

# Restoration of the Peristyle of Diocletian's Palace in Split

---

**Nikšić, Goran**

*Source / Izvornik:* **ASMOSIA XI, Interdisciplinary Studies on Ancient Stone, Proceedings of the XI International Conference of ASMOSIA, 2018, 863 - 870**

**Conference paper / Rad u zborniku**

*Publication status / Verzija rada:* **Published version / Objavljena verzija rada (izdavačev PDF)**

<https://doi.org/10.31534/XI.asmosia.2015/08.05>

*Permanent link / Trajna poveznica:* <https://um.nsk.hr/um:nbn:hr:123:763871>

*Rights / Prava:* [In copyright](#) / [Zaštićeno autorskim pravom.](#)

*Download date / Datum preuzimanja:* **2024-04-25**



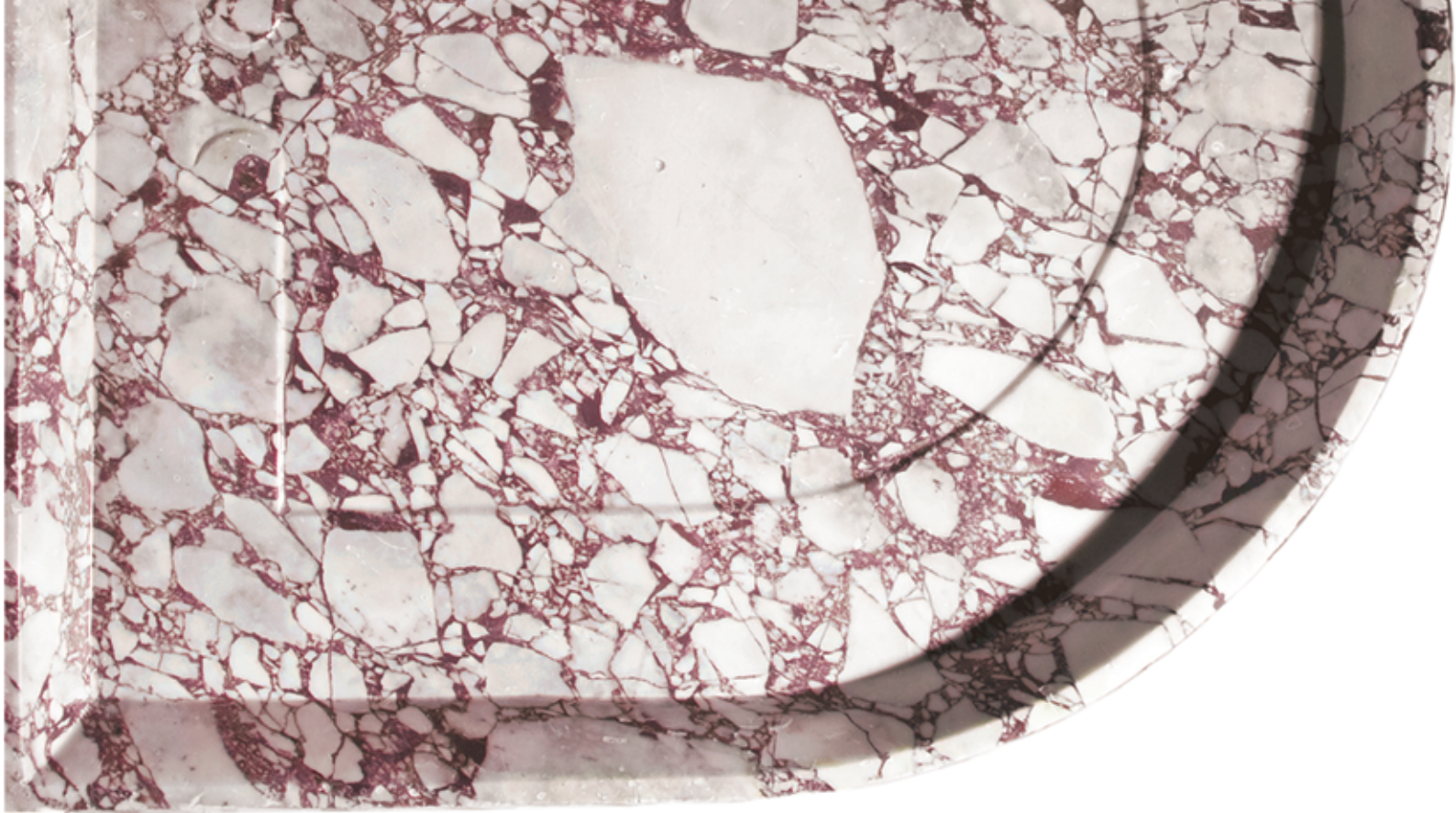
*Repository / Repozitorij:*

[FCEAG Repository - Repository of the Faculty of Civil Engineering, Architecture and Geodesy, University of Split](#)



UNIVERSITY OF SPLIT

  
DIGITALNI AKADEMSKI ARHIVI I REPOZITORIJI



# ASMOSIA XI

Interdisciplinary Studies on Ancient Stone

## PROCEEDINGS

of the XI ASMOSIA Conference, Split 2015

Edited by Daniela Matetić Poljak and Katja Marasović

Interdisciplinary Studies on Ancient Stone  
Proceedings of the XI ASMOSIA Conference (Split 2015)

Publishers:

ARTS ACADEMY IN SPLIT  
UNIVERSITY OF SPLIT

and

UNIVERSITY OF SPLIT  
FACULTY OF CIVIL ENGINEERING,  
ARCHITECTURE AND GEODESY

Technical editor:  
Kate Bošković

English language editor:  
Graham McMaster

Computer pre-press:  
Nikola Križanac

Cover design:  
Mladen Čulić

Cover page:

*Sigma shaped mensa of pavonazzetto marble from Diocletian's palace in Split*

ISBN 978-953-6617-49-4 (Arts Academy in Split)

ISBN 978-953-6116-75-1 (Faculty of Civil Engineering, Architecture and Geodesy)

e-ISBN 978-953-6617-51-7 (Arts Academy in Split)

e-ISBN 978-953-6116-79-9 (Faculty of Civil Engineering, Architecture and Geodesy)

CIP available at the digital catalogue of the University Library in Split, no 170529005



Association for the Study of Marble & Other Stones in Antiquity

# ASMOSIA XI

## Interdisciplinary Studies of Ancient Stone

Proceedings of the Eleventh International Conference of ASMOSIA,  
Split, 18–22 May 2015

Edited by  
Daniela Matetić Poljak  
Katja Marasović



Split, 2018

**Nota bene**

All papers are subjected to an international review.

