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THE MOSAICS OF DURRES AMPHITHEATRE:
AN ASSESSMENT USING TECHNICAL OBSERVATIONS

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Les mosaïques de l'amphithéâtre de Durres : une réévaluation par un examen technique

La chronologie (VI^e^, IX^e^, post-IX^e^ siècle), l'origine culturelle (matrice romane ou byzantine) et l'interprétation de la mosaïque de la chapelle de l'amphithéâtre de Durres ont été longtemps débattues. L'article propose une analyse nouvelle de cette mosaïque en la replaçant dans son contexte architectural grâce à l'étude des techniques de mise en œuvre et l'analyse physico-chimique des tesselles.

La chronologie des tesselles se place entre le VI^e^ et le VII^e^ siècle. Cette datation diffère toutefois de celle de la chapelle qui n'est pas bâtie avant le VII^e^ siècle et qui, pendant le IX^e^ siècle, connaît une phase décorative qui précède la mosaïque. Est ainsi proposée l'hypothèse soit du remploi de tesselles provenant d'une autre mosaïque, soit du déplacement tardif d'une mosaïque paléochrétienne provenant d'un autre site de la ville. [Auteur, révisée par la rédaction]

Byzantine mosaics of Durres amphitheatre

The wall mosaics of a small chapel inserted into the Roman amphitheatre of Durres are an important Byzantine decoration, for which the chronology, the provenance of the mosaicists, the iconographical interpretation and the ideological framework are widely debated. The archaeological and iconographical arguments have produced a multiplication of subjective interpretations about the historical context of the genesis of the mosaic.

The interpretation of these mosaics is complicated by the absence of comparative examples of Byzantine wall mosaics in Illyricum and by the nature of Durres: the terminus of *via Egnatia* – connecting Rome to Constantinople via Thessaloniki –, a place where the cultural currents of East and West meet.

Two recent works on this mosaic corroborate the Byzantine (and not western) origin of the iconographical architecture, but propose opposite interpretations of the chronology.

K. Bowes and J. Mitchell attribute them to *post* 9th-11th centuries based on the architectonical context and the iconographical interpretation of wall and roof paintings, which the mosaics overlap.[1] Conversely, L. Miraj favours an attribution to the 6th-7th centuries, based on an iconographic reading of the better preserved southern panel, in particular on a study of the imperial costume.[2]

1. Bowes, Mitchell 2009, pp. 569-595.
2. Miraj 2013, pp. 60-71.

This paper resumes the principal arguments of the different positions and proposes, by combining a new *in situ* observation of the mosaic technique and the analysis of the glass tesserae, a chronology of the glass tesserae and a hypothesis on their provenance and that of the mosaicists.

Architectonical context and description of the mosaics

The main chapel, containing the mosaics, is located under one *vomitorium* of the second elliptical gallery in the amphitheatre of Durres, situated in the west part of the Byzantine wall (**Figs. 1-2**). This chapel consists of a single nave with an eastern apse outside the wall of the arena; the plan is quadrangular, narrowing to the east, according to the shape of the radial gallery. Two other chapels, dated to around the 6th-7th centuries, are documented in the amphitheatre marking a complex Christianization program of the pagan space, as also seen in other cases.[3]

The chapel was constructed after the abandonment of the amphitheatre, which probably occurred after the earthquake of 345 and after the interruption of gladiator games, according to the imperial laws.[4] Materials from the amphitheatre were recycled to build the chapel: stone slabs and bricks were re-used in the pavement and the altar was constructed in *opus mixtum*, re-using a sixth-century Christian funerary inscription.

The first marker of the defunctionalisation of the amphitheatre are the graves found near the chapel in the galleries. The majority are simple graves dug in the earth and covered with tiles, oriented to the north or south and sometimes with objects similar to those of the Komani civilization.[5] These fibulas and rings are commonly dated 6th-7th centuries, but a recent work showed the difficulty in proposing a precise date, and the extended use of these artefacts until the 10th century.[6] A grave located at the centre of the chapel is dated to the 10th century, according to bronze coins (969-976).

The chronology of the construction of chapel is commonly assigned to the 7th century by the date of the graves, the allegedly Heraclian brick stamp in the western alcove floor and the sixth-century Christian inscription re-used in the altar. Although the stylistic affinities of the mosaics with late antique wall mosaics are another argument frequently used to propose a 6th-7th range, no objective proof is available to suppose this chronology of the building. K. Bowes and J. Mitchell suppose that the above-mentioned elements are a *terminus post quem*, because they have documented a seventh-century abandonment phase of the amphitheatre,[7] and propose a tenth-century chronology for the construction of the chapel, based on coins in the main tomb and medieval ceramics (9th-10th centuries) found outside the chapel.

Fig. 1 – *The chapel of Durres amphiteatre (photo D. Dubois).*

The last mention of the chapel in the written sources is a letter written by Charles I to Johan Scoct and Guarin Shovel in 1280. The chapel was probably used until the Ottoman period, from when the most recent ceramics found in the demolition layers are dated.[8] It was abandoned afterwards, until the excavation of Toçi in 1966[9]

3. For example, in Tarragona and Aphrodisias (Godoy 1999 with references and comparisons).
4. The *munera gladiatoria* are prohibited by Honorius: *CTh* 15.12.1; 9.40.8, Theodoret, *Historia Ecclesistica*, 5.26.
5. Anamali 1993, pp. 435-446; Miraj 1988, pp. 264-265.
6. Nallbani 2002.
7. Bowes, Hoti 2003, p. 388.
8. Toçi 1971; 1975; Santoro *et al.* 2005, p. 771. This hypothesis is corroborated by the fact that the monumental tomb outside the chapel is used until the 14th century.
9. Toçi 1971.

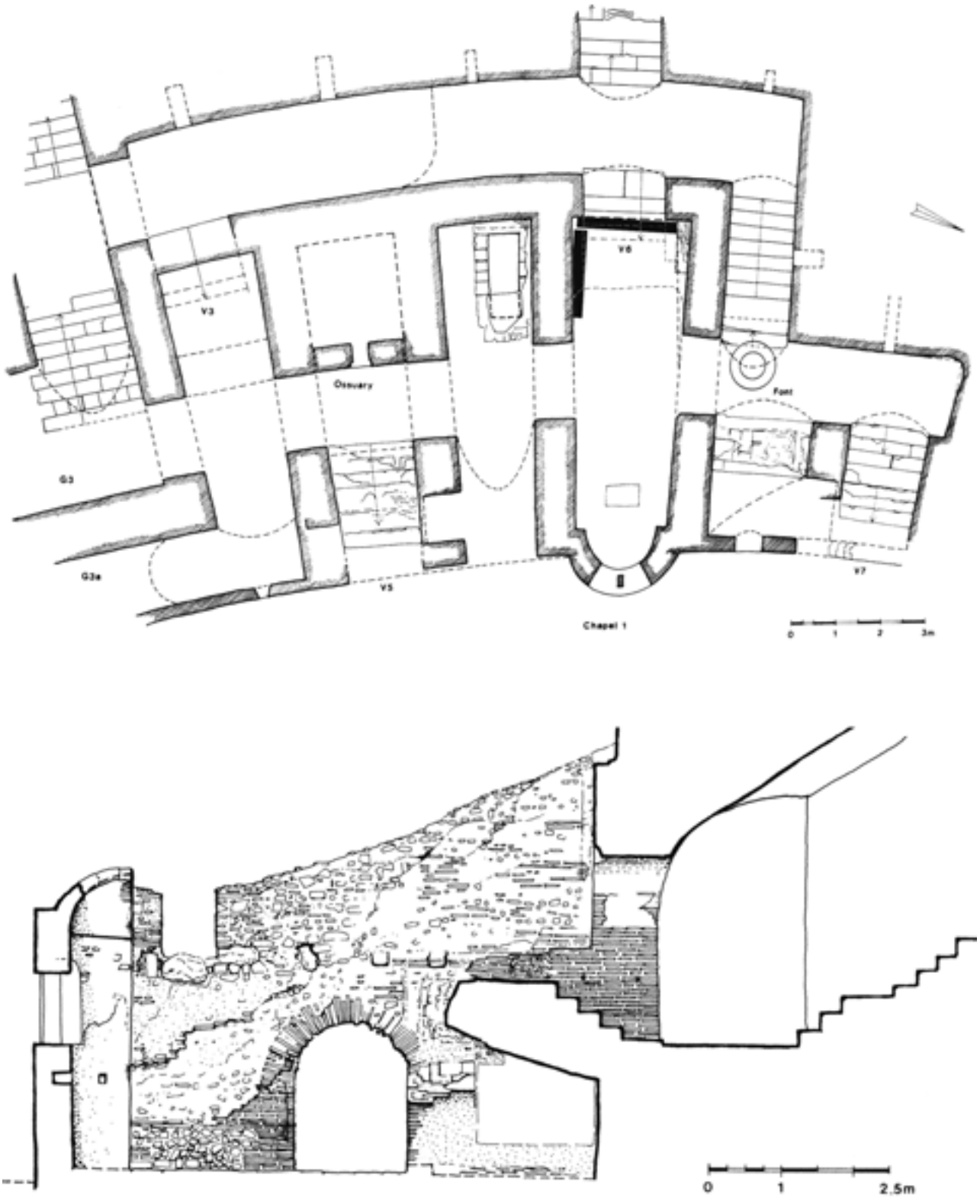

Fig. 2 – *Plan and section of the amphitheatre chapel with underlined the localisation of the mosaics.*

Fig. 3 – *The monumental tombs beside the chapel (photo E. Neri).*

and Miraj in 1983.[10] The subsequent work of S. Santoro[11] and K. Bowes[12] has clarified the postclassical life of the amphitheatre, but without offering new arguments to date the decoration of the main chapel.

The function of this chapel remains contested too. A. Bryer proposes that it was a martyrial shrine, where the cult of St. Asteios, a local martyr, was professed. This hypothesis refers to the monumental tomb beside the chapel (**Fig. 3**).[13] However, the first mention of Asteios's cult in Durres is later (1383). Moreover, the monumental tomb was erected in the 10th century and used until the 14th century,[14] when animal and human bones were collected and redisposed of L. Miraj supposed that the chapel is a representation of imperial power and of the divine investiture of the Emperor, as a monumental burial chamber for one or more important families of the city.[15]

The mosaics are situated in the western and southern walls of the chapel. The panel of the west wall presents a large central figure flanked by two angels, in turn flanked by two female figures (**Fig. 4**). Two inscriptions allow the identification of the female figure in the west as E(IRH)NH and that in the east as COΦIA; to the right of the latter, there is also a fragment of inscription, read as the upper part of the first two letters of AΓIOC. The central figure is almost entirely destroyed and is identified as Christ or Mary, according to the interpretation of the fragmentary *titulus* to the left of the figure. The small damaged figure of a donor is visible below the main figure.

The south wall comprises two panels, with an irregular trapezoidal shape (2.00 × 1.50 m) (**Fig. 5**). The eastern panel shows a half-sized figure of St. Stephen, labelled by the *titulus* O A(ΓIO)C CTEΦANOC. He has a young face and golden hands and is dressed in a tunic and *pallium*. The second panel has a nimbate figure in the centre in imperial robes and a crown with *pendilia*, holding a cruciger staff in the right hand and a globe with a crown inside in the left. Below this main figure, a male and a female donor are represented. Two angels holding a cruciger staff flank the central composition. The inscription in the eastern corner of this panel presents the invocation: +K(YPI)E BOHΘHCON TOY ΔOYΛOY COY AΛEΞANΔPOY ('Lord preserve your servant Alexander'). The frescoes integrate the iconographic program: a Christ Pantocrator with the symbols of the evangelists in the ceiling, and saints (standing nimbate figures) with military clothes in the north wall, among which St. Stephen, labelled by a fragmentary *titulus*. According to J. Mitchell and K. Bowes, these frescoes predate the mosaics and show an initial phase of decoration.[16]

A liturgical bench filled the gap between the mosaics and the floor, as visible in the photographical documentation, prior to the removal of the floor.

