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)
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

**PRESENTATION** ............................................................................................................................................ 15

**NECROLOGY: NORMAN HERZ (1923-2013) by Susan Kane** ............................................................................. 17

1. **APPLICATIONS TO SPECIFIC ARCHEOLOGICAL QUESTIONS – USE OF MARBLE**

Hermaphrodites and Sleeping or Reclining Maenads: Production Centres and Quarry Marks  
*Patrizio Pensabene* ........................................................................................................................................... 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  
*Massimiliano David, Stefano Succi and Marcello Turci* .................................................................................. 33

Alabaster. Quarrying and Trade in the Roman World: Evidence from Pompeii and Herculaneum  
*Simon J. Barker and Simona Perna* .................................................................................................................. 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  
*Simon J. Barker and J. Clayton Fant* .................................................................................................................. 65

Marble Wall Decorations from the Imperial Mausoleum (4th C.) and the Basilica of San Lorenzo (5th C.) in Milan: an Update on Colored Marbles in Late Antique Milan  
*Elisabetta Neri, Roberto Bugini and Silvia Gazzoli* ............................................................................................ 79

Sarcophagus Lids Sawn from their Chests  
*Dorothy H. Abramitis and John J. Herrmann* .................................................................................................. 89

The Re-Use of Monolithic Columns in the Invention and Persistence of Roman Architecture  
*Peter D. De Staebler* ........................................................................................................................................ 95

The Trade in Small-Size Statues in the Roman Mediterranean: a Case Study from Alexandria  
*Patrizio Pensabene and Eleonora Gasparini* ....................................................................................................... 101

The Marble Dedication of Komon, Son of Asklepiades, from Egypt: Material, Provenance, and Reinforcement of Meaning  
*Patricia A. Butz* .............................................................................................................................................. 109

Multiple Reuse of Imported Marble Pedestals at Caesarea Maritima in Israel  
*Barbara Burrell* .............................................................................................................................................. 117

Iasos and Iasian Marble between the Late Antique and Early Byzantine Eras  
*Diego Peirano* .............................................................................................................................................. 123
Thassos, Known Inscriptions with New Data  
Tony Kozelj and Manuela Wurch-Kozelj ......................................................................................................................... 131

The Value of Marble in Roman Hispalis: Contextual, Typological and Lithological Analysis of an Assemblage of Large Architectural Elements Recovered at Nº 17 Goyeneta Street (Seville, Spain)  
Ruth Taylor, Oliva Rodríguez, Esther Ontiveros, María Luisa Loza, José Beltrán and Araceli Rodríguez .................................................................................................................................................. 143

Giallo Antico in Context. Distribution, Use and Commercial Actors According to New Stratigraphic Data from the Western Mediterranean (2nd C. Bc – Late 1st C. Ad)  
Stefan Ardeleanu ................................................................................................................................................................. 155

Amethystus: Ancient Properties and Iconographic Selection  
Luigi Pedroni ......................................................................................................................................................................... 167

2. PROVENANCE IDENTIFICATION I: (MARBLE)

Unraveling the Carrara – Göktepe Entanglement  
Walter Prochaska, Donato Attanasio and Matthias Bruno .................................................................................................. 175

The Marble of Roman Imperial Portraits  
Donato Attanasio, Matthias Bruno, Walter Prochaska and Ali Bahadir Yavuz ........................................................................... 185

Tracing Alabaster (Gypsum or Anhydrite) Artwork Using Trace Element Analysis and a Multi-Isotope Approach (Sr, S, O)  
Lise Leroux, Wolfram Kloppmann, Philippe Bromblet, Catherine Guerrot,  
Anthony H. Cooper, Pierre-Yves Le Pogam, Dominique Vingtain and Noel Worley ..................................................................... 195

Roman Monolithic Fountains and Thasian Marble  
Annewies van den Hoek, Donato Attanasio and John J. Herrmann .......................................................................................... 207

Archaeometric Analysis of the Alabaster Thresholds of Villa A, Oplontis (Torre Annunziata, Italy) and New Sr and Pb Isotopic Data for Alabastro Ghiaccione del Circeo  
Simon J. Barker, Simona Perna, J. Clayton Fant, Lorenzo Lazzarini and Igor M. Villa .................................................................... 215

Roman Villas of Lake Garda and the Occurrence of Coloured Marbles in the Western Part of “Regio X Venetia et Histria” (Northern Italy)  
Roberto Bugini, Luisa Folli and Elisabetta Roffia ...................................................................................................................... 231

