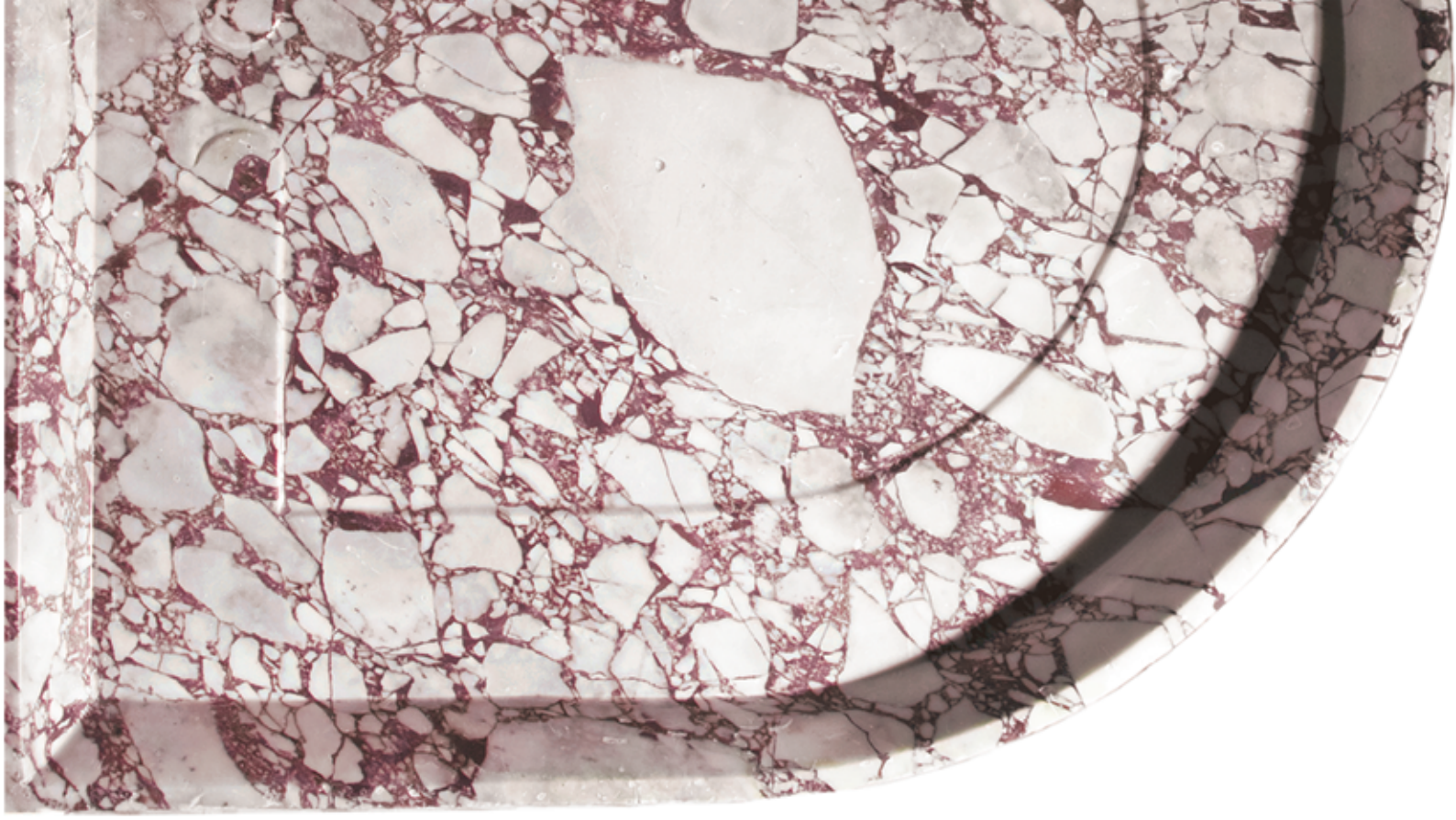
# The Use of Limestones as Construction Materials for the Mosaics of Diocletian's Palace