10. Miraj 1988.
11. Santoro *et al.* 2005.
12. Bowes, Hoti 2003; Bowes, Mitchell 2009.
13. Bryer 1994.
14. Bowes, Mitchell 2009, p. 593.
15. Miraj 2013, pp. 68-70.
16. Bowen, Mitchell 2009, p. 582.

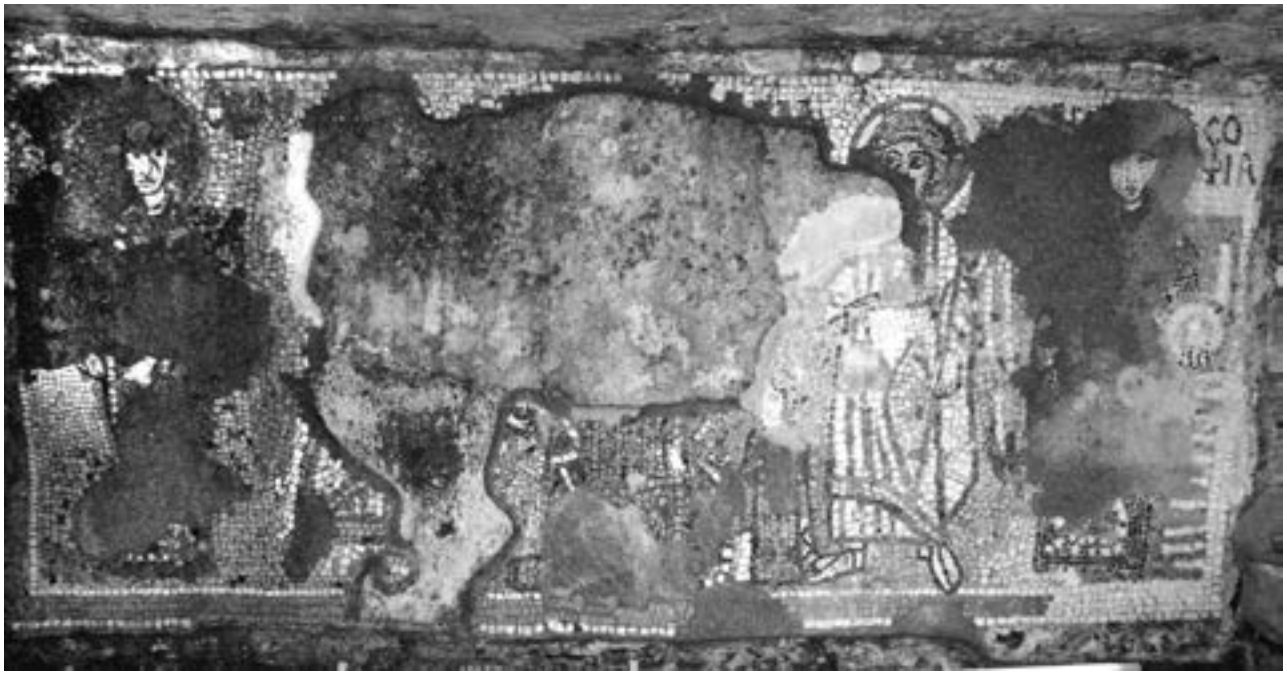

Fig. 4 – *The mosaic panel of west wall (photo D. Dubois).*

Fig. 5 – *The mosaic panels of south wall (photo D. Dubois).*

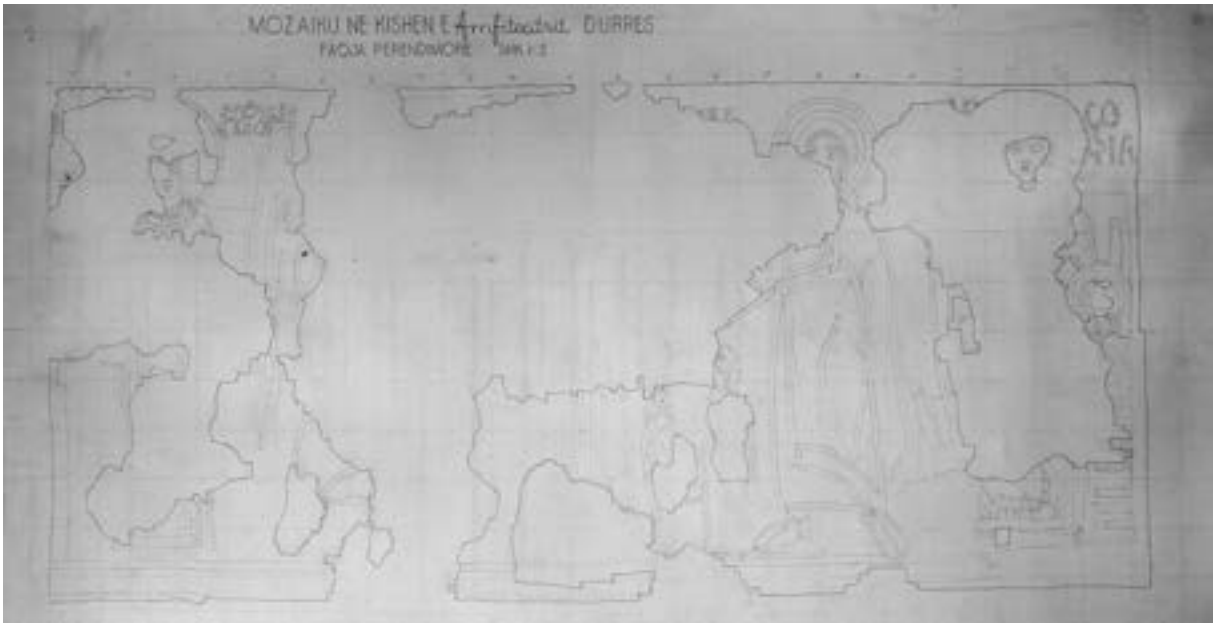

Fig. 6 – *The drawing of 1982 restauration: a/ western mosaic panel; b/ southern mosaic panel (Archives of Cultural Heritage Institute of Tirana).*

Interpretation of the mosaics: state of art

The controversial interpretation of the main figure of the south panel generated different hypotheses, based on its identification as a male or female figure, as an imperial or sacred figure.

The imperial dress (*chlamys* and *loros*), the red shoes, the crown and the *sphaira* allows recognition of an imperial figure. Based on the inscription with the name of Alexander, Toçi proposes to identify it as the Emperor Alexander (912-913), represented here as a protector of this region from the danger of Bulgarian occupation.[17] This chronology fits well with the main tomb found in the chapel. A. Ducellier reconstructs the same scenario, but proposes an identification with Emperor Leo VI[18] and his wife (in the west panel) and attributes the name of Alexandros to the donor.

Refusing the chronology because of the style of the mosaics, L. Miraj proposes recognition of an emperor of the proto-Byzantine period,[19] between Justinian and the Iconoclasm; and M.J. Castrillo suggests a similar chronology (600-850), but identifies the main figure in the southern panel as Constantine and on the west wall as Helena.[20]

Despite accepting recognition of a figure with imperial attributes, N. Thierry supposes that the central figure is Christ *Basileus* and underlines that the mosaics are the synthesis of Roman and Byzantine art between the 7th and 8th century.[21]

Other scholars propose recognising a female figure, in one case an empress[22] or more frequently the Virgin Mary, represented as the Queen of Heaven, according to an iconographic type diffused in the 8th century.[23] The geographical origin of the *Maria Regina* iconography is debated. Some scholars locate its invention in the Roman church, of which it was a symbol,[24] and suppose a Roman filiation of this mosaic. Others argued that there is a late antique model of this iconography in Constantinople[25] and linked the representation and the mosaics to Eastern tradition. In particular, the representation of Virgin with *loros* (attested only in St. Maria Antiqua in Rome and in Durres) could be a quotation of the Eastern language of power.[26]

To resume, the archaeological data and the historical framework favour dating the mosaics around the 10th century, while a stylistic-iconographic analysis allows the proposition of an earlier chronology (6th-9th centuries).

Finally, J. Mitchell and K. Bowes propose a chronology *post* the 9th-10th centuries, period to which they attribute the frescoes under the mosaics. The chronological arguments for the frescoes are iconographical: in particular, the diffusion of the iconography of military saints and the diffusion of the personification of *Sophia* and *Eirene* after the 9th century.[27]

Technical observations on laying technique and materials

These mosaics have been restored many times, but the first survey with an accurate documentation is from 1982. The drawing shows the gaps in the mosaic, still visible today in the same places,[28] filled with a mortar cement (**Fig. 6**).

Ancient restoration with the same typology of tesserae is observed, thanks to the irregular distribution of tesserae in three points of the west wall: in the southern corner, in the northern corner between the feet of the personification of *Sophia* and the angel, and below the feet of the central figure (**Fig. 7**).

The three iconographical panels differ also from a technical point of view. The panel with *Stephanos* is smaller. Although the whitish mortar, rich in lime, is identical in the two panels of the south wall, they are juxtaposed and a vertical separation line is visible where the tesserae are missing. Moreover, a connection error can be observed in the red border (**Fig. 8**). The western panel doesn't have a junction with the southern and is lower than it.

The mosaics overlap the previous frescoes. As already known,[29] this is visible only to the top and left of the panel with *Hagios Stephanos*, where blue and red paint is observed respectively.

Two layers of lime mortar with pounded brick and a total thickness of 3-5 cm characterise the preparation of the setting bed mortar of the mosaics. The mortar is typical of ancient and Byzantine mosaics, in its variant without aggregates of organic materials. This excludes that the panels have been detached and relocated in modern times following restoration.

Some parts of the setting bed preserve a trace of the red, yellow and black preparatory painting. Black corresponds to the outlines of the figures, overlapped by the

17. Toçi 1971, p. 40; 1975, pp. 44-45.
18. Ducellier 1975.
19. Miraj 2013, pp. 67-69.
20. Castrillo 1975.
21. Thierry 1975, pp. 60-62.
22. Pace 2001, retraited in Pace 2003.
23. Runis Jandot 1983, pp. 229-232; Andaloro 1986, pp. 107-108, Cormack 1986; Bowen, Mitchell 2009, pp. 588-591.
24. Nilgen 1981; Pace 2001.
25. Andaloro 1986.
26. Pencheva 2006, pp. 21-26.
27. Bowes, Mitchell 2009, p. 587.
28. The halo of *Stephanos*, the halo and robe of the main figure of the south panel and the central part of the western panel.
29. Bowes, Mitchell 2009; Boschetti 2009.

