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Historical restorations of the *Maqsura* mosaics from the Mosque of Cordoba (Spain)

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ABSTRACT: The *Maqsura* and the *Mihrab* are one of the most important locations of the Mosque of Cordoba (Spain), built during the expansion of the Mosque by the caliph Al-Hakam II (962- 965 AD). The main goal of this study was to identify the glass *tesserae* from the different historical restorations. The mosaics from the *Mihrab*, the *Sabat* chamber and ceiling mosaics presented different types of *tesserae* spread along the two doors and the ceiling attributed to the different campaigns. However, the mosaics from the *Bab Bayt al-Mal* chamber presented different glass compositions because it was completely removed and an exact replica was installed in 1916.

The chemical analysis detected a glass with high contents of PbO, mainly in the replacement *tesserae*, and in the green and yellow original *tesserae*. The original *tesserae* were classified into five different groups: *tesserae* with gold leaf, with inclusions, with bubbles, homogeneous opaque *tesserae* and red opaque *tesserae*.

1 INTRODUCTION

Built in 786 AD, the Great Mosque of Cordoba was significantly expanded during the caliphate of Al-Hakam II (962-965 AD). It was during this campaign that the three doors of the *Maqsura* and the *Mihrab* ceiling were decorated with glass *tesserae* (Nieto 1998). Ancient texts claim that a master mosaicist and the original *tesserae* came from the Byzantine Empire as a present from the Emperor Nikephoros II Phokas (Nieto 1998). In 1236, King Ferdinand III of Castile conquered Cordoba and the bishop of Osma consecrated the Mosque as the Cathedral of the Assumption of the Virgin Mary. In 1368, an altarpiece triptych was placed in front of the *Mihrab* to hide it, while the mosaic on the *Bab Bayt al-Mal* chamber was covered with a canvas. The *Sabat* chamber has since been used as the archive of the Cathedral. The removal of the triptych in the 18th century, and canvas at the beginning of the 20th century, revealed that the glass mosaics were severely damaged. The Cathedral thus ordered their comprehensive restoration. At least three different restoration campaigns are known from textual sources: in 1778 Devreton

consolidated the mosaics in the dome, in 1815 P. Furriel restored the mosaics, and finally, R. Velázquez Bosco replaced the *Bab Bayt al-Mal* mosaics in 1912-1916 (Table 1).

Table 1. Interventions in the *Maqsura* mosaics

Mosaic	Interventions
<i>Bab Bayt al-Mal</i> door	- 1912-16 Ricardo Velázquez Bosco (J&M Maumejean Férres (Madrid)). A replica was made and installed in the door.
Mirhab door	- 1368 San Peter Chapel Altarpiece /in 1771-72 unmounted. - 1772 Balthasar Devreton consolidated the mosaics in the dome and employed re-paintings on mortar for the mosaic intervention. - 1815 Patricio Furriel used coloured glasses+repainting and glasses+painting mortar for the mosaic intervention.
<i>Sabat</i> door	- 1815 Patricio Furriel restored the mosaics.

In order to make a future restoration of the *Maqsura*, the glass *tesserae* from the different historical restorations were characterized in order to distinguish original from historical interventions.

2 MATERIALS AND METHODOLOGY

A total of 90 *tesserae* were analyzed from *Maqsura*: 14 samples from the *Bab Bayt al-Mal* door, 46 from the *Maqsura* door and ceiling, and 30 from the *Sabat* door.

The glass *tesserae* were characterized by the following techniques:

- Optical Microscope LEICA DM4000M (cross section)
- Scanning Electron Microscope JEOL JSM-5600LV and EDX INCA x-Sight Oxford (SEM-EDX) (cross section)
- Fiber Optic Reflectance Spectrometer MAYA 200 PRO Oceans Optics (FORS)
- μ -Raman Spectrometer LabRAM Horiba 300 Jobin Yvon with Olympus microscope (785 nm laser) (μ -Raman)
- Laser Ablation Inductively Coupled Plasma Mass Spectrometer Thermofisher Element XR combined with a Resonetic UV laser microprobe (ArF 193 nm) (LA-ICP-MS).