**Matulić, Branko; Mudronja, Domagoj; Bosnić, Krešimir**



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## Interdisciplinary Studies on Ancient Stone

# PROCEEDINGS

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# CONTENT

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# THE USE OF LIMESTONES AS CONSTRUCTION MATERIALS FOR THE MOSAICS OF DIOCLETIAN'S PALACE

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**Abstract**

The production of the mosaic core of the Diocletian's palace in Split is attributed to the Salonitan mosaic workshop. A previous comparative analysis of individual samples of mosaic components and certain decorative motifs done according to a catalogue model (a globally accepted scientific method) has proven that thesis.
To make progress in this research, with the goal of continued examination of influence models of the same mosaic workshop, research and mapping of the materials utilized is required, in which limestone, marble and dolomite dominate quantitatively. This article gives the results of the first (pilot) laboratory processing and a comparison of several mosaics' structural matter in Diocletian's Palace. The broader agenda of the article is to form catalogues of the materials used and to map their distribution inside the Salonitan workshop's area of influence.

*Keywords*
mosaic, Salonitan mosaic workshop, Diocletian's palace

## Introduction

Remains of mosaics, no matter which way we look at them – as a craft or art, are very frequent inside the Roman province of Dalmatia. This has been confirmed by findings of mosaic remains within archeological research in this area. The collection of mosaics known to us today counts as many as 650 catalogued examples, and it is certain that not all findings have been noted in the scholarly literature, or in any other publicly available source. . Keeping in mind the quantity of what was found, it was hypothesized that there was in the province a school or workshop, responsible for this enormous amount of production, or at least most of the work which we are acquainted with today.[1]

In the middle of the 1990s, a systematic, catalogue treatment of mosaic findings inside the province began, based on an internationally acknowledged form and approach in analyzing mosaic samples, different from the previous ways in which they were published and interpreted[2]. These earlier interpretations were quite subjective and based on personal whims, making it hard to realise that the different authors were describing the same mosaic finding with a given artistic display. [3]

By contrast, the catalogue of artistic displays on mosaics, with the acronym DÉCOR[4], uses a name (worded description) for each sample, and also assigns a combined – alphanumeric code. The beginning of analysis and examination according to this sample catalogue, after a more careful look, provided a new perspective on and interpretation of data known earlier. From this new interpretation came interesting insights into the structure and frequency of the motives, that is, the topographical relations between mosaic samples and the orientation of a certain area from the province according to influences from other areas of the Empire. The conclusion to the interpretation and analysis is that the source of a large number of mosaics and the overall production was the center of the province itself – the city of Salona, which is also a testament to the existence of the Salonitan mosaic school

1 The thesis was presented by several researchers, among which the most significant contribution was made by dr. sc. Marija Buzov and prof. dr. sc. Branko Matulić. See: BUZOV 1985; MATULIĆ 1995; JELIČIĆ-RADONIĆ 2003, 513-52.

2 That graphic and descriptive form was established by the international association for research and examination of Ancient mosaics "Association internationale pour l'etude de la Mosaique antique" (A.I.E.M.A.), which counts over 350 members, people or organizations, across the globe.

3 An exception was prof. dr. sc. Branko Matulić, whose master's thesis and afterwards doctorate and later works took the form of artistic analysis of mosaics, presented in the catalogues "Bulletin de l'AIEMA" (abb. BAIEMA) and "La decor geometrique da la mosaique Romaine" (abb. DÉCOR); MATULIĆ 1994, the same, 2000.

