**From Glass to Glaze in al-Andalus: Local Invention and Technological Transfer**

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**Supplementary Material**

**Analytical Methods**

Polished cross-sections through the glazes of the sherds and of the crucibles were prepared. The polished sections were examined both in reflected light with an optical microscope and in a scanning electron microscope with energy-dispersive spectroscopy (SEM-EDS). A crossbeam workstation (Zeiss Neon 40) equipped with a SEM GEMINI (Shottky FE) column and EDS (INCAPentaFETx3 detector, 30mm2, ATW2 window), operating at 20 KV with 120s measuring times was employed. The glaze and body microstructures were studied and recorded in backscatter mode (BSE), in which the different phases could be distinguished on the basis of their atomic number contrast.

For the chemical compositions of the glazes, areas of weathered glaze and areas near to the interface between the glaze and the fabric were avoided as far as possible. As a result, the glaze totals varied between 97 and 99 per cent, mainly because of the variable state of preservation of the glazes. The analyses were therefore averaged without normalization. An EDS elemental microanalysis system calibrated with oxide and mineral standards and a high lead glass (K229) was used to determine the composition of the glazes (Geller Microanalytical Laboratory, MA, USA). Typical detection limits are 0.1 per cent for Na, Mg, Al, P, K, Ca, Ti, Mn and Fe, 0.2% for Si and Cu and 0.4 per cent for Pb.

The glass samples were mounted in epoxy resin and polished to remove possible corrosion layers. They were analysed by LA-ICP-MS (Schibille et al, 2020). The instrumental setup was a mass spectrometer Thermofisher Element XR and the laser ablation system Resonetic UV laser microprobe (193 nm Excimer laser). The operating conditions were set at 5 mJ with a frequency of 10 Hz and a spot size diameter of 100 μm that was reduced down to 40 μm for glasses with high lead concentrations. A pre-ablation time of 15s was followed by a 30s analysis time measuring fifty-eight elements (for details see Schibille et al, 2020).

***Table S1.*** *Average composition (avg) and standard deviation (stdev) of the Córdoba high-lead glass determined by LA-ICP-MS (Schibille et al., 2020), the compositional data of two Córdoba glass crucible determined by SEM-EDS (wt% normalized to 100 wt%), and chemical composition of the Córdoba glazes determined by SEM-EDS (wt% normalized to 100 wt%).*