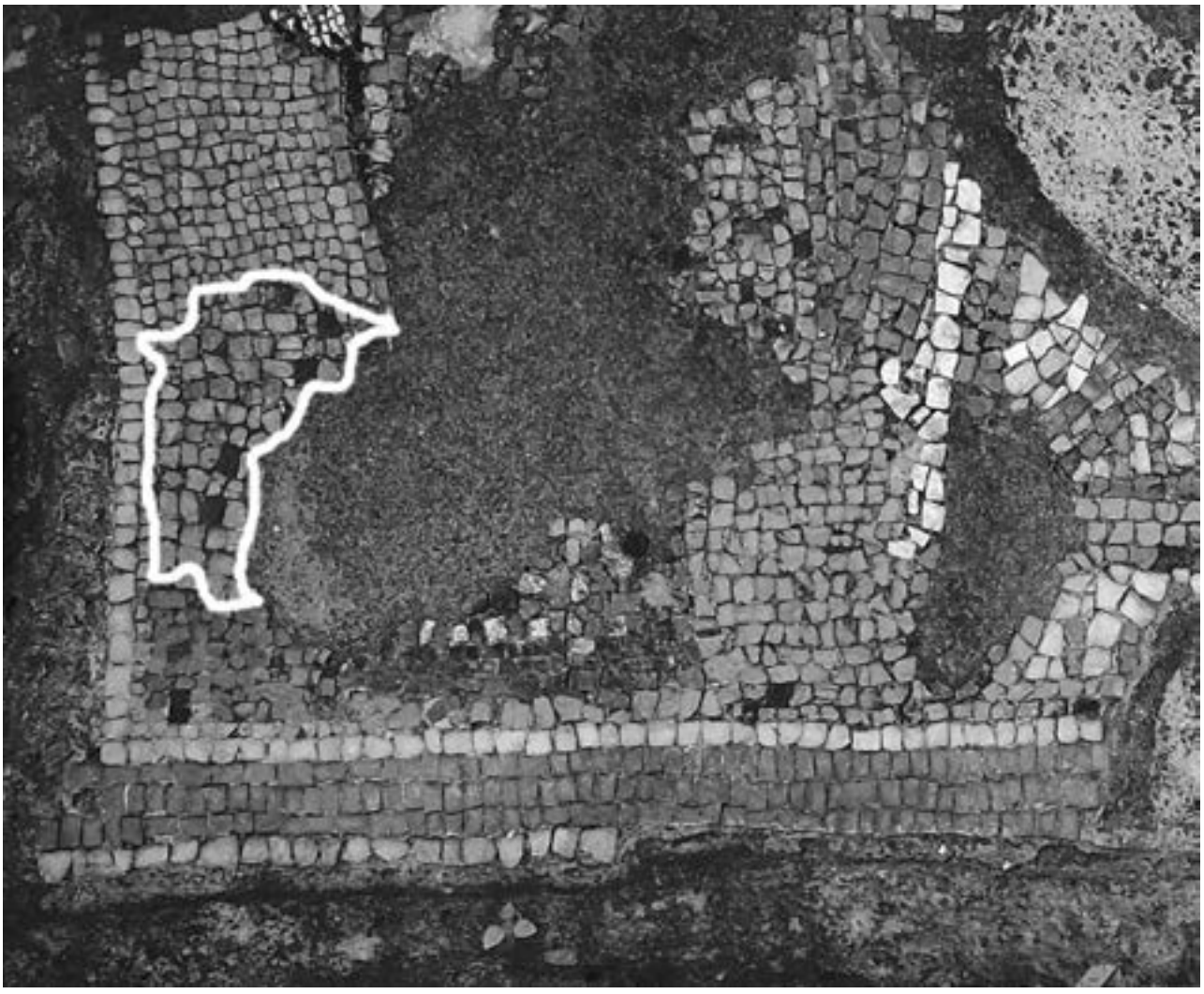

Fig. 7 – *An ancient restauration in the southern corner of west wall (photo E. Neri).*

Fig. 8 – *A connection error in the red border between west and east mosaic panel in the north wall.*

black tesserae; yellow-brown corresponds to the hair and some parts of the clothes; red to the flesh tones. The background of the mosaic does not seem to have preparatory painting and appears white also in the gaps of the tesserae. The preparatory painting, usually employed in Byzantine mosaics, is attested here in the trichrome set (red-yellow-black), often documented in Western and Eastern cases between the 6th and 14th century.[30]

Remnants of nails with rounded heads are found in the southern panels (**Fig. 9**); these are similar in dimension and typology to other nails used in preparatory layers of mosaics between the 6th and 14th century.[31] In this case, they are visible on the mosaics' surfaces, but their heads don't protrude. Therefore, they are too short even to hold a very small lamp to illuminate the figures, as has been suggested in previous studies.[32] In fact, the practice of lighting up and animating the mosaics with lamps is attested,[33] but the hooks used to suspend the lamps in the mosaics are very different from the nails seen here. For example, in the dome of St. Zeno in Rome and in St. Sophia in Thessaloniki they are protruding from the mosaic's surface and have a larger diameter, as is also documented in the restoration report for the windows of the Neonian baptistery.[34]

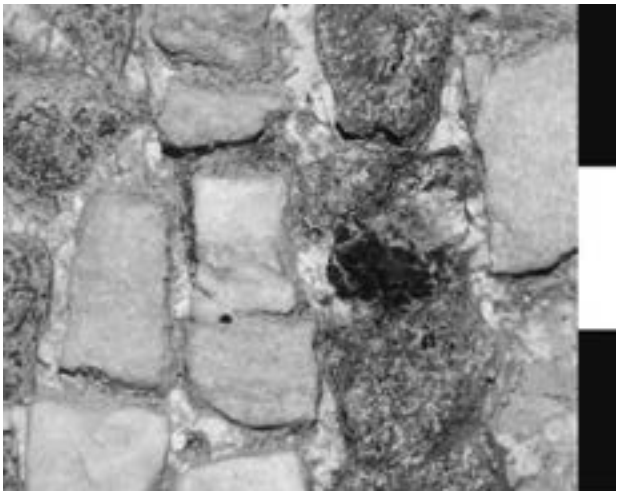

Fig. 9 – *The iron nail in the south wall (photo E. Neri).*

They are also different, however, from the structural nails of the mosaics, because they can be seen on the surface and are sparsely distributed. Since they mark an alignment at the level of the shoulders and the hands of the figures, they could be a mark to trace a line of the composition and to fit the design in the architectonical space, according to the inclination of the roof.

Concerning the materials, stone, painted stone and glass tesserae constitute this mosaic. The white, pink, beige, and pink-orange tesserae are made of limestone. There are two types of red: one is made of white limestone painted in red, the other of glass. The gold tesserae, like in ancient and Byzantine mosaics, are characterised by a sandwiched structure: a thin gold leaf hot-fixed between blown glass (the cartellina) and poured glass (the support). In Durres, however, the cartellina and gold leaf have not been preserved in the majority of the tesserae. They appear to be made of brown and green transparent glass. The palette is completed by the glass tesserae: black and purple-black, three hues of blue (dark blue, brilliant cobalt, deep blue), two hues of yellow, three of green (brilliant green, light green, yellow green), two types of turquoise, and grey.

The quality of the glass tesserae employed is lower than in other cases directly examined in the West (Rome, Milan, Naples), in the Balkans (Butrint, Lin, Elbasan) and in the East (other sites in Turkey: Hierapolis, Kilise Tepe, Mar Gabriel). In fact, the variety of hues for one colour is limited to two or three, the tesserae have an inhomogeneous structure with bubbles, and a layered structure for the red, yellow and green tesserae. Moreover, the turquoise tesserae are weathered on the surface.

Gold tesserae are used exclusively in the halo of the central figure and in the halo and the hands of *Hagios Stephanos*. In the first case, they are placed in neatly separated layers without inclination, like the holy figures in St. Demetrios in Thessaloniki and in the mosaics of the narthex of St. Sophia in Constantinople.[35] Painted red tesserae appear on the border and for some elements of the clothing. The vitreous black tesserae are used to draw the outlines of the figures and for the inscriptions. The yellow characterises the angel's hair, the gems and the details on the military clothes of the angels in the south panel. Their wings are grey. The blue tesserae colour the *loros* of the central figure, the *pallium* of the angels in south panel, and the robe of the personifications of *Eirene* and *Sophia* in the western panel. The background is white; the green and turquoise tesserae render the light and the shadows behind the central figure of the south wall and *Hagios Stephanos*. In particular, on the south wall, the central figure is a source of light, as underlined by the red half-halo of the angels and by the movement of the central figure to the west of the turquoise and green background. Conversely, in the west panel, the light irradiates from the central figure towards the personification of *Eirene*.

30. For instance: in the Nea Moni at Chios, in the Koimesis at Nicea, in the church of Dereagzi and in the fragments from lower church of Amorium (see Neri 2016 with literature, tab. 12 in particular).
31. See Neri 2016 for comparison, tab. 12.
32. Pace 2003; Boschetti 2009; Bowes, Mitchell 2009.
33. See the examples quoted in Nordhagen 1990 and Ivanovici 2016.
34. Ivanovici 2014.
35. Cormack 1985.

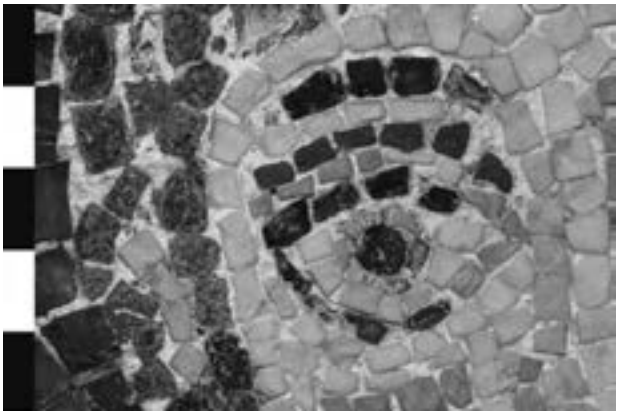

Fig. 10 – *Detail of eye of Agios Stephanos made with one round tessera (photo D. Dubois).*

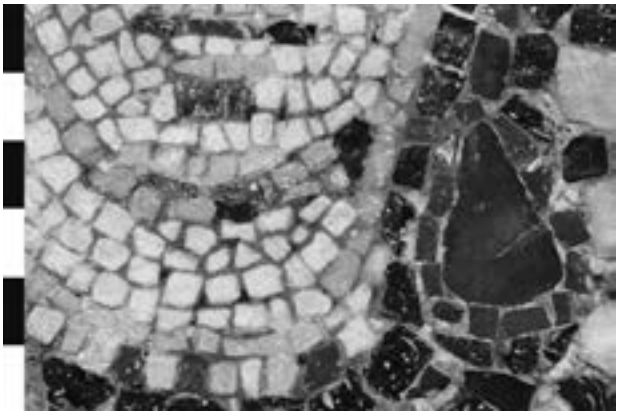

Fig. 11 – *Detail of* pendilia *of central figure in south mosaic (photo E. Neri).*

The small (2-5 mm) pink stone tesserae characterise the flesh tones with coloured shadow, according to the Byzantine tradition and in contrast to the Roman tradition, in which carnation is realised with glass tesserae. The identification of this tradition is corroborated by the way the eyes are rendered with a larger round tessera at the centre, as in the Justinianic mosaic in Ravenna, in Poreč, in Thessaloniki, and in the majority of the mosaics from the Byzantine area (**Fig. 10**). This technique differs from that used in Roman and Milanese mosaics, as well as from that in pre-Justinianic mosaic in Ravenna, where a square tessera the same size as the others is the base of the composition of the eyes.

The *pendilia* and gems are realised with larger round or drop-shaped tesserae, cut with a *grossarium*a plier (**Fig. 11**). This, along with the use of numerous glass cake edges in the composition, seems to indicate the use of new semi-finished products rather than reused materials.

The tesserae are cut in irregular shapes and dimensions (between 0.3 and 1.5 cm), above all in the western panel.

As already underlined,[36] the west panel is less accurate in its execution, but the technical language and the materials are identical to the south panel. This allows us to argue that they were made at the same time, but by two mosaicists (or two groups of mosaicists) with different levels of experience. All the figures are frontal and only the donor in the west panel is in three-quarter view, as in the eleventh-century mosaics of St. Marco in Venice and in the lunette of the imperial door in Constantinople (**Fig. 12**).

In synthesis, the technical observations suggest that the three separate panels belong to the same cycle, realized at the same moment, by mosaicists with the same technical known-how. The technical language has comparisons with the eastern Byzantine area (polymateriality, disposition of gold tesserae, rendering of gems and *pendilia*, eyes with rounded tesserae...), diffused in Thessaloniki and in the Adriatic area from the Justinian age (in Ravenna and Poreč).[37]

Fig. 12 – *Donor in the west panel showed is in three-quarter view* (photo D. Dubois).

36. Boschetti 2009, Bowden, Mitchell 2009; Pace 2003.

37. For Thessaloniki: Bakirtzis *et al.* 2014; For Poreč: Terry, Maguire 2007; For Ravenna and Poreč: Tedeschi 2013.

However, these observations cannot constrain the chronology, because the technical markers recognised were widespread between the 6th and the 14th century.

In this sense, the analytical study of the glass tesserae can contribute substantial data to our understanding of the mosaics, constraining their chronology and tracing the routes of supply, connecting (or not) the hypotheses of the provenance of the mosaicists and their materials.