4 DECOR 2002.

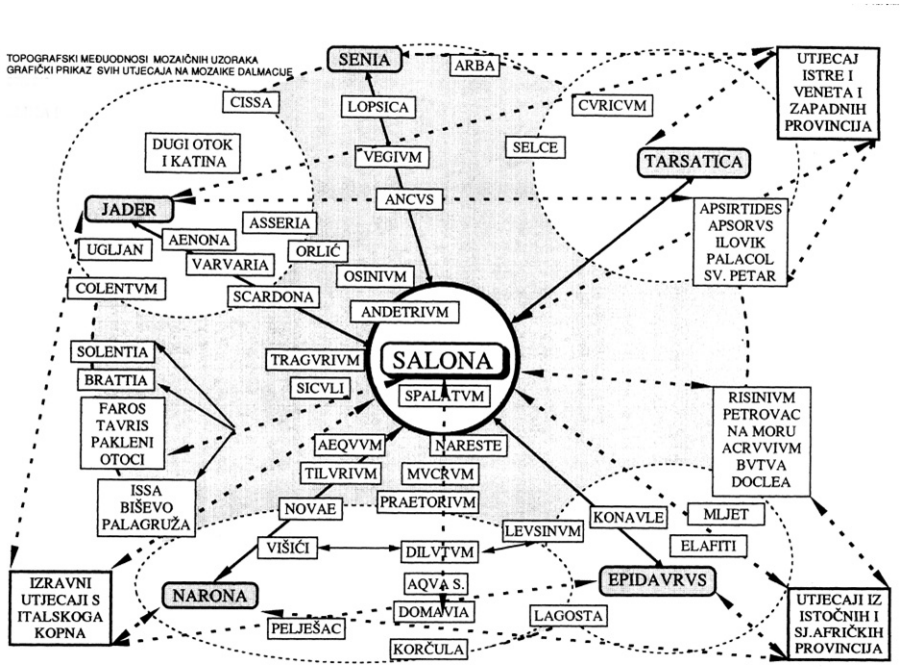


Fig. 1.
Topographic relations of mosaic samples; graphic depiction of all the influences on the mosaics of the province of Dalmatia

or workshop, although there are mosaic findings which predate the time of influence of this workshop. (Fig. 1)

What is not known or understood with clarity about the workshop is the exact time of its founding, the scope of its work and influence, while the specifications of its work in the choice of motives or materials can be defined only circumstantially.[5]

Even though we cannot speak of the exact time of its founding, the start of its influence can probably be assigned to the 2nd century A.D.; and we can follow its most exemplary pieces during the third century, and in the phase of Antiquity, that is, from the fifth to the sixth century during Early Christianity, while its decline probably came in the seventh century, as suggested by there being so few examined samples of mosaics in the Middle Ages in the workshop's sphere of influence.

**Motivation of the research**

Since no significant discoveries have been made in the area of the Roman province of Dalmatia since the last cataloguing capable of making an impact on the knowledge attained through earlier means of examination of the Salonitan school, other methods of studying and analyzing the available materials are needed, for the sake of the development of a pool of information about previously known findings and the acquisition of new knowledge through careful examination of findings already known.

This attitude resulted in the idea of creating a catalogue of the materials used to assemble mosaics in the wider Salona area, that would include not only the city but also nearby localities within its sphere of influence. Since it is in the nature of all ancient craft workshops (whether they are Greek or Roman) to use more or less same sources of material once they are found, the assumption that the same practice would have been resorted to during the acquisition of materials for mosaics to be produced by the Salonitan workshop is logical.

What is specific about the mid-Dalmatian area is the abundance of quarries that exploit white limestones,[6] but there are far fewer quarries that produce black, brown, red, yellow or green stone. Because of this limited availability of resources, it is easier to assume and, eventually, determine their origin and connect the quantity of use of a certain material with the tendencies, that is, preferences of a certain workshop in its use (Fig. 2). Analogously, the specific use of white limestones is hard to assign to any workshop or crafting circle, because these materials are available in great quantity and with similar quality. However, the possibility that a certain workshop owned some of the smaller quarries or worked with a quarry through a longer period should not be underestimated, so the frequency of white limestone usage could also be indicative, if it is proven from a sufficient amount of samples.

