Gold tesserae from roman times to modern era: the investigation of a luxury material

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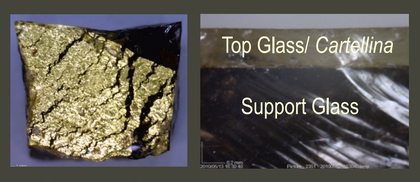
Introduction

The use of gold-leaf glass tessera began in roman times and established with the rich wall mosaics that became the emblematic work of byzantine art. After an inevitable period of decline, gold tessera is still used for the decoration of buildings, objects and the creation of works of art.

Gold-leaf tessera is a unique type of glass tessera, as a gold leaf is enclosed between two layers of usually transparent glass: a layer of glass serving as the support and a second very thin glass, acting as the cover, the top glass (usually called *cartellina*). In order to create the tesserae, a glass cake is produced and then the tesserae were cut off usually in a square shape.



Top and side view of gold tessera

The technique provides an impression of the precious metal (gold) always connected with wealth and luxury, along with its strong symbolisms –for Christian art it signifies the light deriving from God.

Gold tessera was considered to be a costly product, due to its raw materials (gold leaf), dedicated for the decoration of important edifices. However today, it is recognized that the amount of gold needed for their production was smaller than originally estimated (James, 2006); perhaps the gold tessera was valued as a result of its sophisticated manufacture technique. The production of the metal-leaf glass tessera necessitates high expertise of the glassworker and even nowadays, a glass tesserae factory in Venice (*'ORSONI' Smalti Veneziani*) dedicates specific workdays for the production of gold glass tesserae, still made with real gold leaves.

Even though, the creation of the gold background demands an enormous number of tesserae, at the vault of Agia Sofia (10th century mosaics) approximately 160 tesserae were measured at a surface area of 100cm^2, indicating roughly 16,000 tesserae per a square meter (Moropoulou, 2010), gold-leaf glass tessera has not been the subject of a systematic research. Previous published data mainly focused on the composition of glass, while for its decay the detachment of the top glass and the partial or complete loss of the gold leaf have been studied (Verità, 2000; Verità, Falcone, Vallotto, and Santopadre, 2000). The aim of this work is to present the results of a PhD research devoted to byzantine metal-leaf glass tesserae using a non destructive and non invasive methodology.

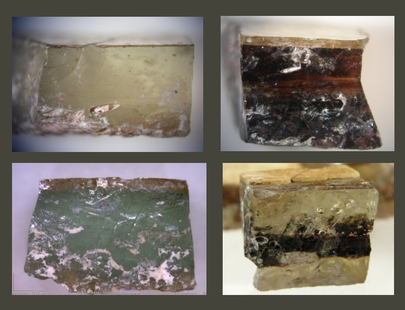
Research Methodology

The research focused on the wall mosaics of the Byzantine Monastery of Daphni (11th century) Athens, Greece. Macroscopic and microscopic examination of a large number of tesserae (*in situ* and loose) followed by the analysis of selected tesserae as received, using Scanning Electron Microscopy coupled with Energy Dispersive X-ray Spectroscopy (SEM/EDS) and supplementary micro- Proton Induced x-ray and γ-ray Emission Spectrometry (μ-PIXE/PIGE performed at ATOMKI-HAS, Debrecen, Hungary (through CHARISMA-FIXLAB, European Program). For a more comprehensive study, examination of gold glass tesserae was also carried out at the Monastery of Osios Loukas (10th century) and as samples at the Department of Conservation and Scientific Research of the British Museum London, *via* access obtained by CHARISMA -ARCHLAB European Program.

Additionally, the modern production of gold glass tesserae was followed at the ANGELO ORSONI srl., 'ORSONI, Smalti Veneziani', a glass tesserae factory in Venice, Italy.

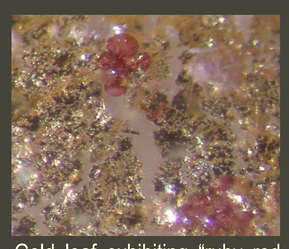
Results- *Technological features*

Gold-leaf tessera colour is defined by the shade of the support glass as the layer of *cartellina* (top glass) is very thin (less than 1mm). In Daphni monastery the simultaneous use of gold-leaf tesserae with different shades of the support glass (yellowish, roughly purple and aqua) was revealed, a feature already indicated by previous workers and attributed to a deliberate choice for aesthetic reasons (Neri and Verità, 2013). In addition, the glass hue was not always uniform, a feature frequently apparent on purple tesserae.



The gold leaf was roughly parallelogram, usually with micro-fissures along with larger breaks, discontinuities and the occasional existence of additional patches. SEM images revealed the presence of minute holes on the gold surface and occasionally a multiple application of the leaf, at least near the edge of the tessera. The thickness of the gold leaf was very small, approximately 0.5 to 0.8 μm.