The quality of the images relies on the quality of the originals provided by the authors.

# CONTENT

<b>PRESENTATION</b> .....	15
<b>NECROLOGY: NORMAN HERZ (1923-2013) by Susan Kane</b> .....	17
<b>1. APPLICATIONS TO SPECIFIC ARCHEOLOGICAL QUESTIONS – USE OF MARBLE</b>	
Hermaphrodites and Sleeping or Reclining Maenads: Production Centres and Quarry Marks <i>Patrizio Pensabene</i> .....	25
First Remarks about the Pavement of the Newly Discovered Mithraeum of the Colored Marbles at Ostia and New Investigations on Roman and Late Roman White and Colored Marbles from Insula IV, IX <i>Massimiliano David, Stefano Succi and Marcello Turci</i> .....	33
Alabaster. Quarrying and Trade in the Roman World: Evidence from Pompeii and Herculaneum <i>Simon J. Barker and Simona Perna</i> .....	45
Recent Work on the Stone at the Villa Arianna and the Villa San Marco (Castellammare di Stabia) and Their Context within the Vesuvian Area <i>Simon J. Barker and J. Clayton Fant</i> .....	65
Marble Wall Decorations from the Imperial Mausoleum (4 <sup>th</sup> C.) and the Basilica of San Lorenzo (5 <sup>th</sup> C.) in Milan: an Update on Colored Marbles in Late Antique Milan <i>Elisabetta Neri, Roberto Bugini and Silvia Gazzoli</i> .....	79
Sarcophagus Lids Sawn from their Chests <i>Dorothy H. Abramitis and John J. Herrmann</i> .....	89
The Re-Use of Monolithic Columns in the Invention and Persistence of Roman Architecture <i>Peter D. De Staebler</i> .....	95
The Trade in Small-Size Statues in the Roman Mediterranean: a Case Study from Alexandria <i>Patrizio Pensabene and Eleonora Gasparini</i> .....	101
The Marble Dedication of Komon, Son of Asklepiades, from Egypt: Material, Provenance, and Reinforcement of Meaning <i>Patricia A. Butz</i> .....	109
Multiple Reuse of Imported Marble Pedestals at Caesarea Maritima in Israel <i>Barbara Burrell</i> .....	117
Iasos and Iasian Marble between the Late Antique and Early Byzantine Eras <i>Diego Peirano</i> .....	123

Thassos, Known Inscriptions with New Data <i>Tony Kozelj and Manuela Wurch-Kozelj</i> .....	131
The Value of Marble in Roman <i>Hispalis</i> : Contextual, Typological and Lithological Analysis of an Assemblage of Large Architectural Elements Recovered at N° 17 Goyeneta Street (Seville, Spain) <i>Ruth Taylor, Oliva Rodríguez, Esther Ontiveros, María Luisa Loza, José Beltrán and Araceli Rodríguez</i> .....	143
<i>Giallo Antico</i> in Context. Distribution, Use and Commercial Actors According to New Stratigraphic Data from the Western Mediterranean (2 <sup>nd</sup> C. Bc – Late 1 <sup>st</sup> C. Ad) <i>Stefan Ardeleanu</i> .....	155
<i>Amethystus</i> : Ancient Properties and Iconographic Selection <i>Luigi Pedroni</i> .....	167
<b>2. PROVENANCE IDENTIFICATION I: (MARBLE)</b>	
Unraveling the Carrara – Göktepe Entanglement <i>Walter Prochaska, Donato Attanasio and Matthias Bruno</i> .....	175
The Marble of Roman Imperial Portraits <i>Donato Attanasio, Matthias Bruno, Walter Prochaska and Ali Bahadır Yavuz</i> .....	185
Tracing Alabaster (Gypsum or Anhydrite) Artwork Using Trace Element Analysis and a Multi-Isotope Approach (Sr, S, O) <i>Lise Leroux, Wolfram Kloppmann, Philippe Bromblet, Catherine Guerrot, Anthony H. Cooper, Pierre-Yves Le Pogam, Dominique Vingtain and Noel Worley</i> .....	195
Roman Monolithic Fountains and Thasian Marble <i>Annewies van den Hoek, Donato Attanasio and John J. Herrmann</i> .....	207
Archaeometric Analysis of the Alabaster Thresholds of Villa A, Oplontis (Torre Annunziata, Italy) and New Sr and Pb Isotopic Data for <i>Alabastro Ghiaccione del Circeo</i> <i>Simon J. Barker, Simona Perna, J. Clayton Fant, Lorenzo Lazzarini and Igor M. Villa</i> .....	215
Roman Villas of Lake Garda and the Occurrence of Coloured Marbles in the Western Part of “Regio X Venetia et Histria” (Northern Italy) <i>Roberto Bugini, Luisa Folli and Elisabetta Roffia</i> .....	231
Calcitic Marble from Thasos in the North Adriatic Basin: Ravenna, Aquileia, and Milan <i>John J. Herrmann, Robert H. Tykot and Annewies van den Hoek</i> .....	239
Characterisation of White Marble Objects from the Temple of Apollo and the House of Augustus (Palatine Hill, Rome) <i>Francesca Giustini, Mauro Brilli, Enrico Gallochio and Patrizio Pensabene</i> .....	247
Study and Archeometric Analysis of the Marble Elements Found in the Roman Theater at Aeclanum (Mirabella Eclano, Avellino - Italy) <i>Antonio Mesisca, Lorenzo Lazzarini, Stefano Cancelliere and Monica Salvadori</i> .....	255