3 RESULTS

3.1 Morphological characterization

The morphological characterization (optical microscope and scanning electron microscope) allowed to distinguish between original *tesserae* and two different historical interventions (Davisson 2003). The original glass *tesserae* were classified according to their appearance into five different groups: *tesserae* with gold leaf, with inclusions, blue *tesserae* with bubbles, homogeneous opaque *tesserae* and red opaque *tesserae* (Fig. 1).

At least two different intervention *tesserae* could be identified, transparent glass *tesserae* with a painted layer on their surface and a group of glass *tesserae* with small and homogeneous inclusions (Fig. 1).

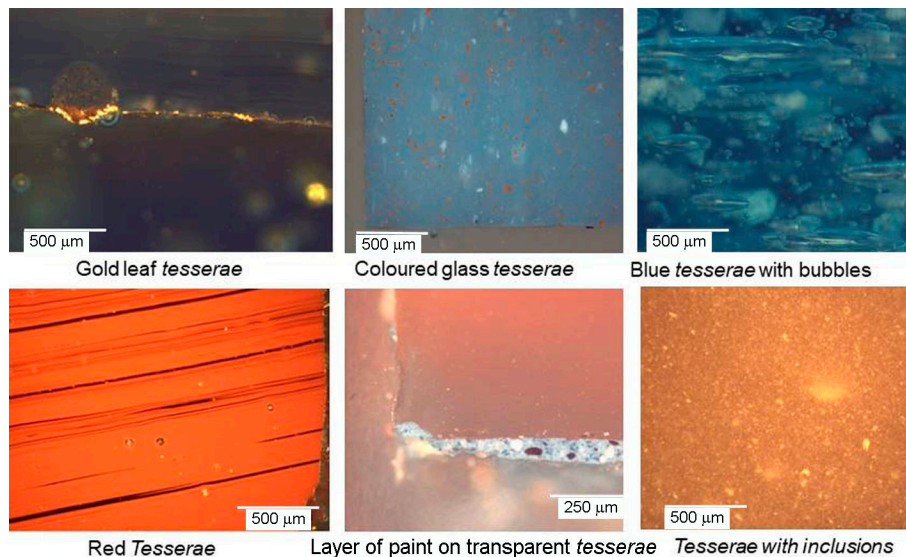


Figure 1. Different original and intervention *tesserae* in cross-section. Base Glass Characteristics.

Multivariate statistical analysis (PCA) of ten base glass elements (B_2O_3 , Na_2O , MgO , Al_2O_3 , P_2O_5 , Cl , K_2O , CaO , TiO_2 , SrO) distinguished numerous base glass characteristics and clearly singles out the twentieth-century restorations, as well as, the high lead glasses (Fig. 2). The twentieth-century samples from the *Bab Bayt al-Mal* door together with some individual samples from the *Mihrab* and *Sabat* doors were tightly clustered in the principal component space of PC1 and PC2 that account for over 60% of the total variance. They are characterized by high soda, very low chlorine and silica-related impurities that suggest the use of synthetic raw materials. The high lead glasses exhibit relatively high chlorine typical of lead glass from the Iberian Peninsula. The majority of samples show moderate levels of silica-related elements such as aluminum and titanium oxides, while the alkali contents (B_2O_3 , Na_2O , MgO , K_2O) as well as CaO and SrO vary significantly, indicative of different fluxing agents.