Glass tesserae analysis

Background of the tesserae production and potentiality of this study

Recent studies have clarified that the tesserae are cut from glass-cakes produced in secondary workshops, where the raw glass from primary centres is opacified and coloured.[38] The localisation and the organisation of the specific workshops for glass-cakes are debated, proposing two contrasting models: either local at the building site, according to late Medieval sources[39], or centralised in a small number of centres, due to the lack of archaeological remains and to the homogeneity of the production recipes.[40]

Physico-chemical analyses of the glass tesserae can constrain the chronological range proposed by the architectonical context, offering a *terminus post quem* to the execution of the mosaic. Additionally, the analytical data can provide indications on the provenance of the raw materials, the reliability of which have vastly improved in recent studies.[41]

For the primary production phase, the transition from a centralised to a local production system between the 6th and 9th century corresponds to a technological change in the choice of fluxes, from *natron*-based in Roman times to ash-based in the Middle Ages (potassium-based in Northern Europe, sodium-based in the Mediterranean area). The intermediate composition (ash- and *natron*-based) and the recycle marks a long transition phase.[42] The differences in the alumina, lime and iron content in the sand used in the glass allow us to track the Levantine and Egyptian provenance of *natron* glass, where the primary furnaces are attested by archaeological remains.[43] For the secondary production phase, the variations in the colouring and opacification recipes and their association with the different types of base glass could suggest the supply routes. However, the available data is insufficient to trace the geographical localisation of secondary workshops. Moreover, the recycling and reuse of tesserae were common practices (although regulated) especially in Late Antiquity and the early Middle Ages, but the indicators to help us recognise these phenomena are defined with increasing accuracy.[44]

Experimental analysis of Durres tesserae

115 glass tesserae detached from the mosaics and collected by restorers at different times have been analysed. The samples are representative of all colours and hues, with the exception of red glass, which was not available in our set. A multianalytical method was followed.

The in situ tesserae on the wall mosaic were preliminarily examined under a stereomicroscope equipped with a digital camera. Then in the laboratory, because of the severe deterioration (most of the tesserae are covered with a yellowish-white crust), the sampled tesserae were ground and polished on one side, before observation under the optical microscope to determine their colour. Small glass fragments were mounted in epoxy resin and polished with a series of diamond pastes down to 0.15 µm. The polished cross-sections were additionally examined by Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICP-MS) at the Centre Ernest-Babelon of the IRAMAT (Orléans) with a standard protocol for glass analysis,[45] thanks to a collaboration with B. Gratuze and N. Schibille.[46] The crystalline phases were studied by Raman spectroscopy performed at the Laboratory MONARIS (Paris), in collaboration with Ph. Colomban[47],

38. James 2006; Foy 2009; Neri 2016.
39. Harding 1989.
40. Neri 2016.
41. Freestone 2005; Freestone *et al.* 2015; Henderson 2013; Degryse 2014.
42. Phelps *et al.* 2016.
43. Nenna 2007; Freestone *et al.* 2015.
44. Freestone 2015.
45. The 193 nm laser was operated at an energy of 5 mJ, a pulse frequency of 10 Hz and a spot size diameter of 100 mm. The procedure consisted of 20 seconds pre-ablation time, followed by 50 seconds of analytical time. Fifty-eight elements were determined by spot-analysis and the spectra were converted by means of an average response factor K_Y into fully quantitative data as previously described (Gratuze 2016; Schibille *et al.* 2016a). Reference materials Corning A and NIST 612 were repeatedly measured throughout the analytical run and accuracy is better than 5% for most major and minor elements and within 5-10% for minor and trace elements.
46. Gratuze 2016; Schibille *et al.* 2016.
47. Two different instruments excited with blue and green laser, respectively (blue excitation is well adapted to record the spectrum of poor coloured silicate glasses and the green excitation offers a good compromise whatever the colour of the analysed material):
    – A LabRam HR 800 spectrometer (HORIBA Scientific, Longjumeau, France) coupled to an Olympus BX microscope (10, 50, and 100 standard and long working distance objectives), equipped with a Coherent Arþ ion laser. Here the 458 nm, blue line, is used. The scanned areas range between 104 and 5 mm^2 as a function of the objective magnification.
    – A LabRam Infinity spectrometer (Dilor, Lille, France) coupled to a BX microscope, equipped with a Nd:YAG green laser (532 nm).
    In order to select the different spots to be analysed by Raman scattering, the crystalline phases and the glass matrix have been examined first under the optical microscope to. Spectra were processed by LabSpec software.

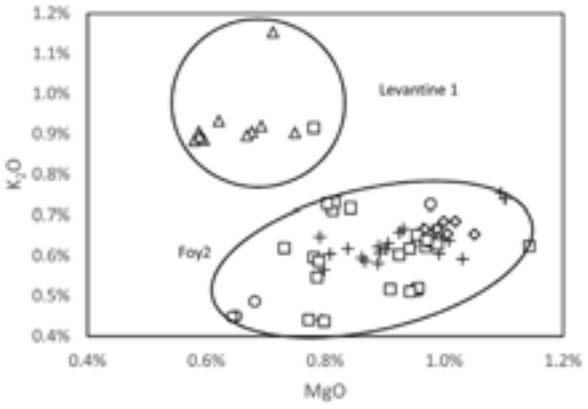

Fig. 13 – MgOVSK_2O plot showing the natron glass composition analysed in ICP-MS (raw data in Neri *et al.* 2017a) for all tesserae with high potassium content for green-turquoise tesserae.

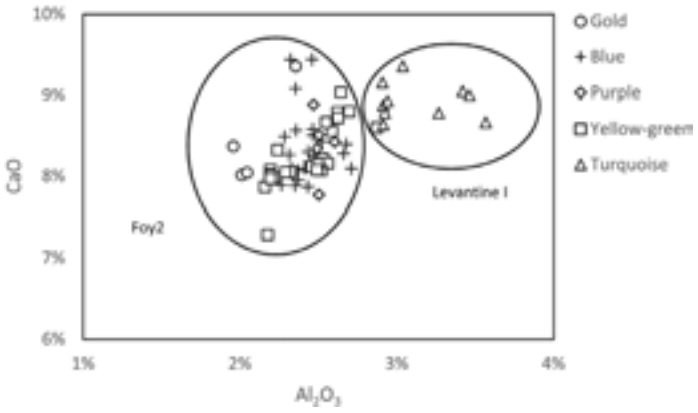

Fig. 14 – CaOVSAl_2O_3 plot showing the Levantine composition of green-turquoise tesserae and the Foy2 composition for the others.

for just ten tesserae. The morphology and the composition of the crystalline phase were subsequently analysed by SEM/EDS at the Centre Ernest-Babelon of the IRAMAT (Orleans). Before the SEM/EDS analysis, polished blocks were carbon-coated using a Quorum K975X high vacuum thermal evaporator coater.[48] The analytical methods and the detailed results are shown and discussed in two previously published papers, in which the raw data is integrally examined.[49]

Results of the analysis

The results here discussed are only those with aspects which are interesting from an archeological point of view and for the interpretation of the mosaic. The base glass composition is discussed separately from colourants, pigments and opacifiers.

- Base glass

The tesserae are made of soda-lime-silica glass; having potassium and magnesium oxide contents below 1.5% and a phosphorus content below 0.2%. They can be identified as natron glass, in agreement with the glass type prevailing in Roman times and until the 9th century. Only two gold tesserae have soda ash flux. For the natron glass, the potassium and magnesium oxide contents (**Figs. 13-14**) show two compositional groups: the first, concerning the majority of samples of all colours, with a lower K_2O content (> 0.75%); the second, represented by a group of 15 turquoise tesserae, with a higher level of K_2O (0.9-1.2%). These two groups also differ in the mineral components associated with the silica source, such as aluminium, calcium, titanium and zirconium.

According to the silica sources, the first group corresponds to the Foy-2 raw glass,[50] also called weak HIMT,[51] HIMT 2,[52] HLIMT[53] or CaO-rich HIMT.[54] This raw glass, produced in Egypt, circulated between the 5th and 7th century.[55] The manganese content in the tesserae of this group (0.9-1.5%, except in the purple-black tesserae, where the manganese is also added to colour) shows the intentional addition of manganese to decolourise a glass rich in iron, a contaminant of the sand with a higher colouring power. Only a small group of green tesserae with lower levels of manganese show a type of raw glass which is not decolourised.

The second group is characterised by high alumina and lime concentrations, lower soda and magnesia contents and lower contamination of heavy elements (Fe, Ti, Zr, V, Hf) compared to the samples of the first group. They can be identified as Levantine I raw glass, produced in Syro-Palestine[56] and circulating in the Mediterranean area between the 5th and 8th century.[57] The low levels of manganese suggest the use of non-decolourised glass. Levantine I raw glass with a low manganese content is attested from the 6th century.[58]

48. The available equipment used at IRAMAT-CEB was a FEI Philips XL40 ESEM with an Oxford Instrument EDX system for microanalysis (Link Pentafet Si(Li) detector). Imaging and analyses were done at 20 kV acceleration voltage, a beam diameter of 1 µm and at working distance of 10 mm. Semi-quantitative determination of the opacifiers and pigments was performed by X-ray microanalysis for 300 s time. The quantification was done using INCA software.
49. Neri *et al.* 2017b; Neri *et al.* 2017a.
50. Foy *et al.* 2003.
51. Rosenow, Rehren 2014.
52. Foster, Jackson 2009.
53. Ceglia *et al.* 2015.
54. Gliozzo 2016.
55. Nenna 2014; Ceglia *et al.* 2015; Cholakova *et al.* 2016; Conte *et al.* 2014; Schibille *et al.* 2016a; 2016b.
56. Brill 1988; Freestone *et al.* 2000.
57. Gliozzo 2016.
58. Freestone *et al.* 2000; Tal *et al.* 2004; Schibille, Mackenzie 2014.

- Colouration and opacification

Gold

Only the support of the analysed tesserae has been preserved, because the gold leaves and the cartellina have been detached.

Only one tessera is transparent and perfectly decolourised by the addition of manganese oxide (MnO 1.7%), contrasting the significant amount of iron (Fe_2O_3 1.7 %).

The glass of the other three tesserae is green, although they have the same composition as the former, with comparable iron (Fe_2O_3 1.1-1.7 %) and manganese (MnO 1.2-1.6 %) content. As demonstrated in a specific study of gold tesserae,[59] the melting conditions and the final redox state of the glass influence the final colour more than the amounts of iron and manganese, as is shown by the similar composition of intensely and slightly coloured areas within the same tessera.

The use of antimony – a decolourant used until the 4th century[60] and later in Rome[61] – is not documented here.

Blue

The blue tesserae were coloured with cobalt oxide and contain copper and iron in higher concentrations compared with other samples, introduced unintentionally through a cobalt ore. The more significant amount of cobalt in four samples (DU_9, DU_9bf, DU_21, DU_3) gives a more brilliant blue.

The nature of the cobalt differs in terms of its correlation with nickel, showing two groups corresponding to two sources of colourants (**Fig. 15a**). In the first, including the majority of the samples, the cobalt is strongly correlated with nickel, as well as indium and lead. This type of correlation is shown in Byzantine glass weights (6th-7th centuries), made from Foy-2 raw glass.[62] This type of cobalt is attested in Byzantine sites from the late 6th and 7th century[63] and in Merovingian glass in the West.[64]

The cobalt / iron ratio differentiates these samples from the samples of the second group, not correlated with nickel, typical of Roman times.[65] Undissolved grains of mineral residue of cobalt are observed by SEM/EDS in one sample; they have a composition of cobalt sulfide associated with iron, copper and manganese (S_2O_3 2.35%, CaO 0.42%, TiO_2 1.5%, V 0.4%, MnO 1.74%, Fe_2O_3 81.6%, CoO 8.61%, Cu_2O_3 3.3%).

The majority of the blue tesserae are opacified by bubbles, according to a technique attested in the Roman and late Roman period.[66]

Yellow

The correlation between lead and tin in yellow and green tesserae and the detection by SEM / EDS of the crystalline phases of lead stannate, show the use of yellow pigments to colour the glass (**Fig. 15b**). Different types of yellow pigments are detected: with iron, with iron and arsenic, without iron and with arsenic, with antimony, or with zinc. This variety of minor components, generally interpreted as a know-how marker linked with chronological changes,[67] is attested for the first time in the same context. The Raman signature shows the use of distinct phases of pyrochlore solid solution (PbSb2x-ySnxMyO7-δ) (**Fig. 16**).