Two Imperial Monuments in Puteoli: Use of Proconnesian Marble in the Domitianic and Trajanic Periods in Campania <i>Irene Bald Romano, Hans Rupprecht Goette, Donato Attanasio and Walter Prochaska</i> .....	267
Coloured Marbles in the Neapolitan Pavements (16 <sup>th</sup> And 17 <sup>th</sup> Centuries): the Church of <i>Santi Severino e Sossio</i> <i>Roberto Bugini, Luisa Folli and Martino Solito</i> .....	275
Roman and Early Byzantine Sarcophagi of Calcitic Marble from Thasos in Italy: Ostia and Siracusa <i>Donato Attanasio, John J. Herrmann, Robert H. Tykot and Annewies van den Hoek</i> .....	281
Revisiting the Origin and Destination of the Late Antique Marzamemi 'Church Wreck' Cargo <i>Justin Leidwanger, Scott H. Pike and Andrew Donnelly</i> .....	291
The Marbles of the Sculptures of Felix Romuliana in Serbia <i>Walter Prochaska and Maja Živić</i> .....	301
Calcitic Marble from Thasos and Proconnesos in Nea Anchialos (Thessaly) and Thessaloniki (Macedonia) <i>Vincent Barbin, John J. Herrmann, Aristotle Mentzos and Annewies van den Hoek</i> .....	311
Architectural Decoration of the Imperial Agora's Porticoes at Iasos <i>Fulvia Bianchi, Donato Attanasio and Walter Prochaska</i> .....	321
The Winged Victory of Samothrace - New Data on the Different Marbles Used for the Monument from the Sanctuary of the Great Gods <i>Annie Blanc, Philippe Blanc and Ludovic Laugier</i> .....	331
Polychrome Marbles from the Theatre of the Sanctuary of Apollo Pythios in Gortyna (Crete) <i>Jacopo Bonetto, Nicolò Mareso and Michele Bueno</i> .....	337
Paul the Silentiary, Hagia Sophia, Onyx, Lydia, and Breccia Corallina <i>John J. Herrmann and Annewies van den Hoek</i> .....	345
Incrustations from Colonia Ulpia Traiana (Near Modern Xanten, Germany) <i>Vilma Ruppinić and Ulrich Schüssler</i> .....	351
Stone Objects from Vindobona (Austria) – Petrological Characterization and Provenance of Local Stone in a Historico-Economical Setting <i>Andreas Rohatsch, Michaela Kronberger, Sophie Insulander, Martin Mosser and Barbara Hodits</i> .....	363
Marbles Discovered on the Site of the Forum of Vaison-la-Romaine (Vaucluse, France): Preliminary Results <i>Elsa Roux, Jean-Marc Mignon, Philippe Blanc and Annie Blanc</i> .....	373
Updated Characterisation of White Saint-Béat Marble. Discrimination Parameters from Classical Marbles <i>Hernando Royo Plumed, Pilar Lapeunte, José Antonio Cuchí, Mauro Brilli and Marie-Claire Savin</i> .....	379

Grey and Greyish Banded Marbles from the Estremoz Anticline in Lusitania <i>Pilar Lapuente, Trinidad Nogales-Basarrate, Hernando Royo Plumed, Mauro Brilli and Marie-Claire Savin</i> .....	391
New Data on Spanish Marbles: the Case of <i>Gallaecia</i> (NW Spain) <i>Anna Gutiérrez García-M., Hernando Royo Plumed and Silvia González Soutelo</i> .....	401
A New Roman Imperial Relief Said to Be from Southern Spain: Problems of Style, Iconography, and Marble Type in Determining Provenance <i>John Pollini, Pilar Lapuente, Trinidad Nogales-Basarrate and Jerry Podany</i> .....	413
Reuse of the <i>Marmora</i> from the Late Roman Palatial Building at Carranque (Toledo, Spain) in the Visigothic Necropolis <i>Virginia García-Entero, Anna Gutiérrez García-M. and Sergio Vidal Álvarez</i> .....	427
Imperial Porphyry in Roman Britain <i>David F. Williams</i> .....	435
Recycling of Marble: Apollonia/Sozousa/Arsuf (Israel) as a Case Study <i>Moshe Fischer, Dimitris Tambakopoulos and Yannis Maniatis</i> .....	443
Thasian Connections Overseas: Sculpture in the Cyrene Museum (Libya) Made of Dolomitic Marble from Thasos <i>John J. Herrmann and Donato Attanasio</i> .....	457
Marble on Rome's Southwestern Frontier: Thamugadi and Lambaesis <i>Robert H. Tykot, Ouahiba Bouzidi, John J. Herrmann and Annewies van den Hoek</i> .....	467
Marble and Sculpture at Lepcis Magna (Tripolitania, Libya): a Preliminary Study Concerning Origin and Workshops <i>Luisa Musso, Laura Buccino, Matthias Bruno, Donato Attanasio and Walter Prochaska</i> .....	481
The Pentelic Marble in the Carnegie Museum of Art Hall of Sculpture, Pittsburgh, Pennsylvania <i>Albert D. Kollar</i> .....	491
Analysis of Classical Marble Sculptures in the Michael C. Carlos Museum, Emory University, Atlanta <i>Robert H. Tykot, John J. Herrmann, Renée Stein, Jasper Gaunt, Susan Blevins and Anne R. Skinner</i> .....	501
<b>3. PROVENANCE IDENTIFICATION II: (OTHER STONES)</b>	
Aphrodisias and the Regional Marble Trade. The <i>Scaenae Frons</i> of the Theatre at Nysa <i>Natalia Toma</i> .....	513
The Stones of Felix Romuliana (Gamzigrad, Serbia) <i>Bojan Djurić, Divna Jovanović, Stefan Pop Lazić and Walter Prochaska</i> .....	523
Aspects of Characterisation of Stone Monuments from Southern Pannonia <i>Branka Migotti</i> .....	537