Calcitic Marble from Thasos in the North Adriatic Basin: Ravenna, Aquileia, and Milan  
John J. Herrmann, Robert H. Tykot and Annewies van den Hoek ............................................................................................ 239

Characterisation of White Marble Objects from the Temple of Apollo and the House of Augustus (Palatine Hill, Rome)  
Francesca Giustini, Mauro Brilli, Enrico Gallocchio and Patrizio Pensabene ............................................................................ 247

Study and Archeometric Analysis of the Marble Elements Found in the Roman Theater at Aeclanum (Mirabella Eclano, Avellino - Italy)  
Antonio Mesisca, Lorenzo Lazzarini, Stefano Cancelliere and Monica Salvadori .................................................................................. 255
## CONTENT

Two Imperial Monuments in Puteoli:
Use of Proconnesian Marble in the Domitianic and Trajanic Periods in Campania
Irene Bald Romano, Hans Rupprecht Goette, Donato Attanasio and Walter Prochaska ........................................... 267

Coloured Marbles in the Neapolitan Pavements (16th And 17th Centuries):
the Church of Santi Severino e Sossio
Roberto Bugini, Luisa Folli and Martino Solito ............................................................................................................. 275

Roman and Early Byzantine Sarcophagi of Calcitic Marble from Thasos in Italy:
Ostia and Siracusa
Donato Attanasio, John J. Herrmann, Robert H. Tykot and Anniewies van den Hoek .................................................. 281

Revisiting the Origin and Destination of the Late Antique Marzamemi ‘Church Wreck’ Cargo
Justin Leidwanger, Scott H. Pike and Andrew Donnelly ................................................................................................. 291

The Marbles of the Sculptures of Felix Romuliana in Serbia
Walter Prochaska and Maja Živić ........................................................................................................................................ 301

Calcitic Marble from Thasos and Proconnesos in Nea Anchialos (Thessaly) and Thessaloniki (Macedonia)
Vincent Barbin, John J. Herrmann, Aristotle Mentzos and Anniewies van den Hoek .................................................... 311

Architectural Decoration of the Imperial Agora’s Porticoes at Iasos
Fulvia Bianchi, Donato Attanasio and Walter Prochaska .................................................................................................. 321

The Winged Victory of Samothrace - New Data on the Different Marbles Used for the Monument from the Sanctuary of the Great Gods
Annie Blanc, Philippe Blanc and Ludovic Laugier ................................................................................................................ 331

Polychrome Marbles from the Theatre of the Sanctuary of Apollo Pythios in Gortyna (Crete)
Jacopo Bonetto, Nicolo Mareso and Michele Bueno ............................................................................................................. 337

Paul the Silentiary, Hagia Sophia, Onyx, Lydia, and Breccia Corallina
John J. Herrmann and Anniewies van den Hoek .................................................................................................................. 345

Incrustations from Colonia Ulpia Traiana (Near Modern Xanten, Germany)
Vilma Ruppienė and Ulrich Schüssler ............................................................................................................................... 351

Stone Objects from Vindobona (Austria) – Petrological Characterization and Provenance of Local Stone in a Historico-Economical Setting
Andreas Rohatsch, Michaela Kronberger, Sophie Insulander, Martin Mosser and Barbara Hodits .............................................. 363

Marbles Discovered on the Site of the Forum of Vaison-la-Romaine (Vaucluse, France):
Preliminary Results
Elsa Roux, Jean-Marc Mignon, Philippe Blanc and Annie Blanc ......................................................................................... 373

Updated Characterisation of White Saint-Béat Marble. Discrimination Parameters from Classical Marbles
Hernando Royo Plumed, Pilar Lapeunte, José Antonio Cuchi, Mauro Brilli and Marie-Claire Savin ........................................ 379
3. PROVENANCE IDENTIFICATION II: (OTHER STONES)

Aphrodisias and the Regional Marble Trade. The Scaenae Frons of the Theatre at Nysa
Natalia Toma ........................................................................................................ 513

The Stones of Felix Romuliana (Gamzigrad, Serbia)
Bojan Djurić, Divna Jovanović, Stefan Pop Lazić and Walter Prochaska ......................... 523

