



Glass and gold: Analyses of 4th–12th centuries Levantine mosaic tesserae. A contribution to technological and chronological knowledge



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ABSTRACT

Fifty-eight gold leaf tesserae from eight archaeological sites situated in the Byzantine Empire and two Early Islamic (one in medieval Palestine), covering the period that goes from the 4th c. to the 12th c., were analysed by EPMA, SEM-EDS and PIXE-PIGE to determine the composition of both the glass and the gold leaves. The good match until the 6th c. between circulating monetary alloys and the gold leaf compositions together with the type of glass used, provided criteria that can be used to date the tesserae fabrication. The data obtained allow newly produced tesserae to be distinguished from re-used ones. Because after the 7th c. the circulation of gold in the Byzantine Empire was less controlled, the same relationship is harder to establish.

The results suggest the existence of workshops in the Eastern and Western part of the Mediterranean and a more advanced technology to manufacture a palette of glass colours for gold leaf tesserae in the Eastern region.

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1. Introduction

One of the best expressions of Late Antique Byzantine and Early Islamic art are gold mosaics. Gold leaf tesserae are made of a beaten thin gold leaf sandwiched between two glass layers, that is, the support, embedded in the mortar, and a thin layer of blown glass, the cartellina, protecting the gold leaf and increasing its brilliance (Fig. 1). Their production and chronology can be evaluated by the analytical study of both the gold and the glass of the tesserae used in the mosaic patterns. The gold alloys, whose composition seems to indicate the use of monetary alloys, could be envisaged to be used as source of information on the mosaics chronology (Neri and Verità, 2013).

The first examples of the use of gold tesserae date back to the 1st c. ACE.; they can be seen in Rome, in the *Nymphaeum of Lucullus* (Bartoli et al., 2013) and in the *Domus Aurea* (Lavagne, 1970), but

their occurrence remains sporadic until the end of the 2nd c. ACE. (Scheibelreiter, 2009). The extensive use of gold leaf tesserae in mosaics seems to begin in the Constantinian age (early 4th c.), continuing under the Ostrogoths, like in the 5th c. mosaics in Ravenna, and in the Byzantine period (Neri, in press). Several remains of gold glass cakes dated to the Roman period and to the Middle Ages were found in archaeological contexts (Verità, 2006; Foy, 2008; Giertz and Ristow, 2013; Neri and Verità, 2013), but remainders of workshops producing gold glass cakes are still unknown.

Mosaics are difficult to be precisely dated. Stylistic and iconographic criteria are insufficient for a good chronological attribution. We remind the cases of the Rotunda of St. George in Thessaloniki and the Monastery of Mar Gabriel in Tur Abdin, with large chronologies of construction. The first one is dated to between the end of the 4th c. and the beginning of the 6th c. (Bakirtzis and Mastora, 2013) and the second one is attributed either to the 6th c. or 8th c. (Hawkins and Mundell, 1973). In addition to this, the loose tesserae found in archaeological contexts can only be dated to between *post* the building date of construction and *ante* their collapse, such as the tesserae from the churches of St. Polyeuctus in Constantinople

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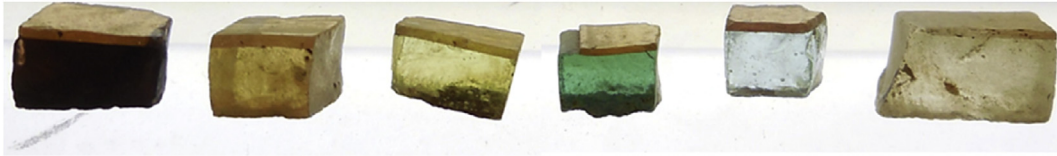


Fig. 1. Gold glass tesserae from Damascus, Umayyad Mosque.

(Harrison and Gill, 1986) and Amorium in Phrygia (Witte-Orr, 2003).

Their production requires the use of large quantities of glass, which between the 1st and the 12th c. ACE. is transparent colourless glass or slightly coloured in natural hues between yellow and green or blue-green. In the Roman times and probably until the 11th c. the practice of making glass was carried out in a limited number of places located near the sources of the raw materials (primary centres), in tank furnaces where several tons of glass could be melted (Freestone, 2005). Once the melting was completed, the furnace was left to cool down and then demolished. The transparent glass, in form of chunks (raw glass or primary glass), was traded and distributed to secondary workshops where it was remelted and made into artefacts (Freestone, 2005). Finally, in the secondary workshops glass cullet from earlier products (broken artworks, window glass, mosaic tesserae, etc) was also melted sometimes, further complicating the final glass composition.

For these reasons, the chemical composition of the glass is not representative of the secondary workshop, but of the primary workshop where the batch was melted (primary glass or raw glass). Only a few compositions can be distinguished for the primary glass, which remain unchanged over long periods of time (Freestone, 2005; Freestone et al., 2005).