5 MATULIĆ 2011, 167-170.

6 PARICA 2012, 345-353.; POPOVIĆ 2012; KATIĆ 2009; BUZOV 2009, 628, 629; DONELLI *et al.* 2009; ZANINOVIĆ 1997, 37-45.


Fig. 2.
Distribution of the relevant quarries in the former Roman province of Dalmatia

Following the study on the works carried out by the Salonitan mosaic workshop, it is especially interesting to study the Diocletian Palace mosaics. Decorating a building of such significance could not have been entrusted to just any workshop, and by the end of the 3rd century, the Salonitan workshop has already established a notable reputation.[7]

Apart from the obvious reasons, it is important to mention that just a small portion of the excavated mosaics attributed to the Salonitan school is available to the public today. Besides two of the major mosaics within Diocletian's palace, mosaics exhibited at the Archaeological Museum, and some of the mosaics visible at the sites, the rest of them have been reburied, not presented, and thus are unavailable for sampling.

It is unquestionable that all the mosaics produced for Diocletian's Palace have not been saved, especially when it is borne in mind that archaeological campaigns have often found only piles of tesserae, or small, sporadic remains. Such remains survived at the dome of Vestibul, two of which were strapped and conserved at the Archaeological Museum store in 1898 by Don Frane Bulić.[8]

At the intersection of Bulićeva Street with the ancient decumanus, the remains of a building that had a courtyard and a portico have been discovered. Recent research assumed that the building was a part of a vast thermae complex, and when the ancient mosaics within were uncovered, a lot of scattered, gilded glass paste tesserae were found, probably a part of a wall or vault decoration. Today, only a part of the preserved mosaic is presented, since the adjacent buildings cover the rest (as shown by the original research).

Not far from this mosaic, right next to the Vestibule on the eastern side, lies a mosaic from the same period, excavated in 1905, and re-excavated in 1963. The latter research recognized the mosaic as a part of the courtyard, that is, a porticus surrounding an ancient building from three sides, completely paved with mosaic. Today, only a part of the northern pavement is presented, the western being disrupted by a medieval street then then continuing in the ground floor of a Roman house, where a part of the southern pavement is also visible.[9]

Since both of the mosaics are visible (exposed

7 Some examples of their executions would be a mosaic depicting the Nine Muses, found in the remains of Roman baths covered by a complex of Christian edifices. Other such examples would be a mosaic depicting Orpheus, which is dated to the 3rd century, mosaics with the image of Triton and Apollo as well as mosaics in Stari Grad on Hvar, found in Srednja ulica (Srinjo kola).

8 JELIČIĆ - RADONIĆ 1999/2000, 62; MATULIĆ 2005, 228.

9 MATULIĆ 2005, 228, which is refering to BULIĆ 1908, NIEMANN 1910, HEBRARD-ZEILLER 1921, BULIĆ - KARAMAN 1927; MARASOVIĆ - MARASOVIĆ 1965; MARASOVIĆ 1967; MARASOVIĆ - MARASOVIĆ 1968; MARASOVIĆ *et al.* 1972., JOVANOVIĆ 1974, SMITH 1979, MEDER 1980; ČREMOŠNIK 1984; BUZOV 1985; BUZOV *et al* 1987; MARASOVIĆ 1989; MARIN - KIRIGIN 1989; BUZOV 1991; MARASOVIĆ 1994; CAMBI 1994; KOLARIK 1994; MATULIĆ 1994/1995; BELAMARIĆ 1997; MEDER 2003.


Fig. 3. Laboratory sample No. 19853 (photo: D. Mudronja)


Fig. 4. Laboratory sample No. 19856, variety A (photo: D. Mudronja)

to the public view), it is necessary to undertake regular maintenance, and conservation campaigns. This also enables study and research on them to take place, mainly undertaken by the Croatian Conservation Institute, while the Arts Academy Section for conservation-restoration participates occasionally.