Aspects of Characterisation of Stone Monuments from Southern Pannonia
Branka Migotti ........................................................................................................ 537
<table>
<thead>
<tr>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Budakalász Travertine Production</td>
<td>545</td>
</tr>
<tr>
<td>Bojan Djurić, Sándor Kele and Igor Rižnar</td>
<td></td>
</tr>
<tr>
<td>Stone Monuments from Carnuntum and Surrounding Areas (Austria) –</td>
<td>557</td>
</tr>
<tr>
<td>Petrological Characterization and Quarry Location in a Historical</td>
<td></td>
</tr>
<tr>
<td>Context</td>
<td></td>
</tr>
<tr>
<td>Gabrielle Kremer, Isabella Kitz, Beatrix Moshammer, Maria Heinrich</td>
<td></td>
</tr>
<tr>
<td>and Erich Draganits</td>
<td></td>
</tr>
<tr>
<td>Espejón Limestone and Conglomerate (Soria, Spain):</td>
<td>567</td>
</tr>
<tr>
<td>Archaeometric Characterization, Quarrying and Use in Roman Times</td>
<td></td>
</tr>
<tr>
<td>Virginia García-Entero, Anna Gutiérrez García-M, Sergio Vidal Álvarez,</td>
<td></td>
</tr>
<tr>
<td>Maria J. Peréx Agorreta and Eva Zarco Martínez</td>
<td></td>
</tr>
<tr>
<td>The Use of Alcover Stone in Roman Times (Tarraco, Hispania Citerior)</td>
<td>577</td>
</tr>
<tr>
<td>Contributions to the Officina Lapidaria Tarracensis</td>
<td></td>
</tr>
<tr>
<td>Diana Gorostidi Pi, Jordi López Vilar and Anna Gutiérrez García-M.</td>
<td></td>
</tr>
<tr>
<td>4. ADVANCES IN PROVENANCE TECHNIQUES,</td>
<td></td>
</tr>
<tr>
<td>METHODOLOGIES AND DATABASES</td>
<td></td>
</tr>
<tr>
<td>Grainautline – a Supervised Grain Boundary Extraction Tool</td>
<td>587</td>
</tr>
<tr>
<td>Supported by Image Processing and Pattern Recognition</td>
<td></td>
</tr>
<tr>
<td>Kristóf Csorba, Lilla Barancsuk, Balázs Székely and Judit Zöldféldi</td>
<td></td>
</tr>
<tr>
<td>A Database and GIS Project about Quarrying, Circulation and Use of</td>
<td>597</td>
</tr>
<tr>
<td>Stone during the Roman Age in Regio X - Venetia et Histria.</td>
<td></td>
</tr>
<tr>
<td>The Case Study of the Euganean Trachyte</td>
<td></td>
</tr>
<tr>
<td>Caterine Previato and Arturo Zara</td>
<td></td>
</tr>
<tr>
<td>5. QUARRIES AND GEOLOGY</td>
<td></td>
</tr>
<tr>
<td>The Distribution of Troad Granite Columns as Evidence for</td>
<td>613</td>
</tr>
<tr>
<td>Reconstructing the Management of Their Production</td>
<td></td>
</tr>
<tr>
<td>Patrizio Pensabene, Javier Á. Domingo and Isabel Rodà</td>
<td></td>
</tr>
<tr>
<td>Ancient Quarries and Stonemasonry in Northern Choria Considiana</td>
<td>621</td>
</tr>
<tr>
<td>Hale Güney</td>
<td></td>
</tr>
<tr>
<td>Polychromy in Larisaean Quarries and its Relation to Architectural</td>
<td>633</td>
</tr>
<tr>
<td>Conception</td>
<td></td>
</tr>
<tr>
<td>Gizem Mater and Ertuñç Denktaş</td>
<td></td>
</tr>
<tr>
<td>Euromos of Caria: the Origin of an Hitherto Unknown Grey Veined</td>
<td>639</td>
</tr>
<tr>
<td>Stepped Marble of Roman Antiquity</td>
<td></td>
</tr>
<tr>
<td>Matthias Bruno, Donato Attanasio, Walter Prochaska and Ali Bahadir</td>
<td></td>
</tr>
<tr>
<td>Yavuz</td>
<td></td>
</tr>
<tr>
<td>Unknown Painted Quarry Inscriptions from Bacakale at Docimium (Turkey)</td>
<td>651</td>
</tr>
<tr>
<td>Matthias Bruno</td>
<td></td>
</tr>
<tr>
<td>The Green Schist Marble Stone of Jebel El Hairech (North West of</td>
<td>659</td>
</tr>
<tr>
<td>Tunisia): a Multi-Analytical Approach and its Uses in Antiquity</td>
<td></td>
</tr>
<tr>
<td>Ameur Younès, Mohamed Gaied and Wissem Gallala</td>
<td></td>
</tr>
<tr>
<td>Building Materials and the Ancient Quarries at Thamugadi (East of</td>
<td>673</td>
</tr>
<tr>
<td>Algeria), Case Study: Sandstone and Limestone</td>
<td></td>
</tr>
<tr>
<td>Younès Rezkallah and Ramdane Marmi</td>
<td></td>
</tr>
</tbody>
</table>
The Local Quarries of the Ancient Roman City of Valeria (Cuenca, Spain)  
Javier Atienza Fuente .......................................................... 683