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Group** | **Sample** | **Colour** | **Object type** | **Na2O** | **MgO** | **Al2O3** | **SiO2** | **P2O5** | **Cl** | **K2O** | **CaO** | **TiO2** | **MnO** | **Fe2O3** | **CuO** | **PbO** |
| Saqunda glass (n=15) | avg |  |  | 0.6 | 0.4 | 4.7 | 33.6 | 0.2 | 0.1 | 1.4 | 4.2 | 0.1 | 0.1 | 1.7 |  | 52.2 |
| stdev |  |  | (0.2) | (0.1) | (0.5) | (1.2) | (0.0) | (0.0) | (0.1) | (0.7) | (0.0) | (0.0) | (0.3) |  | (2.7) |
| Glass Crucible |  |  |  | 0.7 | 0.2 | 5.1 | 35.6 | - | 0.1 | 2.0 | 3.3 | 0.3 | - | 1.8 | 0.1 | 50.9 |
|  |  | 0.9 | 0.3 | 5.2 | 35.5 | - | - | 2.0 | 3.2 | 0.2 | - | 1.5 | 0.2 | 50.9 |
| **Zumbacón Lead glaze** | Z3 | Honey | Beaker | 0.3 | 0.5 | 3.4 | 33.6 | - | - | 1.6 | 5.1 | - | 0.2 | 5.6 | 0.1 | 49.6 |
| Z11 | Honey | Pitcher? | 0.3 | 0.7 | 5.8 | 39.1 | - | - | 1.6 | 5.6 | - | 0.2 | 3.2 | 0.4 | 43.0 |
| Honey (outer) | 0.3 | 0.7 | 6.3 | 41.3 | - | - | 2.1 | 5.8 | 1.1 | - | 2.7 | - | 39.7 |
| Z12 | Green | Beaker | 0.2 | 0.5 | 2.5 | 28.6 | - | - | 1.2 | 3.9 | - | - | 1.1 | 4.7 | 57.3 |
| Z14 | Honey | Beaker? | 0.6 | 0.9 | 5.0 | 40.2 | - | - | 2.0 | 4.7 | 0.3 | 0.3 | 6.9 | 0.4 | 38.8 |
| Z15 | Green | Beaker | 0.7 | 0.9 | 3.7 | 35.6 | - | - | 1.9 | 6.0 | - | - | 2.1 | 2.9 | 46.2 |
| Green | 0.9 | 0.8 | 4.1 | 34.0 | - | - | 1.9 | 5.3 | - | - | 2.2 | 2.9 | 47.9 |
| Z30 | Honey | Pitcher? | 0.4 | 0.7 | 5.7 | 39.2 | - | - | 1.9 | 5.8 | - | - | 4.3 | 0.4 | 41.9 |
| Honey | 0.5 | 0.6 | 4.8 | 35.2 | - | - | 1.9 | 4.8 | - | - | 4.1 | 0.2 | 47.9 |
| Z31 | Honey (inner) | Dish | 0.5 | 0.7 | 5.5 | 35.6 | - | - | 1.8 | 4.6 | 0.4 | - | 3.5 | - | 47.6 |
| Honey (inner) | 0.4 | 0.5 | 5.3 | 36.3 | - | - | 1.7 | 4.7 | 0.4 | - | 2.7 | - | 48.0 |
| Z32 | Honey (inner) | Dish | 0.4 | 0.7 | 5.2 | 37.6 | - | - | 2.4 | 5.9 | - | - | 2.0 | - | 45.0 |
| Honey (inner) | 0.5 | 0.5 | 4.3 | 33.4 | - | - | 1.6 | 4.6 | 0.2 | - | 1.7 | 0.7 | 52.2 |
| Z40 | Green (outer) | Pitcher | 0.1 | 0.5 | 3.6 | 33.5 | - | - | 1.0 | 3.8 | - | - | 2.0 | 2.3 | 53.2 |
| Honey (inner) | 0.2 | 0.5 | 2.5 | 30.7 | - | - | 0.7 | 2.6 | - | 0.2 | 4.4 | - | 58.2 |
| Z49 | Honey (inner) | Beaker | 0.5 | 0.7 | 5.5 | 38.8 | - | - | 2.3 | 6.3 | - | - | 4.9 | 0.3 | 40.8 |
| Z52 | Honey | Unknown | 0.3 | 0.8 | 5.4 | 39.6 | - | - | 1.5 | 5.5 | 0.4 | - | 2.7 | - | 44.1 |
| Z54 | Transparent | Unknown | 0.8 | 0.4 | 4.1 | 35.4 | - | - | 1.5 | 3.8 | 2.3 | - | 0.6 | - | 51.4 |
| Z60 | Honey | Pitcher? | 0.4 | 0.3 | 4.4 | 33.9 | - | - | 1.3 | 3.7 | 0.4 | - | 5.3 | - | 50.2 |
| Z66 | Green | Beaker | 0.2 | 0.6 | 5.0 | 36.5 | - | - | 2.0 | 5.1 | 0.4 | 0.3 | 2.9 | 3.5 | 43.6 |
| Z68 | Honey (inner) | Dish | 0.5 | 0.3 | 3.9 | 32.2 | - | - | 1.7 | 3.9 | 0.3 | - | 1.5 | 0.6 | 55.1 |