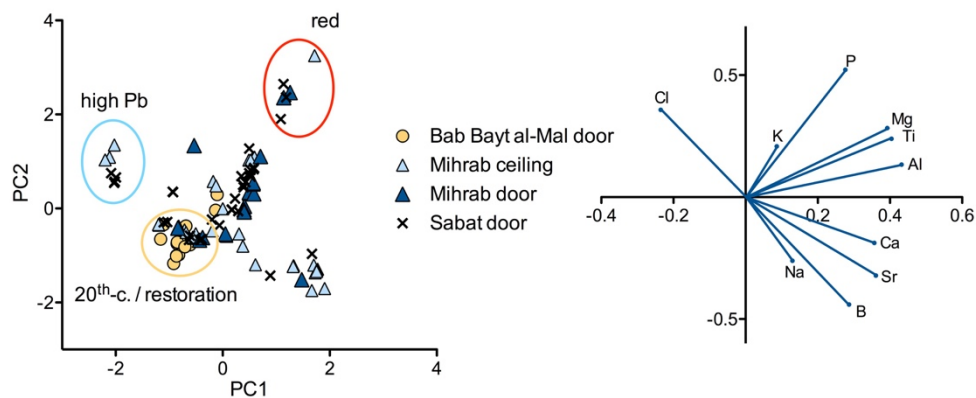


Figure 2. Multivariate statistical analysis of the base glass components.

3.2 Chromophores and Opacifiers

The most common chromophore found in the glasses was iron, which is an impurity of the glassmaking sand. Blue and grey *tesserae* contained cobalt with or without copper ions at different concentration. Mn^{3+} was detected in the purplish and burgundy samples, and nanoparticles of Cu_2O+Cu^0 were observed in the red *tesserae* (Table 2).

The *Mihrab* and *Sabat* doors' opacifiers were SiO_2 (mainly quartz), $Ca_2Sb_2O_7$ and alkaline sulfate, the yellow and green *tesserae* showed $PbSn_{1-x}Si_xO_3$ crystals (Table 3). The twentieth-

century *tesserae* from the *Bab Bayt al-Mal* door contained mainly $\text{Pb}_2\text{Sb}_2\text{O}_7$ and $\text{Ca}_2\text{Sb}_2\text{O}_7$, independently of the glass color (Table3).

Table 2. Chromophores of the glass *tesserae*

Color	Fe ^{2+/3+}	Co ²⁺	Cu ²⁺	Mn ³⁺	Cu ₂ O+Cu ⁰
Yellow	✓				
Light grey		✓	✓		
Dark grey	✓	✓			
Grayish blue	✓	✓			
Light blue		✓	✓		
Blue		✓			
Light green			✓		
Turquoise			✓		
Mauve				✓	
Red					✓

Table 3. Opacifiers of the glass *tesserae*

Location	Bab Bayt al-Mal door (20th century)	Mihrab and Sabat door	Mihrab and Sabat door (possible restorations)
KAlSi ₃ O ₈	✓		
Pb ₂ Sb ₂ O ₇	✓		
Ca ₂ Sb ₂ O ₇	✓	✓	
SiO ₂	✓	✓	✓
Fe ₂ O ₃	✓		
Alkaline sulfate		✓	
SnO ₂		✓	✓
PbSn _{1-x} Si _x O ₃		✓	✓
CaSiO ₃		✓	
Mn ²⁺ Mn ³⁺ ₆ O ₈ (SiO ₄)		✓	

CONCLUSIONS

Based on the chemical composition and morphology we can distinguish between original *tesserae* and two different historical restorations. High contents of PbO were identified in the replacement *tesserae* from Maumejean (20th cent.), as well as the yellow and green original *tesserae*. The original *tesserae* were classified into five different groups: *tesserae* with gold leaf, blue with bubbles, high lead *tesserae* (green and yellow), homogeneous opaque *tesserae* without lead and red opaque *tesserae*. Two different restorations could be identified: painted layer on transparent glass *tesserae* from Patricio Furriel's intervention (1815) and colored glass *tesserae* with inclusions and medium contents of lead from the intervention of Velázquez Bosco (1912, Maumejean glasses).

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