The Stone and Ancient Quarries of Montjuïc Mountain (Barcelona, Spain)  
Aureli Álvarez .............................................................. 693

Notae Lapicidinarum: Preliminary Considerations about the Quarry Marks from the Provincial Forum of Tarraco  
Maria Serena Vinci .......................................................... 699

The Different Steps of the Rough-Hewing on a Monumental Sculpture at the Greek Archaic Period: the Unfinished Kouros of Thasos  
Danièle Braunstein .......................................................... 711

A Review of Copying Techniques in Greco-Roman Sculpture  
Séverine Moureaud .......................................................... 717

Labour Forces at Imperial Quarries  
Ben Russell ................................................................. 733

Social Position of Craftsmen inside the Stone and Marble Processing Trades in the Light of Diocletian's Edict on Prices  
Krešimir Bosnić and Branko Matulić ...................................... 741

6. STONE PROPERTIES, WEATHERING EFFECTS AND RESTORATION, AS RELATED TO DIAGNOSIS PROBLEMS, MATCHING OF STONE FRAGMENTS AND AUTHENTICITY

Methods of Consolidation and Protection of Pentelic Marble  
Maria Apostolopoulou, Elissavet Drakopoulou, Maria Karoglou and Asterios Bakolas ........................................... 749

7. PIGMENTS AND PAINTINGS ON MARBLE

Painting and Sculpture Conservation in Two Gallo-Roman Temples in Picardy (France): Champlieu and Pont-Saînte-Maxence  
Véronique Brunet-Gaston and Christophe Gaston ........................................... 763

The Use of Colour on Roman Marble Sarcophagi  
Eliana Siotto ........................................................................ 773

New Evidence for Ancient Gilding and Historic Restorations on a Portrait of Antinous in the San Antonio Museum of Art  
Jessica Powers, Mark Abbe, Michelle Bushey and Scott H. Pike ........................................... 783

Schists and Pigments from Ancient Swat (Khyber Pukhtunkhwa, Pakistan)  
Francesco Mariottini, Gianluca Vignaroli, Maurizio Mariottini and Mauro Roma ........................................... 793

8. SPECIAL THEME SESSION: „THE USE OF MARBLE AND LIMESTONE IN THE ADRIATIC BASIN IN ANTIQUITY”

Marble Sarcophagi of Roman Dalmatia Material – Provenance – Workmanship  
Guntram Koch ................................................................. 809
CONTENT

Funerary Monuments and Quarry Management in Middle Dalmatia
_Nenad Cambi_ ........................................................................................................... 827

Marble Revetments of Diocletian’s Palace
_Katja Marasović and Vinka Marinković_ ........................................................................ 839

The Use of Limestones as Construction Materials for the Mosaics of Diocletian’s Palace
_Branko Matulić, Domagoj Mudronja and Krešimir Bosnić_ ........................................ 855

Restoration of the Peristyle of Diocletian’s Palace in Split
_Goran Nikšić_ .............................................................................................................. 863

Marble Slabs Used at the Archaeological Site of Sorna near Poreč Istria – Croatia
_Deni Gobić-Bravar_ ........................................................................................................ 871

Ancient Marbles from the Villa in Verige Bay, Brijuni Island, Croatia
_Mira Pavletić and Deni Gobić-Bravar_ ........................................................................ 879

Notes on Early Christian Ambos and Altars in the Light of some Fragments from the Islands of Pag and Rab
_Mirja Jarak_ .................................................................................................................. 887

The Marbles in the Chapel of the Blessed John of Trogir in the Cathedral of St. Lawrence at Trogir
_Deni Gobić-Bravar and Daniela Matetić Poljak_ .............................................................. 899