The Budakalász Travertine Production <i>Bojan Djurić, Sándor Kele and Igor Rižnar</i> .....	545
Stone Monuments from Carnuntum and Surrounding Areas (Austria) – Petrological Characterization and Quarry Location in a Historical Context <i>Gabrielle Kremer, Isabella Kitz, Beatrix Moshhammer, Maria Heinrich and Erich Draganits</i> .....	557
Espejón Limestone and Conglomerate (Soria, Spain): Archaeometric Characterization, Quarrying and Use in Roman Times <i>Virginia García-Entero, Anna Gutiérrez García-M, Sergio Vidal Álvarez, María J. Peréz Agorreta and Eva Zarco Martínez</i> .....	567
The Use of Alcover Stone in Roman Times ( <i>Tarraco, Hispania Citerior</i> ). Contributions to the <i>Officina Lapidaria Tarraconensis</i> <i>Diana Gorostidi Pi, Jordi López Vilar and Anna Gutiérrez García-M.</i> .....	577
<b>4. ADVANCES IN PROVENANCE TECHNIQUES, METHODOLOGIES AND DATABASES</b>	
Grainautline – a Supervised Grain Boundary Extraction Tool Supported by Image Processing and Pattern Recognition <i>Kristóf Csorba, Lilla Barancsik, Balázs Székely and Judit Zöldföldi</i> .....	587
A Database and GIS Project about Quarrying, Circulation and Use of Stone During the Roman Age in <i>Regio X - Venetia et Histria</i> . The Case Study of the Euganean Trachyte <i>Caterine Prevato and Arturo Zara</i> .....	597
<b>5. QUARRIES AND GEOLOGY</b>	
The Distribution of Troad Granite Columns as Evidence for Reconstructing the Management of Their Production <i>Patrizio Pensabene, Javier Á. Domingo and Isabel Rodà</i> .....	613
Ancient Quarries and Stonemasonry in Northern Choria Considiana <i>Hale Güney</i> .....	621
Polychromy in Larisaeon Quarries and its Relation to Architectural Conception <i>Gizem Mater and Ertunç Denktaş</i> .....	633
Euromos of Caria: the Origin of an Hitherto Unknown Grey Veined Stepped Marble of Roman Antiquity <i>Matthias Bruno, Donato Attanasio, Walter Prochaska and Ali Bahadır Yavuz</i> .....	639
Unknown Painted Quarry Inscriptions from Bacakale at <i>Docimium</i> (Turkey) <i>Matthias Bruno</i> .....	651
The Green Schist Marble Stone of Jebel El Hairech (North West of Tunisia): a Multi-Analytical Approach and its Uses in Antiquity <i>Ameur Younès, Mohamed Gaied and Wissem Gallala</i> .....	659
Building Materials and the Ancient Quarries at <i>Thamugadi</i> (East of Algeria), Case Study: Sandstone and Limestone <i>Younès Rezkallah and Ramdane Marmi</i> .....	673

The Local Quarries of the Ancient Roman City of <i>Valeria</i> (Cuenca, Spain) <i>Javier Atienza Fuente</i> .....	683
The Stone and Ancient Quarries of Montjuïc Mountain (Barcelona, Spain) <i>Aureli Álvarez</i> .....	693
<i>Notae Lapidinarum</i> : Preliminary Considerations about the Quarry Marks from the Provincial Forum of <i>Tarraco</i> <i>Maria Serena Vinci</i> .....	699
The Different Steps of the Rough-Hewing on a Monumental Sculpture at the Greek Archaic Period: the Unfinished Kouros of Thasos <i>Danièle Braunstein</i> .....	711
A Review of Copying Techniques in Greco-Roman Sculpture <i>Séverine Moureaud</i> .....	717
Labour Forces at Imperial Quarries <i>Ben Russell</i> .....	733
Social Position of Craftsmen inside the Stone and Marble Processing Trades in the Light of Diocletian's Edict on Prices <i>Krešimir Bosnić and Branko Matulić</i> .....	741
<b>6. STONE PROPERTIES, WEATHERING EFFECTS AND RESTORATION, AS RELATED TO DIAGNOSIS PROBLEMS, MATCHING OF STONE FRAGMENTS AND AUTHENTICITY</b>	
Methods of Consolidation and Protection of Pentelic Marble <i>Maria Apostolopoulou, Elissavet Drakopoulou, Maria Karoglou and Asterios Bakolas</i> .....	749
<b>7. PIGMENTS AND PAINTINGS ON MARBLE</b>	
Painting and Sculpture Conservation in Two Gallo-Roman Temples in Picardy (France): Champlieu and Pont-Sainte-Maxence <i>Véronique Brunet-Gaston and Christophe Gaston</i> .....	763
The Use of Colour on Roman Marble Sarcophagi <i>Eliana Siotto</i> .....	773
New Evidence for Ancient Gilding and Historic Restorations on a Portrait of Antinous in the San Antonio Museum of Art <i>Jessica Powers, Mark Abbe, Michelle Bushey and Scott H. Pike</i> .....	783
Schists and Pigments from Ancient Swat (Khyber Pukhtunkhwa, Pakistan) <i>Francesco Mariottini, Gianluca Vignaroli, Maurizio Mariottini and Mauro Roma</i> .....	793
<b>8. SPECIAL THEME SESSION: „THE USE OF MARBLE AND LIMESTONE IN THE ADRIATIC BASIN IN ANTIQUITY”</b>	
Marble Sarcophagi of Roman Dalmatia Material – Provenance – Workmanship <i>Guntram Koch</i> .....	809