Lead stannate is considered by many scholars to be typical of Byzantine glassmaking technology, in contrast to the Roman tradition with lead antimonate. Recent studies on the *opus sectile* in the Gorga collection showed, already in the Roman period, the simultaneous use of both lead antimonate and lead stannate yellow pigments to produce different yellow hues.[68] However, the pieces from the Gorga collection have heterogeneous provenances and are not well dated. In mosaic tesserae and *sectilia* found *in situ*, lead stannate is used from the late 6th century in Ravenna,[69] as in Asia Minor[70] and in Syro-Palestine,[71] and from the 7th century in Rome.[72]

Moreover, some samples show a significant quantity of arsenic and antimony, correlated to lead stannate. This pigment is attested in beads from the 7th century.[73]

Green

The green tesserae are coloured by copper and iron. In only four samples, is the iron not correlated to titanium, showing the voluntary addition of the former.

From SEM/EDS observation, many tesserae display particles of leaded copper alloy (Cu-Pb) with tin (Cu-Pb-Sn) or silver (Cu-Pb-Ag), also used in Byzantine metallic objects (**Fig. 15c**), demonstrating the use of metallic residues to colour the glass, as observed in other Western and Eastern tesserae between the 4th and 10th century.[74]

59. Neri *et al.* 2016.
60. Jackson 2005.
61. Verità in press.
62. Schibille *et al.* 2016a.
63. Gratuze 2007.
64. Gratuze *et al.* 1992.
65. Gratuze *et al.* 1992.
66. Verità 2000; Maltoni, Silvestri 2016.
67. Lahlil *et al.* 2010.
68. Verità *et al.* 2013.
69. Fiori *et al.* 2004; Fiori 2013.
70. Schibille *et al.* 2012; Neri *et al.* 2016; Neri *et al.* in press.
71. Marii 2013; Lahanier 1987.
72. In the arch of SS. Cosma and Damiano, Verità *et al.* 2002.
73. Neri *et al.* 2017b.
74. Maltoni, Silvestri 2016; Neri 2016; Neri *et al.* 2016.

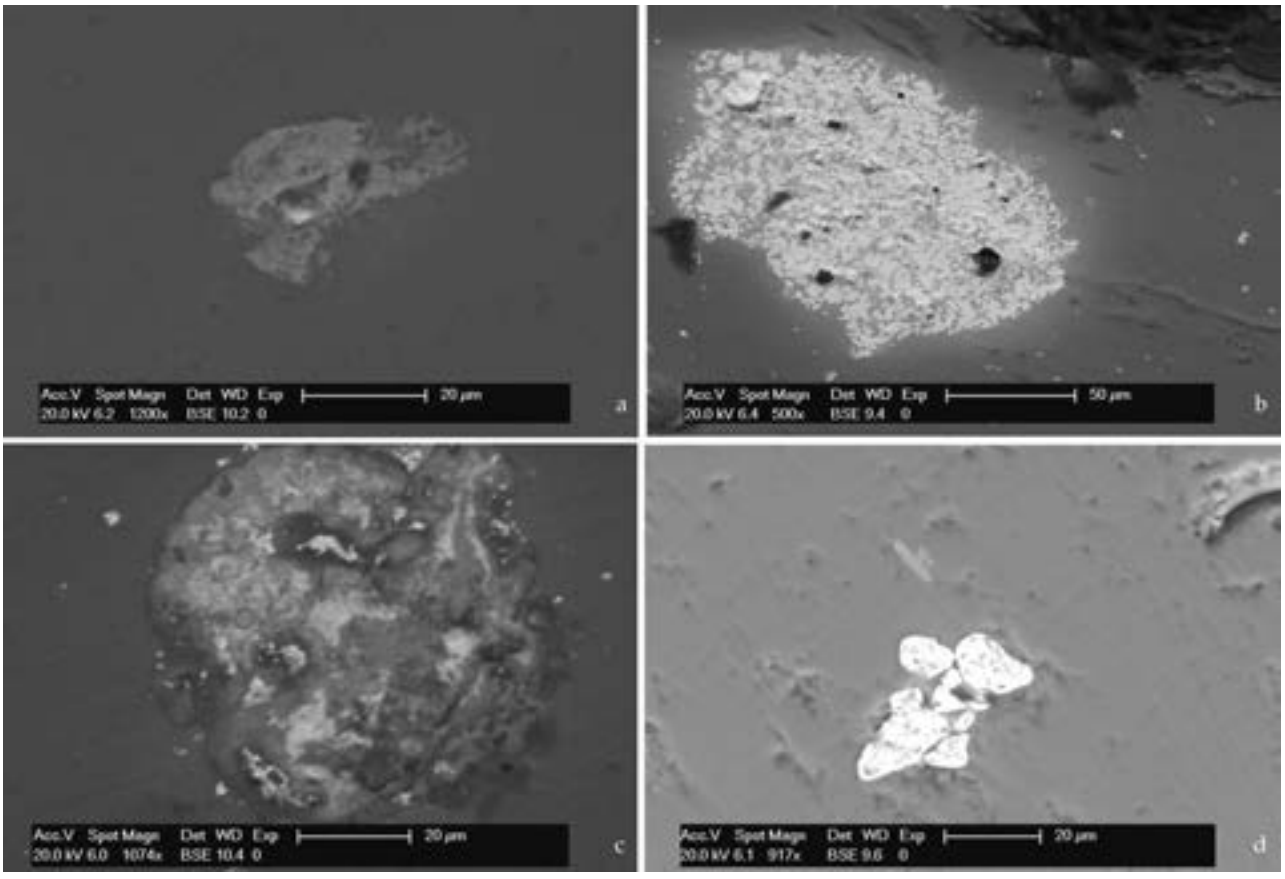

Fig. 15 – *SEM/EDS image showing some crystalline phase: a/ grains of mineral of cobalt with nickel; b/ lead stannate aggregates; c/ metal inclusion of copper alloy; d. inclusion of iron-manganese.*

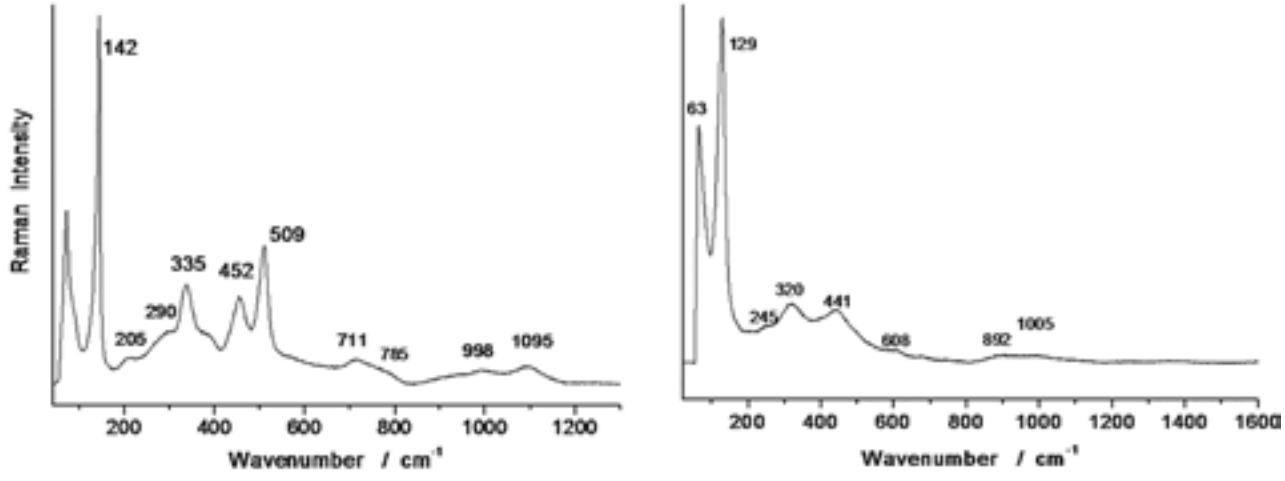

Fig. 16 – *Representative Raman spectra of the different crystalline phase of yellow tesserae: pyrochlore bindhemite solid solution ($PbSb_{2-y}SnxMyO_{7-\delta}$).*

Some green samples show crystalline phases of quartz, detected also by Raman in a different work,[75] but the low density of crystals shows that the quartz is not intentionally added to the melt to opacify the glass, as attested in middle Byzantine mosaics.[76]

Turquoise

Turquoise tesserae were coloured by adding copper oxide to base glass decolourised with manganese (Foy-2 base glass) or without manganese (Levantine I base glass). Copper oxide produces a light blue colour and the presence of oxidised iron tends to shift the colour towards turquoise or green, according to the composition and the oxidising conditions of the melt. For this reason, tesserae made with Foy-2 glass are blue-green rather than turquoise, due to a higher content of iron than in the Levantine I tesserae.

Purple, purple-brown

The purple and purple-brown tesserae were coloured using manganese, added in higher quantities than iron. Some samples show undissolved particles of iron, manganese and silicium by SEM/EDS, characterising the mineral used to colour the glass **(Fig. 15d)**. A particle with the same composition is detected in one tessera from the 7th century phase of the mosaics of SS. Cosma and Damiano in Rome.[77] According to the Venetian recipes, the use of manganese is suggested to obtain purple and black colours: the minerals are alternately roasted, calcined and washed with soda and vinegar[78].

The archeological interpretation of the chemical analysis: chronology and supply of the tesserae

The data points to an early chronology within the range provided by the stylistic observations of the mosaics. The use of *natron* glass for all analysed samples can suggest a *terminus ante quem* of the 8th-9th centuries. Two gold tesserae with soda ash flux, discussed in a previous study,[79] are not statistically significant, but could show a posterior (post 8th-9th centuries) restoration, as observed in other mosaics both in the West and in the East.[80] Moreover, the Foy-2 and Levantine I base glass were produced and circulated between the 5th and late 7th century,[81] and cobalt associated with nickel was exploited and used in glass from the late 6th and 7th century.[82]

This allows the proposal that the tesserae used in the mosaics were produced around the late 6th-beginning of the 7th century.

These tesserae seem to have been newly produced and not made by recycling older glass. Not only is no marker of recycling recognised for the base glass,[83] but also undissolved colorants (pigments, metallic inclusions and mineral residues) seem to indicate a non-recycled glass. Moreover, the use of cobalt sources linked with high impurities of nickel, typical from the 6th century, exclude a re-use of ancient and Late Antique blue tesserae.

The sample of analysed tesserae shows two possible supply routes: the first group includes the majority of the tesserae, produced with Foy-2 glass; the second the turquoise tesserae produced with Levantine I.

The second group shares the same features as a group of turquoise, green and aqua tesserae from mosaics of the late 6th century in Constantinople,[84] in Cilicia[85] and in the Justinianic (mid-6th century) Albanian mosaics.[86] Because these features are not attested in Italy during the same period,[87] we can suppose an eastern provenance.

In the first group, no sub-groups can be identified by opacification recipes, in contrast to other cases, where different opacification and colouration recipes – probably attesting a supply from many workshops, or a re-use and new importation – are shown in the same mosaic.[88] The homogeneity of the Durres sample suggests an *ad hoc* supply for this mosaic.