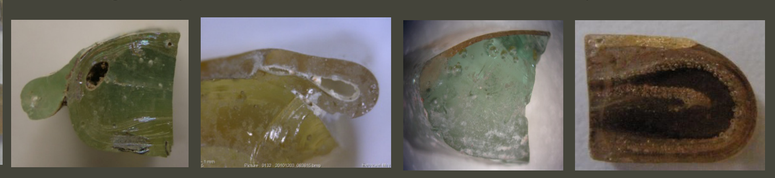
Microscopic examination of the gold leaf /top glass interface indicated the presence of “ruby red areas”, a unique phenomenon of gold-leaf glass tesserae, attributed to the dissolution of the metal leaf and the formation of ruby red shade of glass, due to the presence of colloidal gold particles (Verita and Santopadre, 2010).


Gold leaf exhibiting “ruby red areas” (0.13-0.18 mm in width)

During examination, a large number of tessera deriving from the edge of the glass slab/cake was discovered. All edges exhibited a deformed cubical shape as one of their sides is rounded.


Tessera from the edge of the glass slab

Classification of edges was based on the shape of the *cartellina*’s end point as: (a) trickle tip (b) folded (c) perfectly attached on the support glass (Loukopoulou and Moropoulou 2013a)


Tesserae with different types of *cartellina*’s end points

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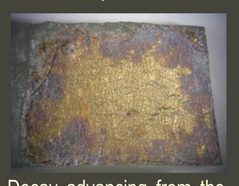
Current manufacturing technique produces a different gold glass slab compare to the ‘picture’ revealed by the examination of the tesserae and particularly the edges. Modern slabs exhibit an elliptical shape with the gold leaf and the *cartellina* (pre-cut in a square pattern) situated at the centre. The gold tesserae are produced by cutting pieces only from the central area of the disc, thus no edges are created and the rest of the glass slab is recycled.


Modern slabs, cutting procedure and the final product tesserae from 'ORSONI' Smalti Veneziani, glass tesserae factory in Venice

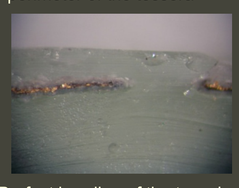
Results- *Decay*

Tesserae were classified according to their condition in three broad categories: well preserved, slightly to moderately and moderately to heavily altered. Tesserae were considered as well preserved when minimum modification was apparent without magnification. In addition, tesserae with partly or complete loss of *cartellina* and the metal leaf ,were classified as a separate category.

The tesserae exhibited common phenomena of glass decay such as, a dull or iridescent surface, a whitish (milky) surface with opalescence and on heavily corroded dark discolouration (brown-black) areas or layers. Physical damage was limited near the edges, while the decay of the *cartellina* appeared to advance from the perimeter of the tessera.


Decay advancing from the perimeter of the tessera

Microscopic examination of the sides of tesserae facilitated the study of the glass/gold interface. On tesserae with light corrosion, a thin whitish layer was detected at the gold interface, while on more decayed ones the altered zones were broader. Perfect bonding of the two glass layers was detected on areas where the gold leaf was missing typically combined with a better preservation of the glass.


Perfect bonding of the two glass layers due to the lack of gold

The most distinctive phenomenon observed was the alteration of the gold tesserae top surface into a greyish appearance, resembling a silver tessera. This was attributed to the corrosion of the glass at the interface with the gold, as microscopic examination revealed that *cartellina* exhibited an opaque greyish zone, while a dark discoloured layer was detected beneath and occasionally on top of the gold leaf.


Gold Silver

Elementary analysis (SEM and μ-PIXE/PIGE) showed that in contact with the gold leaf, both glass layers exhibited advance corrosion (Loukopoulou and Moropoulou 2013b).

Conclusions

The study of the gold-leaf glass tesserae verified that they comprise a distinctive category of glass tesserae due to their manufacture technique and their characteristic way of alteration.

The examination of gold-leaf glass tesserae revealed evidence for their manufacturing technique, indicating that perhaps in medieval period a different practice was followed. The extensive use of the slab's edges demonstrates that all available material was used for the construction of mosaics, either as a deliberate choice, for example due to the shape of the glass slab and/or as a necessity.

The appearance of the decayed gold tesserae is the combined effect of corrosion of the glass at the external surface and at the interface with the gold leaf. Decay of glass occurs also at the interface with the gold leaf as a result of inadequate joining-sealing of the glass layers (top and support glass). Insufficient joining of the glass layers facilitates water infiltration or condensation phenomena resulting to advance corrosion of glass, demonstrating that gold-leaf tesserae are *victims* of their own structure – sandwich glass metal construction.

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