The Use of Limestone in the Roman Province of Dalmatia
_Edisa Lozić and Igor Rižnar_ ....................................................................................... 915

The Extraction and Use of Limestone in Istria in Antiquity
_Klara Buršić-Matijašić and Robert Matijašić_ .............................................................. 925

Aurisina Limestone in the Roman Age: from Karst Quarries to the Cities of the Adriatic Basin
_Caterina Previato_ ......................................................................................................... 933

The Remains of Infrastructural Facilities of the Ancient Quarries on Zadar Islands (Croatia)
_Mate Parica_ .................................................................................................................. 941

The Impact of Local Geomorphological and Geological Features of the Area for the Construction of the Burnum Amphitheatre
_Miroslav Glavičić and Uroš Stepišnik_ .......................................................................... 951

Roman Quarry Klis Kosa near Salona
_Ivan Alduk_ .................................................................................................................. 957

Marmore Lavdata Brattia
_Miona Miliša and Vinka Marinković_ ........................................................................... 963

Quarries of the Lumbarda Archipelago
_Ivka Lipanović and Vinka Marinković_ ........................................................................ 979
Island of Korčula – Importer and Exporter of Stone in Antiquity
Mate Parica and Igor Boržić ................................................................. 985

Faux Marbling Motifs in Early Christian Frescoes
in Central and South Dalmatia: Preliminary Report
Tonči Borovac, Antonija Gluhan and Nikola Radošević ................................................................. 995

INDEX OF AUTHORS .......................................................................................... 1009
Abstract

The paper provides an overview of recent discoveries of infrastructural facilities in ancient quarries on the Zadar islands. The facilities are located in the immediate vicinity of ancient quarries: communications from the quarries to the coast in the form of exit corridors carved in bedrock, paved tracks for transport of stone to the harbor, harbor installations for loading and shipment of stone blocks. The sites are located on Molat, Sestrunj and Dugi Otok islands. The remains of other buildings featured in quarrying complexes were also recorded: a foundry and a water cistern. Some of the infrastructural facilities contain archaeological finds that can be used to date the adjacent quarries. It is important to emphasize that, owing to their favorable geographical position, these sites are well preserved which is quite unique a situation in the entire Mediterranean region. It should be noted that the zones featuring quarries also feature communications to the sea, harbor facilities and auxiliary buildings. Such sites are rarely represented in the archaeological record and it is extremely important to preserve them from modern devastation.

Keywords
infrastructural facilities, quarry harbor, ancient quarry, Zadar islands

The eastern Adriatic coast abounds in prehistoric buildings definitely connected with extraction and collection zones of stone material. However, it is only after the establishment of Roman authority that building activities accelerated, on an unprecedented scale, resulting in an increased demand for quality stone products. The period in question did not go unnoticed but unfortunately, quarrying and problems related to stone acquisition remained at the fringes of the interests of scholars.

The most notable quarrying center is the island of Brač, or to be more precise, the area between Splitska cove and Škrip. F. Bulić identified discarded stone elements in Splitska cove and assumed that the area was an export port for stone products headed for Diocletian’s Palace. Several scholars made the connection between Brač quarries and Roman period public building. P. Didolić emphasized in several discussions of quarrying at Brač that it was the Romans who introduced stonemasonry proper to the area and concludes that stone loading and export were conducted at Splitska harbor for the purpose of building Diocletian's Palace. Several other papers are important for issues related to Brač quarrying such as D. Vrsalović, B. Kirigin who discussed Roman inscriptions and relics found at Škrip, N. Cambi whose seminal contribution includes the issues of late Roman period sarcophagus production at Brač.

M. Katić discussed the Greek colonization period quarries of Srebrena bay on the island of Vis.

The quarrying tradition at Korčula was discovered by M. Gjivoje, while S. Dokoza discussed medieval documents in connection with stone use and trade. Lately, B. Russell and K. Glicksman have discussed quarrying at Brač and Korčula. Sara Popović has made a notable contribution to the knowledge of stone quarrying on Hvar.

J. Jelić and D. Maršić have discussed archaeological finds which can be directly related to quality Trogir stone quarrying at St. Ilija hill.