The opacification with bubbles only for the blue and turquoise tesserae, and with yellow pigments (lead stannates) for yellow and green, differentiates the Durres tesserae from those from Rome, Milan, Ravenna, Asia Minor and Syria in terms of opacification recipes. In fact, in Rome, the tesserae were opacified by calcium

75. Neri *et al.* 2016.
76. At Hierapolis (Neri *et al.* in press), at Hosios Loukas (Arletti *et al.* 2010), in Sicily (Verità, Rapisarda 2008; Arletti *et al.* 2010) and in Torcello (Venice) (Verità, Zecchin 2012).
77. Verità *et al.* 2002.
78. Zecchin 1990.
79. Neri *et al.* 2016.
80. For instance, in northern Italy between the 9th and 11th century: at St. Ambrose in Milan (Neri 2016), St. Justine in Padua (Silvestri *et al.* 2011), St. Vitale in Ravenna (Neri, Verità 2013); in Asia Minor, at St. Polyeuktos in Constantinople (Schibille, McKenzie 2014) and in Hierapolis (Neri *et al.* in press).
81. For the later attestations: Bonnerot *et al.* 2016; Ceglia *et al.* 2015; Cholakova *et al.* 2016; Schibille *et al.* 2016a and 2016b; Gliozzo 2016.
82. Schibille *et al.* 2016a.
83. For the markers of recycling see Freestone 2015; Schibille *et al.* 2012.
84. Schibille, Mc Kenzie 2014.
85. Neri *et al.* in press.
86. Vataj *et al.* 2016; Neri in press.
87. For Milan: Neri *et al.* 2013; Neri 2016; for Ravenna: Fiori *et al.* 2004; Vandini *et al.* 2014; Verità 2011; Fiori 2013; for Padua: Silvestri *et al.* 2012; 2014; for Rome: Verità, Santopadre 1993; Verità *et al.* 2002; Verità, Vallotto 2003; Verità *et al.* 2009; for Faragola: Gliozzo *et al.* 2009.
88. For instance: Verità 2011 for the Neonian baptistery in Ravenna; Neri, Verità 2012 for St. John and St. Laurent in Milan; Neri *et al.* in press, for St. Philip in Hierapolis.

antimoniate from the 4th to the 12th century,[89] as in Faragola (southern Italy)[90] as well as other cases.[91] This recipe, typical of the Roman period, attests the continuity of Roman technology and of raw material supply in the late Roman and Byzantine period, or the re-use of ancient tesserae. The use of tesserae opacified by calcium antimoniate is also predominant in Ravenna and in Classe,[92] where some tesserae were opacified by calcium phosphate in the 5th century.[93] This technique, diffused in Jordan,[94] Syria,[95] Asia Minor and Cyprus[96] from the beginning of the 5th century, is also recognised in northern Italy[97] and not attested in our sample. The Durres tesserae are also different from these opacified by cassiterite in lead-free glass, until now recognised between the 5th and 7th century in Cyprus,[98] Tyana (Cappadocia),[99] and Milan.[100]

Comparing the opacification and colouration recipes of the Durres tesserae with the available data from analysed tesserae from Albania; those of Durres are different from Roman and Late Antique tesserae from southern Albania,[101] where the calcium antimoniate and lead antimoniate are used. However, they are similar to sixth-century tesserae from Byllis, Elbasan, Lin[102] and the Butrint baptistery, opacified by bubbles and lead stannate.[103] This shows a discontinuation of ancient technology from the 6th century. Nevertheless, the sixth-century Albanian tesserae are produced mainly with Levantine glass,[104] in contrast to those of Durres, mostly made with African glass (Foy-2).

The colourant supply and recipes of colouration are similar to these of the analysed tesserae in the Mediterranean area from Antiquity to the Byzantine period, but some peculiarities are shown.

The sources of cobalt to colour the blue tesserae are less pure and contain nickel traces which are not identified in the sixth-century blue tesserae from Albania and could indicate a new route of supply. Schibille *et al.* have proposed a supply of this type of cobalt from the mines of Qamsar in central Iran.[105] From an historical point of view, between the late 6th century and the 7th, the military and diplomatic relationship between the Persian empire and Byzantium was intense, although the aims of these missions were to protect the border of the Empire from Persian expansion. Another possibility is to suppose that this cobalt came from the mine of Alshar (Macedonia); but no archaeological research has been conducted to prove a Byzantine exploitation before the Ottoman period. The north of Greece and the south of the Balkans (Macedonia in particular) are, in fact, geologically rich in Mn, Co, Ni.[106]

The use of metallurgical remains (leaded copper and brass), observed in the Durres samples, is also shown in other Albanian Byzantine tesserae,[107] as well as in tesserae from Milan,[108] Ravenna[109] and Asia Minor,[110] marking a trend in the production of green tesserae in the Byzantine period.

The colouration in purple-brown/black, probably by calcinating a mineral of manganese associated with iron and silica, is also detected in one sample of the seventh-century phase of SS. Cosma and Damiano.[111] This manganese source is not associated with barium and is different from what is commonly attested in Eastern mosaics.[112]

In conclusion, the second group of Durres tesserae does not show a strong parallel with other analysed tesserae and a route of supply cannot be supposed. However, the differences to tesserae from Rome (opacification with antimoniate) and the Levantine area (opacification with calcium phosphate and cassiterite) could illustrate the network of supply and propose a more local production or a provenance from a non-studied area, like Africa, from where the base glass also comes.

Hypotheses on the mosaic history

The tesserae can likely be attributed to the 6th-7th centuries, but the chapel was probably built later with an important building phase in the 9th-10th centuries, when

89. Verità, Santopadre 1993; Verità *et al.* 2002; Verità, Vallotto 2003; Verità *et al.* 2009. The first case with tin-based opacification is S. Maria in Trastevere (Tiberia 1996 with appendix by M. Verità).
90. Gliozzo *et al.* 2009.
91. Lahlil *et al.* 2008. Some Late Antique and Byzantine cases in which calcium antimoniate is used are Antioch in the 4th-5th centuries (Wypyski, Becker 2005), Sagalassos in the 5th century (Schibille *et al.* 2012), St. Polyeuktos in Constantinople in the 6th century (Schibille, McKenzie 2014), Vrina (southern Albania) in the early Byzantine period (Schibille 2011).
92. Vandini *et al.* 2014; Fiori *et al.* 2004; Fiori 2013.
93. Verità 2011.
94. Marii 2013.
95. Lahanier 1987.
96. Neri *et al.* 2016; Silvestri *et al.* 2016; Bonnerot *et al.* 2016.
97. Neri, Verità 2012; Neri 2016.
98. Bonnerot *et al.* 2016.
99. Lachin *et al.* 2009.
100. Neri *et al.* 2013.
101. For Vrina, Schibille 2011; for the Nympheum and Triconch mosaics in Butrint, Neri in press.
102. For these tesserae only a preliminary publication is available (Vataj *et al.* 2016), and a parallel work is in progress by the author.
103. For the Butrint baptistry see Neri in press.
104. Schibille 2011; Vataj *et al.* 2017.
105. Gratuze 2000.
106. Boev, Jelenkovic, 2012.
107. Vataj *et al.* 2017.
108. Neri, Verità 2012; Neri 2016.
109. Vandini *et al.* 2014.
110. Neri *et al.* 2016.
111. Verità in press.
112. Wypyski 2005; Marii 2013; Neri *et al.* 2016.

the frescoes under the mosaics were probably painted, according to their stylistic and iconographical analysis. Even if we refuse this chronology and suppose that the frescoes were painted at the moment of the construction of the building, they cannot have been covered by the mosaics immediately afterwards.

To combine the architectural chronology of the building and the chronology proposed by the analysis of the tesserae, two hypotheses are possible:

1/ The mosaic can be dated *post*-10th century and it re-used tesserae dismantled from another 6th-7th mosaic;
2/ The three panels of this mosaic belong to a sixth-seventh-century mosaic, from which they were detached and re-located in this context after the 10th century or later, while the monumental tomb was being used (14th century).

The first hypothesis is supported by the fact that the re-use of tesserae was a current practice in Late Antique and Medieval times. The Late Antique law about the preservation of *decus* tries to contain this use and many literary sources, specifically mentioning the tesserae,[113] attest the common practice of removing the tesserae from ruined buildings and re-using them in new mosaics, with or without the legal permission of the authorities to which the building belonged. However, the hypothesis of the re-use of ancient tesserae in a late Byzantine mosaic is in contrast with the iconographical and stylistic reading of this mosaic, dated no later than the 10th century. For the second hypothesis, the practice of recomposing the fragments of Late Antique mosaics in Medieval times has not been systematically studied, but some examples are known in Rome between the 12th and 13th century.[114] Some technical details can corroborate this hypothesis. In fact, only two walls are covered by mosaics; the ceiling and the north panel do not have mosaic decoration, and do not show the remains of any ancient mosaics superposed to the painted layers. Three panels (instead of two) occupy two walls; the west panel does not touch the southern one, and the panel with *Hagios Stephanos* is smaller than the others. The junction between the two panels on the south wall does not correspond to the mark of a scaffolding day ("pontata"), but attests a separation between two parts of the composition. Furthermore, the relation between the figures and the architectonical space is not well assessed for the southern panel: the halo of the main figure touches the ceiling and the inscription above the angel is mutilated in the upper part. Moreover, there is a mistake in the layout of the frame between the panel with *Stephanos* and the neighbouring panels. Following this hypothesis, the nails could be a marker to ensure the correct placement of the panels. C^{14} analyses of the mortar of the preparation layers of the mosaic and more accurate archaeological investigation in this context, could offer further indications and a more correct interpretation.

In both cases, the spread between the chronology of the tesserae and of the architectonical context suggests a late mosaic, using ancient material or re-composing the parts of an ancient mosaic, documenting the probable existence of a sixth-seventh-century mosaic somewhere in Durres.

However, nothing is known about the Christian buildings of Durres outside the amphitheatre[115] and therefore the possible original collocation of these panels or tesserae.

Conclusions

The analysis of the glass tesserae has shown the probable existence of an early Byzantine wall mosaic in Durres, made with newly produced tesserae, probably imported in little part from the Levant and in part from another workshop, using African base glass and not located in Rome. However, this is in contrast with the architectonical context and suggests that the mosaic in the chapel is a late Byzantine remake. A late Byzantine phase is also attested in the decoration of the other chapel of the amphitheatre, showing an intention to raise the importance of the Christian buildings in the amphitheatre.

About the original provenance of the tesserae or of the panels, before their final destination in the amphitheatre chapel, no hypothesis can be formulated until a new study and new excavations pertaining to the Christian topography of the city are carried out, to better contextualise and understand this important mosaic. If this mosaic dates from the 7th century, this poses an important historical question about its donor, which it is essential to answer by investigating its context. In fact, this mosaic could be an important document to explain how the local church was organised to fill a power *vacuum*, as underlined in other sites, and with which consequences.

113. Neri 2016, pp. 124-128.
114. The fourth-fifth-century head of Christ in the Torriti apse mosaic of St. John in Lateran comes from another ancient mosaic according to Cecchelli 1961, pp. 13-18, but the ninth-century restoration makes a verification impossible. Innocent III restores the ancient mosaics of St. Peter and Paul Outside the Walls, using parts of ancient mosaics (Andreescu 1977, p. 22 for the sources attesting this operation). The cut-and-paste of ancient parts is also attested in S. Maria Maggiore in Rome (Bertelli 1975, pp. 40-42). For the case of the Medieval mosaics of the exterior façade, reusing Early Christian fragments, see Piazza 2010.
115. The surveys of a topography of Durres available are Santoro 2003; Davis 2003; Gutteridge 2003; Miraj 2013.

We can underline that the 6th-7th centuries were a delicate period for the Balkans and for Durres. After the Justinianic reinforcement of the *limes* and the strengthening of the routes of communication, according to the defensive policy of the emperor, no imperial intervention in the Balkans is known of between 572 and 591, because of the ongoing Gothic war. Only after 591 Mauritius had a strong intervention program in the Balkans to contrast the Slavic presence, also upgrading the *Egnatia* and maybe reinforcing the role of Durres. Subsequently, the sources underline the Byzantine absence from 602 to 843, when *Dyrrachium* became capital of a *theme*.[116] Moreover, the Durres church, originally under the administration of Roman papacy through the *vicarius* of Salona, was firmly positioned with Constantinople from the late 5th century when Bishop Sicinius participated and signed the acts of the council *quinsexto in Trullo*,[117] which caused the military reaction of the Rome and Ravenna Church. The artwork studied could have been executed within this historical framework.

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116. Bavant 2004; Cheynet 2006.
117. Duchesne 1892.

Bibliography

Anamali S.
1993 "Oreficerie, gioielli bizantini in Albania: Komani," in *XL corso di cultura sull'arte ravennate e bizantina*, Ravenna, pp. 435-446.