Funerary Monuments and Quarry Management in Middle Dalmatia <i>Nenad Cambi</i> .....	827
Marble Revetments of Diocletian's Palace <i>Katja Marasović and Vinka Marinković</i> .....	839
The Use of Limestones as Construction Materials for the Mosaics of Diocletian's Palace <i>Branko Matulić, Domagoj Mudronja and Krešimir Bosnić</i> .....	855
Restoration of the Peristyle of Diocletian's Palace in Split <i>Goran Nikšić</i> .....	863
Marble Slabs Used at the Archaeological Site of Sorna near Poreč Istria – Croatia <i>Đeni Gobić-Bravar</i> .....	871
Ancient Marbles from the Villa in Verige Bay, Brijuni Island, Croatia <i>Mira Pavletić and Đeni Gobić-Bravar</i> .....	879
Notes on Early Christian Ambos and Altars in the Light of some Fragments from the Islands of Pag and Rab <i>Mirja Jarak</i> .....	887
The Marbles in the Chapel of the Blessed John of Trogir in the Cathedral of St. Lawrence at Trogir <i>Đeni Gobić-Bravar and Daniela Matetić Poljak</i> .....	899
The Use of Limestone in the Roman Province of Dalmatia <i>Edisa Lozić and Igor Rižnar</i> .....	915
The Extraction and Use of Limestone in Istria in Antiquity <i>Klara Buršić-Matijašić and Robert Matijašić</i> .....	925
Aurisina Limestone in the Roman Age: from Karst Quarries to the Cities of the Adriatic Basin <i>Caterina Prevato</i> .....	933
The Remains of Infrastructural Facilities of the Ancient Quarries on Zadar Islands (Croatia) <i>Mate Parica</i> .....	941
The Impact of Local Geomorphological and Geological Features of the Area for the Construction of the Burnum Amphitheatre <i>Miroslav Glavičić and Uroš Stepišnik</i> .....	951
Roman Quarry Klis Kosa near Salona <i>Ivan Alduk</i> .....	957
Marmore Lavdata Brattia <i>Miona Miliša and Vinka Marinković</i> .....	963
Quarries of the Lumbarda Archipelago <i>Ivka Lipanović and Vinka Marinković</i> .....	979

Island of Korčula – Importer and Exporter of Stone in Antiquity <i>Mate Parica and Igor Borzić</i> .....	985
Faux Marbling Motifs in Early Christian Frescoes in Central and South Dalmatia: Preliminary Report <i>Tonči Borovac, Antonija Gluhan and Nikola Radošević</i> .....	995
<b>INDEX OF AUTHORS</b> .....	1009

# RESTORATION OF THE PERISTYLE OF DIOCLETIAN'S PALACE IN SPLIT

Goran Nikšić

City of Split, Service for the Old City Core, Split, Croatia (goran.niksic@split.hr)

## Abstract

Various types of granite and marble used for the construction and decoration of Diocletian's palace and of its central square – the Peristyle – were imported from distant regions of the Empire, mostly from Egypt and Asia Minor. Apart from that, local limestone of the highest quality, quarried mostly on the neighbouring island of Brač, was used for building the monumental parts of the Palace. Organized by the City of Split and executed by the Croatian Conservation Institute, the restoration of the Peristyle constituted one of the most important conservation and restoration operations carried out in Croatia. Started in 2003 as a stone cleaning operation, it developed into a ten-year long, complex restoration project including archaeological, geophysical and geo-mechanical research, consolidation of foundations and upper structures, cleaning and conservation of stone, plaster and other materials, lighting and presentation of this multi-layered monument.

## Keywords

Peristyle, laser cleaning, stone restoration

Diocletian's Palace has been a topic of scientific interest for a long time, but there has been no full consensus about some of its basic elements, from the typological definition to the original purpose of the building, from the original appearance of the whole down to the reliable reconstruction of the architectural parts. Traditionally, Diocletian's Palace has been described as a unique combination of an imperial villa and a typical Roman fortification, a blend of a lavish *villa rustica* and a military camp.<sup>1</sup>

Recent research has proposed a new understanding of the original purpose of the imperial complex in Split: Diocletian's Palace was first conceived for the imperial manufacture of textiles, and was later, probably already during the construction, adapted for the residence of the

retired emperor. The Palace, which only looked like a fortified villa, housed an unusual combination of functions: a textile workshop, imperial apartments and religious buildings serving the cult of the deified emperor.<sup>2</sup>

In parallel with a fresh historical and architectural reinterpretation, new insights have been made in recent years into the use of structural systems and of materials.<sup>3</sup> Among the materials used for building of the imperial palace, local limestone of the highest quality, quarried mostly on the neighbouring island of Brač, was the prime structural material, especially in the most prominent places, such as the perimeter walls, the religious buildings – the Mausoleum and the temples – and the central square, or courtyard – the so-called Peristyle – placed between them.<sup>4</sup> To enhance the monumental expression of the conspicuous exteriors and interiors, the builders used a variety of decorative stones and marbles, imported from various parts of the empire, mostly from Egypt and Asia Minor.<sup>5</sup>

In the light of new interpretations of the original function of Diocletian's palace, a fresh perspective can be offered on the architecture of its central square – the Peristyle. (Fig. 1) As a result of changes in design introduced during the construction, the architecture of the Peristyle assumed an ambiguous character, between the solid, massive structure of the Vestibule on the south side and the light, free-standing colonnades, separating it from the sacred enclosure of the Mausoleum to the east and that of the temple area to the west. From the beginning the Peristyle had some serious weaknesses and mistakes built into its very structure.

2 BELAMARIĆ 2003; BELAMARIĆ 2004.

3 NIKŠIĆ 2004; NIKŠIĆ 2011; NIKŠIĆ 2015.

4 In the imperial palace in Split other building materials – brick, mortar and concrete – had equally important roles, especially in places where they were not expected to be seen. An overview of building techniques and materials in Diocletian's Palace is given in: BUBLE 2009. On the use of brick in Diocletian's Palace see: NIKŠIĆ 2015.

5 BULIĆ 1923; MARASOVIĆ, MATETIĆ POLJAK 2010; MARASOVIĆ, MATETIĆ POLJAK, GOBIĆ BRAVAR 2015.

1 NIEMANN 1910; HÉBRARD, ZEILLER 1912; BULIĆ, KARAMAN 1927; MARASOVIĆ 1994.





Fig. 1. View of the Peristyle before restoration (photo: B. Ostojić)

The link between the longitudinal free-standing arcaded colonnades and the transversal porch of the Protyron – the entrance to the imperial quarters – at the south end of the square was not resolved very successfully, either at the conceptual level or in the execution, with the blank wall at the end of the colonnades, and the corners of the Protyron pediment “eaten away”. The Protyron was presumably first conceived as a classical porch, free on three sides, and then transformed into a scenographic decoration squeezed between two massive walls. Evidence of that situation was found already by Niemann who pointed out the difference between the mouldings of the trabeations of the Protyron pediment and of the lateral colonnades.<sup>6</sup> The ends of the pediment are covered by the walls at the south end of the colonnades which were obviously added in a later variant of the design, putting out of context the piece of the trabeation still visible on top of the wall on the east side of the Protyron.