Sampling and petrographic - mineral analysis of the black, red and green tesserae, a specific type of material present in both of the mosaics, started with the sampling of both mosaics. This method was selected because of its availability at the moment, being the only suitable to estimate the potential of this pioneering attempt of cataloguing and mapping. In the following phases (which will, it is hoped, occur in the near future) it will be necessary to include other nuclear and spectroscopic techniques of analysis, and also to form a public information base for dissemination of the research data.

Quarries with similar materials that were assumed to be active during Antiquity were sampled along with them, and the material found was mainly not widely spread over the province, but specific to a certain area (to microlocations). Such quarries are Dolac, where Zeleni Jadran green stone is still quarried, a quarry in the village of Velić, near the Roman castrum of Tilurium, from where the rough black, low quality building stone was quarried up to a recent date, and the small quarry of Kamenari in Montenegro, near Boka Kotorska, where a red stone is excavated and used mainly for masonry.

Petrographic-mineral analysis was undertaken by macroscopic observation, and the observation of the ground samples under polarizing light. It is important to mention that the results of only six samples are now published, while analysis of the complete mosaic material of the available mosaics is planned, as a part of a wider project dealing with the creation of a reference catalogue of materials and their distribution over mosaics within the province.

## Samples

| LAB. NUMBER | SAMPLING LOCATION | COLOUR | CODE |
|---|---|---|---|
| 19853 | Dolac Donji quarry | Green | DOLAC_Z_1 |
| 19854 | Mosaic, Bulićeva Street | Black | BUL_C_1 |
| 19855 | Mosaic, Arhiđakonova Street | Red | ARC_CR_1 |
| 19856 | Mosaic, Arhiđakonova Street | Green | ARC_Z_1 |
| 19857 | Velić quarry | Black | VELIC_C_1 |
| **19858** | Kamenari quarry | Red | BOKA_CR_1 |

## Analysis results

Sample lab. No. 19853 (Fig. 3)

Homogenous, grainy structure, made of well-sorted particles, dominantly bioclastic; strong reaction with diluted HCl – which implies limestone composition

Description of the microscopic sample - examination of the microscopic sample identified a homogenous, grainy structure, made of thickly packed bioclasts. Bioclastic material dominates its composition, and is mainly made of benthic foraminifera fragments (*Discocyclina* sp., *Operculina* sp., *Rotalia* sp., *Nummulites* sp.), fragments of red algae, briozoa, and a smaller amount of shells. Plankton foraminifera appear sporadically (*Globigerinatheka* sp.). Completely preserved foraminifera appear sparsely, and are mostly

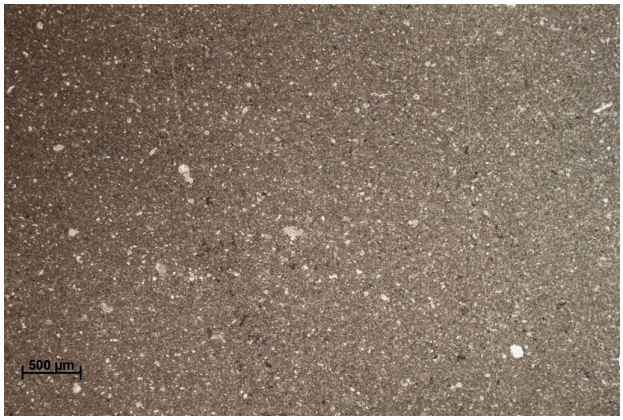


Fig. 5. Laboratory sample No. 19858 (photo: D. Mudronja)