Several scholars were concerned with Zadar area. M. Suić has pinpointed the islands of the Zadar

---

1 BULIĆ 1900, 20.
3 DIDOLIĆ 1957, 99.
4 VRSALOVIĆ 1968, 48.
5 KIRIGIN 1979.
6 CAMBI 2007, 105.
7 KATIĆ 2009, 33.
8 GJIVOJE 1970.
9 DOKOZA 2009.
10 RUSSELL, GLICKSMAN 2015.
11 POPOVIĆ 2012.
12 JELIĆIĆ 1981.
archipelago as the source of stone for building projects in Roman-period Zadar. D. Magaš and R. Filipi discuss the great Roman-period quarries at Sestrunj island. Z. Brusić has mapped the most significant quarries in the Zadar archipelago.

General matters related to stone quarrying on the Croatian coast and hinterland were discussed by the following scholars: R. Makjanić, B. Crnković, Lj. Šarić, S. Dunda, N. Džaja, A. Škegro, R. Zlatunić and M. Parica.

Although the number of scholars who have at some point discussed quarrying is rather great, the information on the infrastructural facilities that were definitely a part of the Roman-period quarries is quite scarce. Research into and field surveys of several Roman-period quarries have revealed a large number of archaeological remains that were an integral part of a quarry complex. It is precisely these features that are the theme of this paper. The stone extraction zones are merely referred to by their location, followed by a short description. The main concerns are, however, the infrastructural facilities that accompanied such sites. First and foremost these include the remains of harbor facilities such as remains of stone piers used to load cargo and supply ships, ramps used to lower the blocks to the harbor facilities as well as the remains of several other buildings that were a part of a quarry complex.

Three quarries in the islands off Zadar are selected for the purposes of this paper. Apart from the extraction zones themselves, these sites include preserved infrastructural facilities that were a part of the quarrying complexes.

**Molat**

Looking from north to south, the first site is located at Molat Island. The extraction zone is situated on the slope of Bonaster Hill, at an altitude of 70 m above sea level; the average height of the artificial cliff is 11 m. The quarry contains a small number of pick-axe tool marks which might be dated to the original Roman-period quarry. The majority of traces visible today are from the late medieval and early modern periods. Characteristic of the latter period is the large amount of spoil left. An exit corridor carved into the base rock is clearly visible on the northern side of the quarry (Fig. 2). This section was probably a part of the original Roman-period quarry. The argument to sustain such a claim is that the extraction from this corridor was carried out in the
southerly direction. Recent interventions in the quarry only continued this movement towards the south while the use of the exit corridor continued.

The exit corridor is, in fact, the beginning of a trackway i.e. a ramp used to lower stone blocks. The track can be followed several dozens of meters, only to fade away into the thick forest.

The beginning of the ramp track used to lower stone blocks is determined by the exit corridor carved into the bedrock. The termination of the track, on the other hand, can be followed to the sea shore where the Roman period harbor structure begins to emerge. These structures were related to the activities at the quarry.

In the vicinity of the spot where the pier is joined with the coast, a refashioning or rather an adjustment of the bedrock is clearly visible. This feature forms the ramp leading to the pier itself. This refashioning continues under the sea level as well, where it is clear that the irregular bedrock is missing which is the case on both sides of this communication (Fig. 4.) This is, in effect, the termination of the lowering ramp leading from the quarry to the pier. The feature is discernible at the sea shore because the sea has degraded the bedrock along the sea shore making it easier to determine the remains of the lowering ramp. It is clearly visible that the ramp-road terminates precisely at the stone pier.

The area between the quarry and related harbor is extremely overgrown with thick vegetation. However, the aerial photo clearly displays vegetation marks representing the road. Likewise, it is impossible to determine without excavation whether the road was paved or the bedrock was merely adapted for the purpose. The entire harbor assemblage and the communication terminus are below sea level today. The sea level has risen since the Roman period, when it was about 1.6 to 2 m below contemporary sea level (Fig. 5), suggesting the facilities were built in the Roman period. For a more detailed elaboration on changing sea levels see: SURIĆ 2009; LAMBECK et al. 2010; ANTONIOLI et al. 2007; FAIVRE et al. 2010.
The harbor pier, which was used for loading stone blocks on the ships, is located at M. Zaganj cove. It is 12 m long and the structure is positioned perpendicular to the shore line. The structure is built from amorphous uncut stones, 60 cm in diameter. A large number of Roman amphorae fragments, as well as several ballast stones were found on the bank surface. The selection of the building site for the harbor is quite curious. It would have probably been better to build the harbor in the V. Zaganj cove, 250 m south-west of the M. Zaganj cove i.e. just below the quarry. The actual harbor site was probably chosen for the protection from the southern winds it provided. Perhaps the gradual descent of terrain towards M. Zaganj cove also played a part, making it ideal for building a ramp for lowering the stone blocks.