The great majority of columns in the Peristyle, as well as in other parts of the Palace, were imported from Egypt as ready-made elements taken from existing

buildings. The small differences in height of these columns were compensated by variations in height of limestone capitals and bases which were made locally.

One of the consequences of the abrupt transformations of the plan was the misalignment of the transverse axis of the square and the east-west axis of the *temenoi*. An *ad hoc* solution was found by using columns of different colours – red granite columns were positioned in front of the Vestibule (the entrance to the imperial apartment) and in front of the Mausoleum and the Temple.<sup>7</sup> The red granite (syenite) was used as a substitute for the purple porphyry, which was the most precious material and had an imperial significance. (Fig. 2) For the remaining two pairs of columns at the north end of the square grey marble was used.<sup>8</sup> Of those, the two columns

7 NIKŠIĆ 2009.

8 Previous authors described those columns in different ways, but the most recent article (MARASOVIĆ, MATETIĆ POLJAK, GOBIĆ BRAVAR 2015, 1004) identifies the material of all four columns as Proconnesian marble, although only the western pair is easily recognisable as such.

6 NIEMANN 1910, 47.





Fig. 2. Peristyle, west colonnade, a red granite column (photo: G. Nikšić)



Fig. 3. Peristyle, west colonnade, a Proconnesian marble column. Toolmarks are still visible (photo: G. Nikšić)

on the east side were reused from an earlier, probably Egyptian building, and carry incisions made with a sharp object.<sup>9</sup> Facing them are two columns of Proconnesian marble which seem to be commissioned specially for the Peristyle and have never received a final polish. (Fig. 3)

All these improvisations contribute to the overall impression of an eclectic, heterogeneous, *ad hoc* solution of the difficult problem, reflecting in a nutshell the complexities of the Palace as a whole. Diocletian's Palace is full of examples where serious mistakes were committed and instant solutions were found by the highly skilful Roman builders. It is fair to say that, considering the circumstances, the end result is in a way successful. Once we understand that the builders did not look for perfection because it would have been an improbable task, with overwhelming time pressure and crazy deadlines, and with the design brief changing probably several times in the course of construction, we can only admire their skill in masking the imperfections of the details and diverting the onlooker's attention from them.

The already complex architecture of the Roman Peristyle became even more intricate with the addition of many buildings of different periods. It can be said that the imperfect architecture of the Peristyle was enhanced by later accretions which are an added value to the remarkably well preserved original structure which took on a new meaning as cathedral square and centre of the city.

Over the past two hundred years, the Peristyle has seen numerous conservation and restoration interventions of various scopes and outcomes, reflecting the attention it has always attracted from experts and general public. Such partial interventions resolved specific problems, but sometimes also resulted in the creation of new ones. At the beginning of the third millennium, we have finally witnessed a comprehensive project which, for the first time, encompassed the complex in its entirety.

A ten-year restoration campaign was stimulated by the initial grant of the World Monuments Fund, and an additional financial support of the Ministry of Culture of the Republic of Croatia, while most of the funding was provided by the City of Split. The work was organized by the Service for the Old City Core and executed by the Croatian Conservation Institute. Started in 2003 as a stone cleaning operation, it developed into a complex project including archaeological, geophysical and geo-mechanical research, consolidation of foundations and upper structures, cleaning and conservation of stone, plaster and other materials, lighting and presentation of this multi-layered monument.

9 These incisions called *wusum* are frequent in Egyptian sacred buildings and were made to extract powder of the sanctified material for prophylactic use. Personal relation of J-P. Brun.



Geotechnical and archaeological investigations of foundations and the ground beneath them, performed to collect data necessary for the structural design, revealed important new information about the history of the buildings and about the causes of decay. It was established that the Roman structure was mostly founded on solid ground or on solid remains of older structures and, to a lesser extent (pillars of the *decumanus* porch) on insufficiently stable ground. Archaeological investigation provided new insight into the historical development of the buildings.<sup>10</sup> Of special interest was the insight into the foundations of the east colonnade, which seem to have belonged to an earlier structure, and a large ceramic vessel – an ancient *pithos* – which was damaged by a drainage channel belonging to the construction of Diocletian's Palace.

Seventeen centuries of demolition and construction have left traces in the robust Roman structure, as well as on buildings dating from later periods. Some of the problems encountered during the structural rehabilitation were already present in Diocletian's time. The "arcuated lintel" of the Prothyron from the beginning exerted a horizontal thrust that still continues to cause structural damage. At their northern ends, long arcades push the arches of the *decumanus* porticos, and consequently the house and the church attached to them, inflicting structural damage on them. The low terminal arches of the porticoes buttress the tall colonnades quite unsuccessfully, anticipating medieval structural ideas in an awkward way.

Structural problems were partially dealt with on several occasions. At the beginning of the 20th century a part of the east colonnade was dismantled and reassembled, and two columns of grey marble were patched with cipollino marble. Approximately at the same time, an attempt was made to stop the deformations in Prothyron. Stone blocks of the arch and the wall were reinforced with copper clamps. Steel ties were set on two levels connecting the pediment wall to the Vestibule.

During the recent restoration works at the Peristyle, for the first time, the structure was analyzed as a whole and the problem of structural stability was fully addressed. The leading principle of the structural strengthening consisted in recovering stability and preventing further deformation using minimum and non-invasive interventions. Monitoring of stress and strain was conducted before, during and after the treatment in critical locations in order to determine deformation growth – its intensity and speed. Stress measurement of the copper clamps on the Prothyron pediment has shown that the hundred-year-old intervention is still effective.



Fig. 4. Peristyle, relieving arch above the portal leading into the Vestibule before restoration (photo: Ž. Bačić)

From the structural point of view, the Peristyle is exceptionally heterogeneous, with Roman elements that are partly free-standing and partly embedded in later buildings. In order to understand the behaviour of the complex structure, a computer model was used to test vertical and horizontal (earthquake) loads. Based on the results of these tests, a program of structural rehabilitation was designed. Critical areas of foundations and walls were grouted with lime-based material. Special attention was given to the grouting of joints between capitals, columns and lintels, so that their edges would be discharged of some of the concentrated load created by the tilting of the columns.