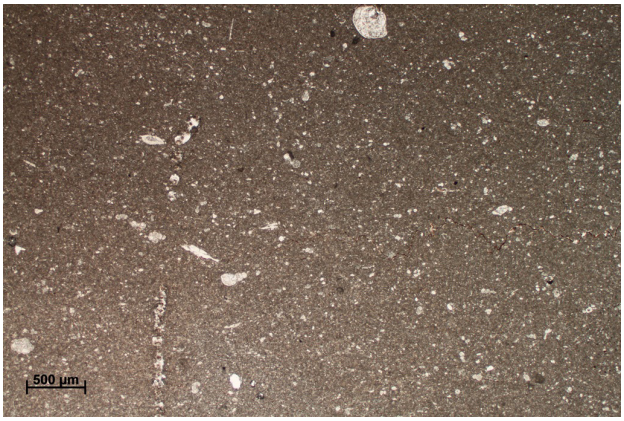


Fig. 6. Laboratory sample No. 19855 (photo: D. Mudronja)

fragmented, which suggests their redistribution at some point. Among non-skeletal particles, pelloid grains have been noted. Size of the clast is within the interval of coarse-grained sandstone. Considering the noted characteristics of the composition and the structure, the sample can be determined as bioclastic (foraminifer) limestone, originating from the Eocene, most likely a part of the flysch formation.

Based on its characteristics, the sample was defined as bioclastic foraminiferic limestone, from the geological age of Eocene.

Sample lab. No. 19856

Seven mosaic tesserae, all of which cause a strong reaction with diluted HCl – limestones;

After examination of all of the seven tesserae, two varieties of grainstone packstone, with smaller and bigger grains, were selected for sample preparation.

Variety A: bioclastic material made of thickly packed, mostly fragmented bioclasts of Eocene benthic foraminifera (*Discocyclina* sp., *Operculina* sp., *Rotalia* sp., *Nummulites* sp.), echinoderms, shells, Briozoi, and sporadically planktonic foraminifera (*Globigerinatheka* sp.) Based on all of the observed characteristics, the sample was identical to sample 19853, identified as bioclastic foraminipheric limestone, from the geological age of Eocene. (Fig. 4)

Variety B features a fine-grained, homogenous structure, made of calcite particles (most likely skeletal karst), peloid in its grainy support. Angular grains of quartz, uniformly darkened, appear sporadically. According to particle size, this is classified as a fine-grained sandstone. The sample was identified as biocalcarenite.

Sample lab. No. 19858 (Fig. 5)

Brownish, strong reaction with diluted HCl - limestone; predominantly small grained micritic material, with significant traces of bioturbation; broken surface is convex –concave, without gloss.

Within the micritic material (base), there are some (sporadically) scattered planktonic foraminifera, preserved and fragmented, most likely the Upper Cretaceous group of planktonic foraminifers. Material was defined as biomicrite wackestone.

Sample lab. No. 19855 (Fig. 6)

Seven small tesserae, from among which two brownish varieties were extracted: a strong reaction with diluted HCl is present in all of them – limestones.

One of the varieties was characterised a with micrite base within rarely distributed planktonic foraminifera. Few of them were completely conserved (mostly fragmented in tiny calcite particles). Based on its characteristics, this variety is an exact match with sample 19858.

The material can be defined as biomicrite wackestone.

Sample lab. No. 19857 (Fig. 7)

Dark, black sample, strong reaction with diluted HCl – limestone; a sugary-looking fracture – most likely the result of recrystallization, the sawn and polished surface reveals a nonhomogeneous structure formed as irregular clasts, originating from *in situ* clastic sedimentation.

Clasts are of centimetre dimensions, slightly round edged but irregular, while interstices are filled with tiny grained grainstone – packestone material (grey coloured).

A homogenous, finely crystalline structure, made of anhedral calcite crystal can be noticed. Sporadically, nests filled with quite large sparite crystals can be perceived (most likely the sparite fillings of the cavities, occurring during the meltdown in diagenesis, suggesting recrystallization with destruction of primary limestone structure. Material is defined as recrystallized limestone. (Fig. 9)

Sample lab. No. 19854 (Fig. 8)

Five tesserae, all of which are limestones, reacted intensively with diluted HCl, prevalently tiny grained packstones to wackstones. Observing the microscopic