As attested by historical documents (Neri, 2012) and by published chemical analyses (Neri and Verità, 2013), this picture is complicated by the fact that, between the 4th and 12th centuries, gold leaf tesserae from dismantled ancient mosaics have also been reused in new mosaics (Freestone, 1993; DeLaine, 1997; Wypyski, 2005; Greenhalgh, 1989; Cutler, 2002; François and Spieser, 2002; Schibille and Freestone, 2013).

The work performed in the secondary centre to make gold tesserae was likely very similar to the practises adopted today. The raw glass had to be remelted, and one part was blown into thin wall spheres from which pieces (the *cartellina*) were cut similar in size to the beaten gold leaves. On the gold leaves laid on the surface of the glass pieces, molten glass was poured to form the support. A cake was obtained by pressing, from which the gold tesserae were cut.

In order to provide identification criteria for the date of fabrication of gold tesserae, analyses of the gold leaves were also performed. The elemental analysis carried out on 40 gold tesserae from Italian mosaics dated to the 1st–9th c. ACE. showed the use of pure gold and gold alloys with Ag contents up to 8 wt%. The good agreement between the Ag contents in the gold leaves and in gold coins circulating in that period, strongly suggested the use of the latter (or monetary alloys) to fabricate gold leaves (Neri and Verità, 2013).

Many historical and technical issues point to this association (Neri and Verità, 2013). In Late Antiquity, the circulation of gold was strictly controlled, particularly between 325 and 610 (from Constantine to Heraclius) when the fiscal administration was ruled by three institutions, two of which belonged to the *sacrae largitiones* (the sacred largesse). The sacred largesse controlled all operations related to gold and silver, from the mine where they were extracted to the workshops where they were processed, to the mint where they were transformed into coins, and to other places connected

with their circulation. All the operations and major transactions with gold and silver coins (including taxes) were also controlled by the sacred largesse, as well as the circulation of ingots that could for example be linked to the activity of goldsmiths in the Palace (Carlà, 2009; Guest, 2005; Johns, 2011). The overwhelming role of the state in the circulation and the production of coinage until the 7th c. crisis, has been yet underlined (Hendy, 1985). However, a more complex picture has been done in the Roman-barbarian reigns. The complexity of the circulation of gold during the migration period (e.g. Guerra and Roux, 2002) requires further studies to define the source of gold of leaves of the mosaic tesserae¹. For this reason the sampling not considered in this paper this area.

The quantity of gold necessary to fabricate gold mosaic tesserae was too large to be ignored by the sacred largesse (about 5 g of gold are necessary to obtain 1 m² of 0.5 μm thick gold leaf). To produce the gold tesserae for the 6th c. churches in Ravenna and St. Sophia in Constantinople, about 2800 and 8500 *solidi* (one *solidus*: 4.5 g) were necessary, respectively, which corresponds to about 12.6 and 38 kg of gold, respectively (Neri, in press). In the *Notitia Dignitatum* (6th c.), a list of offices in the late Roman Empire, the production of gold and silver leaves is included as one of the activities performed by the sacred largesse. As is argued for jewellery, probably the gold leaves and maybe the gold tesserae were produced in the state-run industries, connected to mint workshops (Delmaire, 1981; Johns, 2011).

Large quantities of precious metal are difficult to control inside workshops. The use of gold coins instead allows the systematisation of the number of foils produced by hammering, resulting in an adequate control of the number of leaves produced by one craftsman per period of time (for example per day) without the difficulties connected to the security and distribution of the metal.

Medieval and modern recipes report the use of gold coins to produce gold leaves (*petala aurea*) (Manoscritto di Lucca, 1932 8th c.; Cennini, 1390–1437) or “to fetch (gold) from the mint” (Diderot and D’Alembert, 1751–1772). It must be stressed that in the Byzantine Empire the composition of the alloy used to issue gold coins and their weight were always rigorously controlled, even after the disappearance of the sacred largesse in 610 (Morrisson, 2002). From 610 onwards, gold could circulate with less difficulty.

The aim of this work is to enlarge the study previously carried out for 4th to 9th c. Italian mosaics (Neri and Verità, 2013) to Levantine 4th–12th c. gold leaf tesserae (Byzantine and Early Islamic) and to investigate the workshops organization and chronology of the mosaics. The data obtained allowed checking whether monetary gold alloys were used in the fabrication of gold leaves, giving an overview of the type of glass employed, improving the dating criteria for the tesserae and glass colouring techniques, and distinguishing between newly produced and reused materials.

The combination of particle induced X-ray and gamma-ray emission (PIXE-PIGE), using the AGLAE accelerator at C2RMF, and

¹ Here we should recall the decision taken by Theodoric concerning the recovery of gold from graves and the new sources for gold mining (Cassiodorus, *Variae*, 4.34 and 9.3). The free circulation of gold in the *barbaricum* is also attested by the ingot without imperial mark found at Sutton Hoo (Kent, 1975, 646–647).

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