In order to slow down further deformation of the Prothyron, non-invasive interventions were conducted that have greatly reclaimed its stability. The roof of the Prothyron, which was (unjustifiably) installed in mid-20th century, was improved to add rigidity to the structure. A threefold wooden revetment was firmly fixed to the wooden roof beams anchored in the stone pediment on the north side and in the massive wall of the Vestibule on the south. Old copper clamps on the pediment were kept, and steel were replaced with stainless steel ties.

A large relieving arch built of brick and tufa stone above the portal leading from the Prothyron to the Vestibule was heavily damaged and was, probably in the Middle Ages, supported with stone masonry. In this way the load of the wall was transferred onto the stone lintel which consequently broke in the middle (Fig. 4). The arch was restored using blocs of tufa stone and bricks matching the original ones in shape and dimensions (Fig. 5).

Structural rehabilitation of the church of St. Roch, attached to the northern end of the east colonnade, was another complex task. Carbon straps were fixed to the masonry vault, to the longitudinal cornices and to the interior surface of west façade. Several crushed stone

10 MADIRAZZA 2013.



Fig. 5. Peristyle, relieving arch above the portal leading into the Vestibule after restoration (photo: Croatian Conservation Institute)

blocks on the outer side of the same façade were replaced or patched with stone or artificial stone. The wall was grouted to reduce the load concentrated on the exterior edges of ashlar which had originally been carved with slanted sides and installed without joints.

Previous to the restoration treatment of the stone surface, extensive investigation was conducted in order to determine the stone type, the composition of the crust and patina, the type and quantity of salts in the stone. Detailed laboratory tests helped to determine compatible materials to be used in restoration, methods of cleaning and consolidation of the stone surface.

Mineralogical and petrographic comparison of stone samples from the Peristyle and from quarries on the island of Brač established that the stone used for building of the Peristyle was biomicrite limestone of the wackestone type, very similar to the stone from the quarries at Škrip, Plate and Rasohe on Brač. There were several types of soiling and damage found on the Peristyle stone: surface sediments (black crusts and greyish patinas), harmful (soluble) salts, biological soiling, eroded areas and mechanical damage.

The dark crust on the stone, up to one centimetre thick, generally consisted of gypsum, soot and iron oxides, with occasional calcium oxalate dihydrate (weddelite) particles. The greyish patina was identified as weddellite and, at places, gypsum. The yellowish patina found beneath the black crust consists of calcium oxalate monohydrate (whewellite) and dihydrate (weddellite). In addition to mineral patinas, algae and lichen covered large surfaces of stone. They were removed by washing and applying biocidal products based on quaternary ammonium salts, which proved to be effective in preventing the renewed growth of lichen.<sup>11</sup>



Fig. 6. Peristyle, east colonnade, pilaster capital, laser cleaning (photo: G. Nikšić)

The main method selected for removing the dark sediments was laser cleaning, which has many advantages over other cleaning techniques: minimum invasiveness, high precision and level of control, and selectiveness (Fig. 6). Together with the simultaneous work on the Golden Gate, the Peristyle project was the first case where this most advanced technology was used for cleaning not only the decorated parts, but the whole surface of stone, marking the start of its widespread use in Croatian conservation practice. It was also a unique opportunity to test and compare, on the same scaffolding, the performance of different types of laser machines.<sup>12</sup>

Only after the removal of the soiling could fine details of original Roman carving be fully appreciated, revealing the skill and beauty of the stonemasonry of the ancient masters (Figs. 7-10). Another virtue of the laser cleaning method is the possibility of removing the harmful sulphate crusts without damaging the yellowish natural patina, which acts as a protective layer due to the fact that calcium oxalate is far less soluble in the acidic and neutral environment than calcium carbonate.

In areas which had been exposed to intensive washing by rainwater, the oxalate patina disappeared, and the stone became exposed and vulnerable. To recreate the protective layer a method normally used for treatment only of sculptures and decorated surfaces was adopted for the whole of the stone structures of the Peristyle: an artificial layer of calcium oxalate was created through the reaction of ammonium oxalate (applied directly or in poultices) and calcium carbonate present in the stone. In the same way highly soluble gypsum was transformed into more stable calcium oxalate.

For desalination of salt-contaminated areas of stone the common ammonium-barium method was used.

11 MUDRONJA 2013, 27.

12 MATIJACA 2013, 42.





Fig. 7.  
Peristyle, east colonnade, detail before  
restoration (photo: G. Nikšić)



Fig. 8.  
Peristyle, east colonnade, detail  
after restoration (photo: Croatian  
Conservation Institute)



Fig. 9. Peristyle, cornice of the Prothyron gable, detail before  
restoration (photo: Croatian Conservation Institute)



Fig. 10. Peristyle, cornice of the Prothyron gable, detail after  
restoration (photo: Croatian Conservation Institute)





Fig. 11. Peristyle, general view after restoration (photo: G. Nikšić)

It consists of two steps. The first step involves treating the gypsum on the stone with an ammonium carbonate solution, which transforms the gypsum into a soluble ammonium sulphate. In the second step, barium hydroxide is used to transform the remaining gypsum and ammonium sulphate from the preceding step into stable barium sulphate.<sup>13</sup>

To minimize future exposure to rainwater and soluble salts, and to increase the resistance to weathering, stone surfaces were protected with a solution of silicic acid ester (ethyl silicate), with the addition of Paraloid b-72 for partial consolidation. Lead flashing with a drip edge was applied on upper horizontal surfaces. Bird control netting and spikes were installed to prevent damage from bird droppings.

Inappropriate cement patches from previous restorations were removed as were metal elements anchored in stone. Corroded iron clamps and dowels were replaced with stainless steel ones. In cases where this was not possible, they were treated with a solution of corrosion inhibitor.