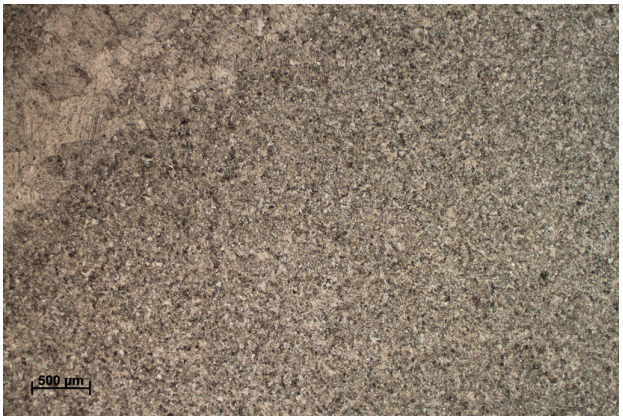


Fig. 7. Laboratory sample No. 19857 (photo: D. Mudronja)

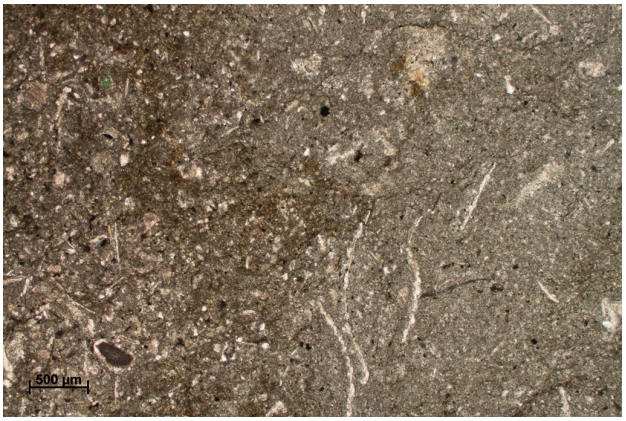


Fig. 8. Laboratory sample No. 19854 (photo: D. Mudronja)

specimen a mostly tiny-grained but non homogeneous structure due to bioturbation was noticed. The base is made of micritic material mixed with tiny calcite particles. Elongated, straight to slightly bent bioclasts are spread all over the base (most likely the remains of tiny shells and echinoderms). The material went through the process of bioturbation (hence its non-homogenous structure). A small portion of the specimen is characterised by more micritic material, without tiny calcite particles, also filled with elongated skeletal remains of shells, and by all odds, echinoderms. A microsparite component with a significant amount of brown limonite matter is present within some regions. Based on all of its characteristics, the material is defined as biomicritic packstone to wackstone.


Fig. 9. Laboratory sample No. 19857, magnified (photo: D. Mudronja)

## Conclusion

As for the properties of the materials, the analysis of the samples suggested the following

Green tesserae of the Arhiđakonova street mosaic (19856) are made of two varieties, one of which is identical to a Dolac Donji quarry, while the other is not similar (marked as variety A).

Red tesserae of the Arhiđakonova Street mosaic (19855) are also made of two varieties, one of which is identical to a Boka quarry sample (marked as variety B). Black tesserae samples (19854) are not similar to the Velić quarry.

The analysis done was just a test to discover if it was plausible to assume that most of the materials used by the Salonitan mosaic workshop were local. Determining and connecting the well known quarries from Salona's area of influence to its mosaic materials would, however enable a wider project. Forming a catalogue, and/or mapping the materials used would, of a necessity, require the use of further petrographic mineral, nuclear and spectroscopic identification methods. Once the base of the materials used takes shape, it will be easier and more accurate (combined with previous methods of identification) to assign a certain mosaic to a certain workshop and period.

Material bases are a prerequisite for many other studies of the crafts from Antiquity. So far, we do not have any usable material databases for the study of ancient mosaics in Croatia. Furthermore, we also do not have material bases to compare to similar databases largely made abroad. The first step to that goal was taken in this research, which can be described as a pioneering but obviously deficient attempt towards cataloguing and mapping the stones used in Salona during antiquity. Nevertheless, if we manage to emphasise the need for such a project, and spark the interest of scientific disciplines working towards the same purpose within Croatia's scholarly and professional network, then no effort will have been in vain.

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