| Honey (outer) | 0.4 | 0.5 | 4.4 | 34.2 | - | - | 1.8 | 4.7 | 0.3 | - | 1.8 | - | 52.1 |
| Z69 | Honey (outer) | Unknown | 0.5 | 0.7 | 5.3 | 35.9 | - | - | 2.1 | 5.6 | 0.4 | - | 2.3 | - | 47.3 |
| Honey (inner) | 0.5 | 0.6 | 4.8 | 34.0 | - | - | 1.9 | 5.0 | - | - | 2.1 | - | 50.4 |
| Z50 | Green (outer) | Unknown | 0.2 | 0.3 | 5.1 | 37.3 | - | - | 1.7 | 5.5 | 0.3 | - | 3.2 | 1.9 | 44.7 |
| Green (inner) | 0.5 | 1.0 | 6.0 | 40.6 | - | - | 3.5 | 6.0 | 0.5 | 0.2 | 3.5 | 1.5 | 36.8 |
| Z72 | Brown | Unknown | 0.4 | 1.1 | 9.0 | 39.0 | - | - | 2.5 | 8.7 | 0.6 | - | 2.9 | - | 35.9 |
| Z45 | Brown | Unknown | 0.3 | 0.6 | 6.7 | 45.4 | - | - | 2.8 | 6.5 | 0.4 | - | 3.3 | 0.4 | 33.6 |
| avg | Honey/Brown (n=20) |  | 0.4 | 0.6 | 5.1 | 36.8 | - | - | 1.8 | 5.2 | 0.4 | 0.2 | 3.4 | 0.4 | 46.1 |
| stdev |  |  | (0.1) | (0.2) | (1.3) | (3.6) | - | - | (0.5) | (1.2) | (0.3) | (0.1) | (1.5) | (0.2) | (6.4) |
| avg | Green (n=7) |  | 0.4 | 0.7 | 4.3 | 35.2 | - | - | 1.9 | 5.1 | 0.4 | 0.2 | 2.4 | 2.8 | 47.1 |
| stdev |  |  | (0.3) | (0.3) | (1.2) | (3.7) | - | - | (0.8) | (0.9) | (0.2) | (0.1) | (0.8) | (1.1) | (6.7) |
| **M. Auxiliadora Lead glaze** | MX20 | Green (inner) | Pitcher | 0.7 | 0.6 | 3.9 | 36.7 | - | - | 1.4 | 4.2 | 0.2 | - | 1.7 | 2.0 | 48.7 |
| Green (outer) | 0.5 | 0.6 | 3.6 | 36.3 | - | - | 1.4 | 4.4 | 0.0 | - | 2.6 | 1.3 | 49.1 |
| MX21 | Honey (inner) | Pitcher | 0.5 | 0.4 | 5.0 | 36.7 | - | - | 1.7 | 4.4 | 0.3 | - | 2.0 | - | 49.1 |
| Honey (outer) | 0.6 | 0.5 | 5.2 | 38.7 | - | - | 1.9 | 5.1 | 0.5 | - | 2.3 | - | 45.2 |
| MX23 | Green (inner) | Pitcher | 0.6 | 0.7 | 4.4 | 39.5 | - | - | 2.1 | 5.6 | 0.5 | - | 1.8 | 1.2 | 43.5 |
| Green (outer) | 0.7 | 0.7 | 4.2 | 38.4 | - | - | 1.9 | 4.8 | 0.3 | - | 2.0 | 1.9 | 45.2 |
| MX25 | Green (inner) | Pitcher | 0.4 | 0.4 | 4.1 | 35.7 | - | - | 1.4 | 1.5 | 0.2 | - | 1.1 | 1.7 | 53.5 |
| Green (outer) | 0.4 | 0.4 | 4.3 | 36.1 | - | - | 1.5 | 2.2 | 0.2 | - | 1.2 | 1.7 | 51.8 |
| MX22 | Honey (inner) | Pitcher | 0.4 | 0.5 | 4.1 | 34.6 | - | - | 1.8 | 4.9 | 0.3 | - | 3.6 | - | 49.8 |
| Honey (outer) | 0.4 | 0.6 | 4.1 | 33.0 | - | - | 1.6 | 4.4 | 0.1 | - | 3.3 | - | 52.4 |
| MX26 | Green (outer) | Beaker | 0.4 | 0.5 | 4.1 | 36.0 | - | - | 1.2 | 2.6 | 0.1 | 0.4 | 1.5 | 1.7 | 51.4 |
| Honey (inner) | 0.3 | 0.6 | 4.1 | 35.6 | - | - | 1.4 | 3.1 | 0.2 | - | 3.0 | - | 51.7 |
| avg | Honey (n=5) |  | 0.4 | 0.5 | 4.5 | 35.7 | - | - | 1.7 | 4.4 | 0.3 | - | 2.9 | - | 49.6 |
| stdev |  |  | (0.1) | (0.1) | (0.6) | (2.2) | - | - | (0.2) | (0.8) | (0.1) | - | (0.7) | - | (2.8) |
| avg | Green (n=7) |  | 0.5 | 0.6 | 4.1 | 37.0 | - | - | 1.6 | 3.6 | 0.2 | 0.4 | 1.7 | 1.6 | 49.0 |
| stdev |  |  | (0.1) | (0.1) | (0.3) | (1.4) | - | - | (0.3) | (1.5) | (0.2) | (0.2) | (0.5) | (0.3) | (3.6) |