**Sestrunj-Padrare**

An extremely large complex of Roman period quarries is located in the southern part of Sestrunj Island (under local place names Donje and Gornje Padrare). The quarries exploited the slab-like stones, sedimented in thin layers, up to 70 cm thick. This kind of stone can be used to build walls, pavements and the thickest layers are quite adequate for building ramparts. The initial information on this complex is provided by A. Filipi and D. Magaš25. They have dated the quarries to the Roman period, based on surface archaeological finds.

Gornje Padrare quarry is located on the eastern slope of Gračina Hill. The assumed altitude is 60 – 80 m above the sea level. The extraction zone plan is semicircular in shape, maximum width is 400 m, and the area covered is 2,34 ha. The average height of the artificial cliff is measured at 2.5 m in the area under survey.

25 MAGAŠ-FILIPI 1983.
The Donje Padrare extraction zone consists of 11 quarries stretching one kilometer in length. The quarries are open pits, stretching in the northwest-southeast direction, forming a line at an altitude of 120 m above the sea level. The quarry pits are rather narrow but also extremely deep. The height of the artificial cliff is 9 m.

The area around the quarry is extremely overgrown with vegetation. Therefore, the beginning of the ramp track for lowering stone blocks is not visible. However, it can be assumed that the transport of extracted stone was conducted through a natural gully at the hill slopes’ junction. This natural communication is the most plausible arrangement because this zone consists of small eroded gravel and it requires the least intervention in the bedrock. The assumed track is covered in thick vegetation and it stretches from the center of Gornje Padrare quarry to the sea, terminating at Karanke, a Roman-period harbor. Some smaller interventions are visible, such as refashioning of the natural rock at certain rather inaccessible sections of the track in order to form an unobstructed communication through the lowering ramp.

Karanke Cove is located to the north of the Gornje and Donje Padrare quarry complex. A well preserved harbor installation is found at this site. It was built, beyond any doubt, as an integral part of Roman-period quarries, since the natural channel stretching from the direction of the quarries (used for transportation) terminates at the very Karanke harbor. The harbor installation includes several stone banks, built from amorphous stone, 30-60 cm in diameter. Two larger stone banks are discernible, nearly joining in the middle section of the construction, making a large, horseshoe-shaped harbor. The outer bank sections are at an average depth of 2.5 m beneath contemporary sea level. A clear break in the bank is visible, resembling an

---

The harbor installation is discussed in detail in PARIĆA 2012.
opening. This feature is located at the point where the banks are nearly joined. The break in the construction is interpreted as a narrow entrance for ships, providing complete protection\textsuperscript{27}. Larger ships for stone transport must have docked at the outer sides of these banks. The track between two parallel banks, in the direction of the profile A-B probably represents the remains of the original communication proceeding from the quarry (Fig. 7). This claim is supported by the fact that the terrain descends regularly and gradually at this section and also by the lack of base rock rising from the surrounding area.

Several fragments of amphorae and tableware were found in the harbor installation area. Amphora fragments with preserved typological characteristics can be designated as Dres.sel 6b types. This type is dated to the first half of the 1\textsuperscript{st} century AD, based on mouth form\textsuperscript{28}.

\textsuperscript{27} MAGAŠ-FILIPI 1983, 76.

\textsuperscript{28} JURIŠIĆ 2000, 6; STARAC 1997; CIPRIANO 2009.

Dugi Otok

The central part of Dugi Otok Island features two groups of quarries, which in fact comprise a single large quarrying complex. The northern quarry group is located in the vicinity of Ovča Cove while the southern group is positioned at the Padrare site, about two kilometers to the south.

The Ovča Cove (Fig. 9) is located roughly two kilometers south of Savar village. Four quarries are visible in the immediate vicinity of the cove and several other locations where trial stone block extraction is clearly discernible. Some of the quarries were in use during the late medieval and early modern periods. The largest quarry displays traces of early modern exploitation using wedges and gunpowder. However, a section of the original Roman period quarry is preserved in the central part of the quarry complex. The pits are regular in shape and a trench is visible, excavated using a heavy pick-axe. A layer of Roman period amphora fragments is clearly visible in the profile.
of this particular quarry section. The layer stretches above
the base rock and spoil is deposited above it.