Completely disintegrated stone elements were replaced with new stone. Partly damaged elements were repaired with stone or mortar patches, depending on the

condition of the stone, its size and structural role. Traditional tools were used for finishing of the reconstructed surface.<sup>14</sup>

Apart from stone, plastered surfaces were cleaned, repaired and consolidated.

Particular attention was given to the final presentation of the Peristyle. The new lighting discreetly enhances the architectural features and creates a unique atmosphere at night.

Due to the Peristyle's importance in the fields of classical archaeology, art history and architecture, and given the complexity of the conservation-restoration problems, numerous Croatian and foreign experts and institutions were involved in the project. The multidisciplinary approach, which is becoming an increasingly important feature of contemporary conservation and restoration practices, has been shown here as an essential component without which the set objectives could not have been accomplished. The contributions of experts from different fields gave the project additional scientific weight.<sup>15</sup>

Because of the importance of the Peristyle as the most significant element of the historic core of Split,

13 MUDRONJA 2013, 28.

14 MATIJACA 2013, 46-47.

15 MARINKOVIĆ 2013, 49.

inscribed on the UNESCO World Heritage List, and in view of the complexity of conservation issues, involving a large number of Croatian and foreign experts and institutions, the project has been one of the most important conservation and restoration campaigns in Croatia. It provided an excellent opportunity for the professional development of young experts in state-of-the-art restoration procedures, and raised the bar for improving the conservation standards in the historic core of Split and in the region (Fig. 11).

## BIBLIOGRAPHY

- BELAMARIĆ J. 2003: "The Date of Foundation and Original Function of Diocletian's Palace at Split", *Hortus artium medievalium* 9, 173-185.
- BELAMARIĆ J. 2004: "Gynaecium Iovense Dalmatiae – Aspalatho", in A. DEMANDT, A. GOLTZ, H. SCHLANGE-SCHÖNINGEN (eds.): *Diokletian und die Tetrarchie. Aspekte einer Zeitenwende*, Berlin / New York, 141-162.
- BUBLE S. 2009: "Dioklecijanova palača – izvor poznavanja rimske tehnike građenja", in N. CAMBI, J. BELAMARIĆ, T. MARASOVIĆ (eds.): *Dioklecijan, tetarhija i Dioklecijanova palača o 1700. obljetnici postojanja (Diocletian, Tetrarchy and Diocletian's Palace on the 1700<sup>th</sup> Anniversary of Existence)*, Split, 135-161.
- BULIĆ F. 1908: "Materiale e provenienza della pietra, delle colonne nonché delle sfingi del Palazzo di Diocleziano a Spalato e delle cononche ecc. delle basiliche Christiane a Salona", *Bullettino di Archeologia e Storia Dalmata* 31, 86-110.
- BULIĆ F., KARAMAN LJ. 1927: *Palača cara Dioklecijana u Splitu*, Zagreb.
- HÉBRARD E., ZEILLER J. 1912: *Spalato. Le palais de Dioclétien*, Paris.
- MADIRAZZA V. 2013: "Archaeological Investigation", in G. NIKŠIĆ (ed.): *Peristyle 2003-2013. Catalogue of the exhibition of conservation-restoration works at the Peristyle of Diocletian's Palace in Split*, Split, 19-25.
- MARASOVIĆ K., MATETIĆ POLJAK D. 2010: "Upotreba dekorativnog kamena u Dioklecijanovoj palači u Splitu", *Histria Antiqua*, 19, 89-100.
- MARASOVIĆ K., MATETIĆ POLJAK D., GOBIĆ BRAVAR Đ. 2015: "Colored marbles of Diocletian's palace in Split", in *ASMOSIA X*, 1003-1019.
- MARASOVIĆ T. 1994: *Dioklecijanova palača, svjetska kulturna baština*, Split / Zagreb.
- MARINKOVIĆ V. 2013: "Results of Conservation-restoration Interventions" in: G. NIKŠIĆ (ed.), *Peristyle 2003-2013. Catalogue of the exhibition of conservation-restoration works at the Peristyle of Diocletian's Palace in Split*, Split, 49-51.
- MATIJACA M. 2013: "Conservation-restoration Treatment", in G. NIKŠIĆ (ed.): *Peristyle 2003-2013. Catalogue of the exhibition of conservation-restoration works at the Peristyle of Diocletian's Palace in Split*, Split, 39-47.
- MUDRONJA D. 2013: "Natural Science Research at the Peristyle", in G. NIKŠIĆ (ed.): *Peristyle 2003-2013. Catalogue of the exhibition of conservation-restoration works at the Peristyle of Diocletian's Palace in Split*, Split, 27-31.
- NIEMANN G. 1910: *Der Palast Diokletians in Spalato*, Wien.
- NIKŠIĆ G. 2004: "The Restoration of Diocletian's Palace – Mausoleum, Temple, and Porta Aurea (with the analysis of the original architectural design)", in A. DEMANDT, A. GOLTZ, H. SCHLANGE-SCHÖNINGEN (eds.): *Diokletian und die Tetrarchie. Aspekte einer Zeitenwende*, Berlin / New York, 163-171.
- NIKŠIĆ G. 2009: "The Restoration of the Peristyle of Diocletian's Palace in Split", in E. EMMERLING (ed.): *Toccare – non toccare*, München, 116-129.
- NIKŠIĆ G. 2011: "Diocletian's Palace – Design and Construction", in G. v. BÜLOW, H. ZABEHLICKY (eds.): *Bruckneudorf und Gamzigrad. Spätantike Paläste und Großvillen im Donau-Balkan-Raum*, Bonn, 187-202.
- NIKŠIĆ G. 2013: "Structural Strengthening" in: G. NIKŠIĆ (ed.), *Peristyle 2003-2013. Catalogue of the exhibition of conservation-restoration works at the Peristyle of Diocletian's Palace in Split*, Split, 33-37.
- NIKŠIĆ G. 2015: "The use of brick in Diocletian's Palace at Split", in *Archeologia dell'Architettura XX*. E. BUKOWIECKI, R. VOLPE, U. WULF-RHEIDT (eds.): *Il laterizio nei cantieri imperiali. Roma e il Mediterraneo. Atti del I workshop "Laterizio"* (Roma, 27-28 novembre 2014), 206-209.