Andaloro M.
1986 "I mosaici parietali di Durazzo o dell'origine costantinopolitana del tema iconografico di Maria Regina," in O. Feld, U. Peschlow (dir.), *Studien zur spätantiken und byzantinischen Kunst*, 3, Bonn, pp. 103-115.

Andreescu Treadgold I.
1977 "La mosaïque murale : histoire des restaurations, évolutions de ses techniques," in *Mosaïque n.* 1, *détérioration et conservation (Actes du 1er Symposium international sur la conservation des mosaïques, Rome, 2-5 novembre 1977)*, Paris, pp. 19-35.

Arletti R., Fiori C., Vandini M.
2010 "A study of glass tesserae from mosaics in the monasteries of Daphni and Hosios Loukas (Greece)," *Archaeometry* 52, pp. 796-815.

Bakirtzis Ch., Kourkoutidou-Nikolaidou E., Mavropoulou-Tsioumi Chr.
2014 *Mosaics of Thessaloniki: 4th to 11th Century*, Athens.

Bavant B.
2004 "L'Illyricum," in C. Morrisson (dir.), *Le monde byzantin*, I. *L'Empire romain d'Orient (330-641)*, Paris, pp. 307-351.

Bertelli C.
1975 "Un antico restauro nei mosaici di Santa Maria Maggiore," *Paragone*, pp. 40-42.

Boev B., Jelenkovic R.
2012 "Allchar deposit in Republic of Macedonia – Petrology and age determination," in A. I. Al-Juboury (dir.), *Petrology – New Perspectives and Applications* 411, Rijeka, pp. 131-168.

Bonnerot O., Ceglia A., Michaelides D.
2016 "Technology and materials of early Christian Cypriot wall mosaics," *Journal of Archaeological Science. Report* 7, pp. 649-661.

Boschetti C.
2009 "Alcune osservazioni sui mosaici e sulle pitture dell'anfiteatro di Durazzo," in S. Santoro, A. Hoti, B. Sassi (dir.), *L'anfiteatro romano di Durazzo. Studi e scavi. 2004-2005* (Annuario della Scuola archeologica di Atene e delle Missioni Italiane in Oriente 83, serie III, 5, II), pp. 789-799.

Bowes K., Mitchell J.
2009 "The main chapel of the Durres amphitheatre," *MÉFRA* 121/2, pp. 569-595.

Bowes K., Hoti A.
2003 "An amphiteater and its afterlives: survey and excavations in the Durres amphitheater," *JRA* 16, pp. 380-394.

Brill R. H.
1988 "Scientific investigations of the Jalame glass and related finds," in G. D. Weinberg (dir.), *Excavations at Jalame: Site of a Glass Factory in Late Roman Palestine*, University of Missouri, Columbia, pp. 257-291.

Bryer A.
1994 "Saint Asteios and the chapel in Dyrrachion," *Θυμίασμα στη μνήμη της Λασκαρίνας Μπούρα* 1, pp. 41-45.

Castrillo M. J.
1975 "L'énigme de la mosaïque de Durrës," *Archéologia* 79, pp. 82-83.

Cecchelli C.
1961 "A proposito dell'abside Lateranense," *Miscellanea Bibliothecae Hertzianae* 16, pp. 13-18.

Ceglia A., Cosyns P., Nys K., Terryn H., Thienpont H., Meulebroeck W.
2015 "Late Antique glass distribution and consumption in Cyprus: a chemical study," *Journal of Archaeological Science* 61, pp. 213-222.

Cheynet J.-Cl.
2006 "Les Balkans," in J.-Cl. Cheynet (dir.), *Le monde byzantin II. L'empire byzantin (641-1204)*, Paris, pp. 457-471.

Cholakova A., Rehren T., Freestone I. C.
2016 "Compositional identification of 6th c. AD glass from the Lower Danube," *Journal of Archaeological Science. Reports* 7, pp. 625-632.

Conte S., Chinni T., Arletti R., Vandini M.
2014 "Butrint (Albania) between eastern and western Mediterranean glass production: EMPA and LA-ICP-MS of late antique and early Medieval finds," *Journal of Archaeological Science* 49, pp. 6-20.

Cormack R.
1985 *The Church of Saint Demetrios: The Watercolours and Drawings of W.S. George*, Thessaloniki.
1986 *Writing in Gold. Byzantine Society and its Icons*, London.

Davis J.
2003 "The Durres regional archaeological project: archaeological survey in the territory of Epidamnos/Durres in Albania," *Hesperia* 72, pp. 41-119.

Degryse P.
2014 *Glass Making in the Graeco-Roman World*, Leuven.

Ducellier A.
1975 *La façade maritime de l'Albanie au Moyen Âge, Durazzo et Valona du XIe au XVe siècle*, Thessaloniki.

Duchesne L.
1892 "L'Illyricum ecclésiastique," *Byzantinische Zeitschrift* 1/3, Paris.

Fiori C.
2013 "Mosaic Tesserae from the Basilica of San Severo and glass production in Classe, Ravenna, Italy," in C. Entwistle, L. James (dir.), *New Light on Old Glass: Recent Research on Byzantine Mosaics and Glass*, London, pp. 33-41.

Fiori C., Vandini M., Mazzotti V.
2004 *I colori del vetro antico. Il vetro musivo bizantino*, Vicenza.

Foster H. E., Jackson C. M.
2005 "'A whiter shade of pale'? Chemical and experimental investigation of opaque white Roman glass gaming counters," *Glass Technology* 46/5, pp. 327-333.

Foy D.
2009 "Les revêtements muraux en verre à la fin de l'Antiquité : quelques témoignages en Gaule méridionale," *Journal of Glass Study* 50, pp. 51-65.

Foy D., Picon M., Vichy M., Thirion-Merle V.
2003 "Caractérisation des verres de la fin de l'Antiquité en Méditerranée occidentale : l'émergence de nouveaux courants commerciaux," in D. Foy, M.-D. Nenna (dir.), *Échanges et commerce du verre dans le monde antique (Actes du colloque de l'Association française pour l'archéologie du verre, Aix-en-Provence et Marseille, 7-9 juin 2001)*, Montagnac, pp. 41-85.

Freestone I. C.
2005 "The provenance of ancient glass through compositional analysis," *Materials Research Society Symposia Proceedings* 852, pp. 1-14.
2015 "The recycling and re-use of Roman glass: analytical approaches," *Journal of glass studies* 57, pp. 29-49.

Freestone I. C., Gorin-Rosen Y., Hughes M. J.
2000 "Primary glass from Israel and the production of glass in Late Antiquity and the early Islamic period," in M.-D. Nenna (dir.), *La route du verre. Ateliers primaires et secondaires du second millénaire av. J.C. au Moyen Âge*, Lyon, pp. 65-83.

Freestone I. C., Bailey J., Jackson C. (dir.)
2015 *Glass of the Roman world*, Oxford.

Gliozzo E.
2016 "The composition of colourless glass: a review," *Archaeological and Anthropological Sciences*, pp. 1-29, online (doi: 10.1007/s12520-016-0388-y).

Gliozzo E., Santagostino Barbone A., D'Acapito F., Turchiano M., Memmi Turbanti I., Volpe G.
2009 "The sectilia panels of Faragola (Ascoli Satriano, Southern Italy): a multi-analytical study of the green, marbled, blue and blackish glass slabs," *Archaeometry* 50/3, pp. 389-415.

Godoy C. Fernandez
1999 "Basilica de l'amfiteatre de Tarragona," in *Del Roma al Romanic*, Barcelona, pp. 177-179.

Gratuze B.
2000 "Annexe. Étude chimique des verres de l'atelier de Beyrouth," *Syria* 77, pp. 291-296.
2007 "La composition des verres de Xanthos," *Anatolia Antiqua* 15, pp. 247-254.
2016 "Glass characterization using laser ablation-inductively coupled plasma-mass spectrometry methods," in L. Dussubieux, M. Golitko, B. Gratuze (dir.), *Recent Advances in Laser Ablation ICP-MS for Archaeology*, Berlin / Heidelberg, pp. 179-196.

Gratuze B., Soulier I., Barrandon J.-N., Roy D.
1992 "De l'origine du cobalt dans les verres," *Revue d'archéometrie* 16/1, pp. 97-108.

Gutteridge A.
2003 "Cultural geographies and the ambition of Latin Europe: the city of Durres and its fortifications 400-1501," *Archeologia Medievale* 30, pp. 19-65.

Harding C.
1989 "The production of Medieval mosaics: the Orvieto evidence," *DOP* 43, pp. 73-102.

Henderson J.
2013 *Ancient Glass. An Interdisciplinary Exploration*, Cambridge.

Ivanovici V.
2014 "'Luce renobatus'. Speculations on the placement and importance of lights in Ravenna's Neonian Baptistery," in D. Mondini, V. Ivanovici (dir.), *Manipolare la luce in epoca premoderna / Manipulating light in premodern times*, Milano, pp. 19-29.
2016 *Manipulating Theophany. Light and Ritual in North-Adriatic Architecture (ca. 400-ca. 800)*, Berlin.

Jackson C. M.
2005 "Making colourless glass in the Roman period," *Archaeometry* 47, pp. 761-780.

James L.
2006 "Byzantine glass mosaic tesserae: some material considerations," *Byzantine and Modern Greek studies* 30/1, pp. 29-47.

Lachin M. T., Serra C. L., Silvestri A., Molin G. M.
2009 "Vitreous mosaic from Tyana (Cappadocia)," in *Late Antique/Early Byzantine glass in the Eastern Mediterranean*, Izmir, pp. 171-183.

Lahanier C.
1987 "Études des tesselles de mosaïques et de verre à vitre syriens," in M. T. Canivet, P. Canivet (dir.), *Huarte, sanctuaire chrétien d'Apamène : IVe-VIe s.* (Bibliothèque archéologique et historique, 122), Paris, pp. 331-346.

Lahlil S., Biron I., Galoisy L., Morin G.
2008 "Rediscovering ancient glass technologies through the examination of opacifier crystals," *Applied Physics A* 92, pp. 109-116.

Lahlil S., Cotte M., Biron I., Szlachetko J., Menguy N., Susini J.
2010 "Synthesizing lead antimonate in ancient and modern opaque glass," *Journal Analytical Acta Spectrometry* 26, pp. 1040-1050.

Maltoni S., Silvestri A.
2016 "Innovation and tradition in the fourth century mosaic of the Casa delle Bestie Ferite in Aquileia, Italy: archaeometric characterisation of the glass tesserae," *Journal of Anthropological and Archaeological Science*, online (doi:10.1007/s12520-016-0359-3).

Marii F.
2013 "Glass tesserae from the Petra Church," in C. Entwistle, L. James (dir.), *New Light on Old Glass: Recent Research on Byzantine Mosaics and Glass*, London, pp. 11-18.

Miraj L.
1988 "The new excavations in the amphitheatre of Durres," *Iliria* 2, pp. 264-265.
2013 *Dyrrachium in the Early Christian and Byzantine Period*, Tirane.

Nallbani H.
1974 "Mozaiku i Kishes se Amfiteatrit ne Durres," *Monumentet* 7-8, pp. 11-118.

Nallbani E.
2002 *La "civilisation de Komani" de l'Antiquité tardive au Haut Moyen Âge, VIe-IXe s.*, PhD Dissertation, University Paris 1 Panthéon Sorbonne, Paris.

Nenna M. D.
2007 "Production et commerce du verre à l'époque impériale : nouvelles découvertes et problématiques," *Facta* 1, pp. 125-147.
2014 "Egyptian glass abroad. HIMT glass and its markets," in D. Keller, J. Price, C. Jackson (dir.), *Neighbours and Successors of Rome: Traditions of Glass Production and Use in Europe and the Middle East in the Later 1st Millennium AD*, Oxford, pp. 178-193.

Neri E.
2016 *Tessellata vitrea in età tardoantica e altomedievale: produzione dei materiali e loro messa in opera. Considerazioni generali e studio dei casi milanesi*, Turnhout.
in press "Glass material of Roman and Byzantine mosaics from Butrint: distribution, supply, production and technology by SEM/EDS analysis," M. P. Raynaud (dir.), *Corpus of Mosaics from Albania I: Butrint*, Bordeaux, in press.

