray spectra obtained was done using the software WinAxil 4.0, version 4.1.2, of Canberra Eurisys Benelux.

Results

All the coins investigated (except one imitation) consist of a silver/copper alloy with traces of lead and in some cases also gold. The silver content of the coins is shown in Fig. 4. The chemical composition of the Trajanic coins of the 2nd consulate is almost identical to that used during the reign of the emperor Nerva, namely approximately 87% Ag and 13% Cu. In three coins of these two periods a higher silver concentration of approximately 93% could be determined. However, in the 3rd consulate of Trajan the silver content of the denarii drops to approximately 79% Ag and 21% Cu. The chemical composition remains at this value for his entire reign. In addition only a small group of six objects showing a silver content of approximately 93% could be observed.

Within the consulates III to VI only two coins of Trajan show similar chemical compositions to the lower-silver coins of his 2nd consulate or of the reign of Nerva (approximately 87% silver). Nevertheless, they might as well be outliers belonging to one of the two standards of fineness in use at this time. A full discussion will be available soon in Uhlir et al. 2007.

Conclusion

The systematic investigations which could be carried out on cross-sections of 68 Trajanic coins by using µ-XRF yield a clear and precise result concerning the chemical composition used for the denarii in Trajan’s reign:

Whereas in the 2nd consulate the specimens investigated show a silver content similar to the period of Nerva, a remarkable decrease in the amount of silver from approximately 87% to about 79% in Trajan’s denarii between the years AD 99 and AD 100 (second and third consulate, respectively) could be determined: This was the standard alloy the Roman mint adhered to in the following periods until the end of Trajan’s reign (AD 117).

A closer look at the historical background helps to explain the drastic change in the composition of the alloy: When Trajan came into power in January of the year AD 98, he did not stay in the empire’s capital city Rome but in Germany being the governor (*legatus Augusti pro praetore*) of the Roman province of *Germania superior*. After his accession to the throne, he did not return to Italy but remained in the northern provinces of the Imperium Romanum for almost two years: He traveled along the rivers Rhine and Danube together with his staff inspecting the troops of the Roman frontier provinces. It was only in the late autumn of AD 99 that Trajan entered Rome for the first time as an emperor. In AD 101, he left the capital again for a military campaign against the Dacians (in today’s Romania), for his “First Dacian War”, which ended with a Roman victory in AD 102.

The results of the metallurgical analyses of the Trajanic denarii tie in well with these facts: The silver content was reduced in AD 100, precisely when Trajan was in Rome for the first time during his reign. In this period, intense preparations for the Dacian campaign were doubtless being carried out. The Roman mint’s scope in reducing the silver content of the denarii surely was to save money and to relieve the state’s budget.

Acknowledgement

The authors gratefully acknowledge the financial support of this project by the Austrian Science Fund (FWF Project No. P17462, Finanzgeschichtliche Aspekte der traianischen Münzprägung).
References


---

Fig. 1: Coin No. 20, 4th consulate of Trajan

intact

dissected

Fig. 2: Polycapillary focussing unit

The primary x-ray beam is focussed within the approximately 300,000 bent glass capillaries due to total reflection. The beam diameter obtained is 120 µm FWHM (40 kV and 0.4 mA for Fe-Kα).
Fig. 3: Cross-section of coin no. 27, measurement position 1 (of 5), showing a sample area of 2 x 1.5 mm

Fig. 4: Graph of the silver content of the analysed coins

<table>
<thead>
<tr>
<th>coin no.</th>
<th>emperor</th>
<th>consulate</th>
<th>special characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - 3</td>
<td>Nerva</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 - 11</td>
<td>Trajan</td>
<td>II</td>
<td></td>
</tr>
<tr>
<td>12 - 15</td>
<td>Trajan</td>
<td>III</td>
<td></td>
</tr>
<tr>
<td>16 - 20</td>
<td>Trajan</td>
<td>IIII</td>
<td></td>
</tr>
<tr>
<td>21 - 29</td>
<td>Trajan</td>
<td>IIII</td>
<td>victory issue</td>
</tr>
<tr>
<td>30 - 37</td>
<td>Trajan</td>
<td>V</td>
<td>long legend</td>
</tr>
<tr>
<td>38 - 56</td>
<td>Trajan</td>
<td>V</td>
<td>short legend</td>
</tr>
<tr>
<td>57 - 68</td>
<td>Trajan</td>
<td>VI</td>
<td></td>
</tr>
<tr>
<td>69</td>
<td>Trajan</td>
<td></td>
<td>provincial issue</td>
</tr>
<tr>
<td>70 - 71</td>
<td>Trajan</td>
<td></td>
<td>contemporary imitations</td>
</tr>
</tbody>
</table>

Table 1: Coins acquired on the coin market for analyses with sample preparation

<table>
<thead>
<tr>
<th>x-ray tube</th>
<th>molybdenum anode</th>
</tr>
</thead>
<tbody>
<tr>
<td>tube voltage</td>
<td>35 kV</td>
</tr>
<tr>
<td>tube current</td>
<td>0.8 mA</td>
</tr>
<tr>
<td>acquisition time</td>
<td>200 s</td>
</tr>
</tbody>
</table>

Table 2: µ-XRF measurement conditions