Neri E., Verità M.
2012 "La produzione di tessere musive a Milano tra IV e V sec.? Un'indagine archeologico-archeometrica," in A. Coscarella (dir.), *Il vetro in Italia: testimonianze, produzioni, commerci in età basso medievale. Il vetro in Calabria: vecchie scoperte, nuove acquisizioni (Atti delle XV Giornate Nazionali di studio sul vetro, Università della Calabria, 9-11 giugno 2011)*, Cosenza, pp. 15-32.
2013 "Glass and metal analyses of gold leaf tesserae from 1st to 9th century mosaics. A contribution to technological and chronological knowledge," *Journal of Archaeological Science* 40, pp. 4596-4606.

Neri E., Conventi A., Verità M.
2013 "Glass mosaic tesserae from the 5th-6th century baptistery of San Giovanni alle Fonti, Milan, Italy. Analytical investigations," in C. Entwistle, L. James (dir.), *New Light on Old Glass: Recent Research on Byzantine Mosaics and Glass*, London, pp. 1-10.

Neri E., Jackson M., O'Hea M., Gregory T., Blet-Lemarquand M., Schibille N.
2016 "Analyses of glass tesserae from Kilise Tepe: new insights and a reassessment of an early Byzantine production technology," *Journal of Archaeological Science. Reports* 11, pp. 600-612.

Neri E., Morvan C., Colomban Ph., Guerra M. F., Prigent V.
2017a "Late Roman and Byzantine mosaic opaque 'Glass-ceramics' Tesserae (5th-9th century)," *Ceramics International* 42/16, pp. 18859-18869.

Neri E., Gratuze B., Schibille N.
2017b "Dating the mosaics of the Durres amphitheatre through interdisciplinary analysis," *Journal of cultural heritage*, online (doi.org/10.1016/j.culher.2017.05.003).

Neri E., Biron I., Verità M.
in press "A lost mosaic (6th-9th c.) from Hierapolis (Turkey): PIXE/PIGE and SEM/EDS analysis of glass tesserae," *Archaeological and anthropological science*.

Nilgen U.
1981 "Maria Regina. Eine politischer Kultubildtypus?," *Romishes Jarburch fur Kunstgeshichte* 19, pp. 1-33.

Nordhagen J.
1990 "Gli effetti prodotti dall'uso dell'oro, dell'argento e di altri materiali nell'arte musiva dell'alto Medioevo," in J. Nordhagen (dir.), *Studies in Byzantine and Early Medieval Painting*, London, pp. 131-143.

Pace V.
2001 "Between East and West," in M. Vassilaki (dir.), *Mother of God: Representations of the Virgin in Byzantine art*, Milano, p. 425, n. 3.
2003 "Mosaici e pittura in Albania (VI-XIV secolo). Stato degli studi e prospettive di ricerca," in M. Buora (dir.), *Progetto Durres: l'indagine sui beni culturali albanesi dell'antichità e del Medioevo – tradizioni di studio a confronto (Atti del primo incontro scientifico, Parma-Udine, 19-20 aprile 2002)*, Trieste, pp. 93-128.

Pentcheva B.
2006 *Icons and Power: The Mother of God in Byzantium*, University Park of Pennsylvania State.

Phelps M., Freestone I. C., Gorin-Rosen Y., Gratuze B.
2016 "Natron glass production and supply in the late Antique and early Medieval Near East: the effect of the Byzantine-Islamic transition," *Journal of Archaeological Science* 75, pp. 57-71.

Piazza S.
2010 "Mosaïques en façade des églises de Rome (XIIe-XIIIe siècles) : renaissance d'un modèle paléochrétien," *Hortus Artium Medievalium* 16, pp. 137-150.

Rosenow D., Rehren Th.
2014 "Herding cats – Roman to Late Antique glass groups from Bubastis, northern Egypt," *Journal of Archaeological Science* 49, pp. 170-184, online (doi: https://doi.org/10.1016/j.jas.2014.04.025).

Runis-Jandot J.
1983 "La mosaïque murale dans la chapelle de l'amphithéâtre de Dyrrachium," *Iliria* 1, pp. 229-232.

Santoro S.
2003 "Lo stato degli studi sull'urbanistica di Epidamnos-Dyrrachion," in M. Buora (dir.), *Progetto Durres: l'indagine sui beni culturali albanesi dell'antichità e del Medioevo – Tradizioni di studio a confronto (Atti del primo incontro scientifico, Parma-Udine, 19-20 aprile 2002),* Trieste, pp. 93-128.

Santoro S., Hoti A., Sassi B. (dir.)
2005 *L'anfiteatro romano di Durazzo. Studi e scavi. 2004-2005* (Annuario della Scuola archeologica di Atene e delle Missioni Italiane in Oriente 83, serie III, 5, II), Athens, pp. 717-806.

Schibille N.
2011 "Supply routes and the consumption of glass in first millennium CE Butrint (Albania)," *Journal of Archaeological Science* 38, pp. 2939-2948.

Schibille N., McKenzie J.
2011 "Glass tesserae from Hagios Polyeuktos, Constantinople: their early Byzantine affiliations," in D. Keller, J. Price, C. Jackson (dir.), *Neighbours and Successors of Rome: Traditions of Glass Production and Use in Europe and the Middle East in the Later 1st Millennium AD.*, Oxford, pp. 114-127.

Schibille N., Degryse P., Corremans M., Specht Ch.
2012 "Chemical characterisation of glass mosaic tesserae from sixth-century Sagalassos (south-west Turkey): chronology and production techniques," *Journal of Archaeological Science* 39, pp. 1480-1492.

Schibille N., Meek A., Tobias B., Entwistle C., Avisseau-Broustet M., Da Mota H., Gratuze B.
2016a "Comprehensive chemical characterisation of Byzantine glass weights," *PlosONE* 11/12, online, e0168289 (doi: 10.1371/journal.pone.0168289).

Schibille N., Sterrett-Krause A., Freestone I. C.
2016b "Glass groups, glass supply and recycling in Late Roman Carthage," *Archaeological and Anthropological Sciences*, pp. 1-19, online (doi: 10.1007/s12520-016-0316-1).

Silvestri A., Tonietto S., Molin G.
2011 "The Paleo-Christian glass mosaic of St. Prosdocimus (Padova, Italy): archaeometric characterisation of 'gold' tesserae," *Journal of Archaeological Science* 38, pp. 3402-3414.

Silvestri A., Tonietto S., Molin G. M., Guerriero P.
2012 "The Paleo-Christian glass mosaic of St. Prosdocimus (Padova, Italy): archaeometric characterisation of tesserae with antimony- or phosphorus-based opacifiers," *Journal of Archaeological science* 39, pp. 2177-2190.
2014 "The Paleo-Christian glass mosaic of St. Prosdocimus (Padova, Italy): archaeometric characterisation of tesserae with copper- or tin-based opacifiers," *Journal of Archaeological Science* 42, pp. 51-67.

Silvestri A., Nestola F., Peruzzo L.
2016 "Multi-methodological characterisation of calcium phosphate in late-Antique glass mosaic tesserae," *Microchemical Journal* 124, pp. 811-818.

Tal O., Jackson-Tal E., Freestone I. C.
2004 "New evidence of the production of raw glass at late Byzantine Apollonia-Arsuf, Israel," *Journal of Glass Studies* 46, pp. 51-66.

Tedeschi C.
2013 "Mosaics and materials," in L. James, C. Entwistle (dir.), *New Light on Old Glass: Recent Research on Byzantine Mosaics and Glass,* London, pp. 60-29.

Terry A., Maguire H.
2007 *Dynamic splendour. The wall mosaics in the cathedral of Eufrasius in Porec*, Poreč.

Thierry N.
1975 "À propos de la mosaïque murale de Durrës," *Archéologia* 83, pp. 60-62.

Tiberia V.
1996 *I mosaici del XII secolo e di Pietro Cavallini in Santa Maria in Trastevere: restauri e nuove ipotesi*, Todi.

Toçi V.
1971 "Amfiteatri i Dyrrahit," *Monumentet* 2, pp. 37-41.
1975 "Amfiteatri i Durresit," *Monumentet* 6, pp. 42-46.

Vandini M., Arletti R., Cirelli E.
2014 "Five centuries of mosaic glass at Saint Severus (Classe, Ravenna)," *Ocnus* 22, pp. 91-108.

Vataj E., Hobdari E., Röhrs S., Vandenabele P., Civici N.
2017 "Analytical Characterization of glass tesserae from mosaics of Early Christian basilicas in Albania," *Applied Physics A* 123/76, online (doi: 10.1007/s00339-016-0661-z).

Verità M.
2000 "Tecniche di fabbricazione dei materiali musivi vitrei: indagini chimiche e mineralogiche," in E. Borsook (dir.), *Medieval Mosaics, Light, Color, Materials (Giornata di studi, Firenze, 1 May 1998)*, Cinisello B., pp. 47-64.
2011 "Tessere vitree del battistero Neoniano: tecniche e provenienza," in C. Muscolino, A. Ranaldi, C. Tedeschi (dir.), *Il battistero Neoniano. Uno sguardo attraverso il restauro*, Ravenna, pp. 73-87.
in press "I materiali vitrei dei mosaici parietali a Roma tra IV e XIII secolo: tecnologia e degrado," in M. Andaloro (dir.), *I mosaici di Roma nei cantieri di restauro dell'ICR*, Istituto Superiore per la Conservazione e il Restauro, Roma.

Verità M., Santopadre P.
1993 "Le analisi delle tessere musive vitree: esempi d'applicazione nelle indagini preliminari al restauro del mosaico absidale della Cappella dei Santi Primo e Feliciano," in G. Basile, A. Pandolfi, B. Mazzone, C. Prosperi Porta, M. S. D'Urbano, P. Bianchetti, B. Profilo, P. Santopadre, M. Verità, E. Anselmi, C. D'Angelo, C. Mora, "Il restauro del mosaico di S. Stefano Rotondo a Roma," *Arte Medievale* 1, pp. 197-228.

Verità M., Profilo B., Vallotto M.
2002 "I mosaici della basilica dei santi Cosma e Damiano a Roma: studio analitico delle tessere vitree," *Rivista della Stazione Sperimentale del Vetro* 5, pp. 13-23.

Verità M., Vallotto M.
2003 "Analisi delle tessere musive," in V. Tiberia (dir.), *Il mosaico di Santa Pudenziana a Roma. Il restauro*, Todi, pp. 178-199.

Verità M., Rapisarda S.
2008 "Studio analitico di materiali musivi vitrei del XII-XIII secolo dalla Basilica di Monreale a Palermo," *Rivista della stazione sperimentale del vetro* 2, pp. 15-29.

Verità M., Arena M. S., Carruba A. M., Santopadre P.
2009 "Materiali vitrei nell'opus sectile di Porta Marina (Ostia Antica)," *Bollettino dell'Istituto Centrale del Restauro* n.s. 16-17, pp. 78-94.

Verità M., Maggetti M., Saguì L., Santopadre P.
2013 "Colors of Roman glass: an investigation of the yellow sectilia in the Gorga Collection," *Journal of Glass Studies* 55, pp. 21-34.

Verità M., Zecchin S.
2012 "Scientific investigations of byzantine glass tesserae from the mosaics on the south chapel of Torcello's Basilica, Venice," in D. Ignatiadou, A. Antonaras (dir.), *Annales du 18e Congrès de l'Association internationale pour l'histoire du verre (Thessaloniki, septembre 2009)*, Thessaloniki, pp. 315-320.

Wypyski M. T.
2005 "Technical analysis of glass mosaic tesserae from Amorium," *DOP* 59, pp. 183-192.

Wypyski M. T., Becker L.
2005 "Glassmaking technology at Antioch," in L. Becker, Ch. Kondoleon (dir.), *Glassmaking Technology at Antioch*, in *The Arts of Antioch*, Worcester, pp. 115-175.

Zecchin S.
1990 *Vetro e vetrai di Murano. Studi sulla storia del vetro*, Venezia.