A lowering ramp is clearly visible in precisely this,
central, part of the quarry, descending in the direction
of the cove. (Fig. 10) Spoil heaps are formed on either
sides of the track. Even the early modern period spoil
did not cover the track, so it was definitely used in this
period, as well as the communication towards the sea.
The track can be followed in its entire length. The 4-me-
ter-width is visible in the field because on both sides a
small bank was formed while the track was being cleared.
The bedrock springs around the track so it is reasonable
to assume that the bedrock on the track itself was refash-
toned. However, only archaeological excavations could
confirm such a claim.

The ramp for lowering stone blocks, described
above, terminates at the bottom of Ovča Cove. A harbor
installation or rather a stone pier was built in the immedi-
ate vicinity. It is very well preserved because the cove is well
protected. The structure is submerged about two meters
below contemporary average sea level. (Fig. 11). Visible
remains of the structure are 11 m long and 5 m wide. The
pier fill consists of pieces of mid-sized amorphous stone.
The average size of stones is about 15 – 30 centimeters in
diameter. A rather large quantity of various archaeological
finds was discovered in the pier fill and around the struc-
ture, such as pottery fragments, amphorae, tegulae, dolia
and several pieces of ballast stone. Several brick fragments
with hydraulic mortar were found at the cove bottom, near
the modern artificial shore line. Roman period cisterns
were built using such material, so the existence of such a
structure in the immediate vicinity seems quite plausible.
The harbor construction can be dated to the Roman peri-
od, based on portable archaeological finds.

The second group of quarries is located in the Pa-
дрare area, about two kilometers south of Ovča Cove. The
group consists of several quarries, including four larger
and several smaller operations. Some of the larger quarries
display trackway traces passing through the refuse mate-
rial and descending towards a natural small gully between
two hills. Stone pavement is visible on a lowering ramp
section (Fig. 12). The structure is visible in the length of
about 10 meters. However, eroded soil and stones have
covered this communication way so one can assume that
excavations would reveal a significantly larger portion of
the ramp. All the lowering ramp tracks from the multiple
quarries are finally joined in a single track which follows
a small natural dale terminating at a small harbor.

A small harbor is visible at this site. It is in fact a
small cove cut into the shore line. The southern side is
a natural promontory extended with a small stone bank
about 3 meters long. Therefore, the natural promontory
and the stone bank extension together make up a dock-
ing zone capable of receiving a ship. Archaeological finds
were discovered in the docking zone area including sev-
eral amphorae body shards, bricks and a well preserved
amphora neck. The latter is hard to determine, due to the
poor preservation. The concentration of archaeological
finds is significantly smaller than in the Ovča Cove.

In the immediate vicinity of the docking con-
struction described above, where the sea heavily erodes
the shore, a profile is documented featuring traces of ar-
chitecture and large quantities of iron slag. The slag could
be connected to a foundry in which stonemasonry tools would have been repaired.

The three quarrying complexes presented in this paper feature, apart from stone block extraction zones, additional infrastructural facilities. The Molat quarry is an example of an exit corridor carved in the bedrock, often featured in the eastern Adriatic such as Sv. Ilija – Kućiće kava and Voluja – Vinišće. Mediterranean examples include Gölemezli, Turkey, Angera, Italy, and Sant Julià, Spain.

The featured quarries also include visible remains of a lowering ramp. It is in fact a communication between the quarry and the harbor facilities. Practically all quarries feature some form of ramp, though with varying degrees of preservation and ineligibility. The quarries utilize natural gullies as block lowering ramps i.e. the track descends gradually in a straight line from the quarry to the gully and then all the way to the sea. Refashioning of the bedrock is recorded at certain locations, facilitating unhindered movement of stone blocks. The ramp at Padrare on Dugi Otok is the only site recorded thus far featuring a stone pavement, such as that featured at the Pentelic quarry. It is possible that other quarry tracks on Zadar islands feature pavements but this is hard to sustain without archaeological excavations.

All the sites presented in this paper feature harbor installations. Their importance lies in the fact that they are well preserved. The cause of such a state of affairs is the environment protected by the islands, the rising of the sea level and, finally, the lack of aggressive building interventions. Harbor installations can be dated as far back as the 1st century AD, based on pottery fragments at harbor installations. These activities can be related to major public building projects in Romanized coastal towns. However, there is much to be gained by systematic archaeological excavations in these areas. The features and facilities are well preserved, which makes this area uniquely important and holding a promise of major insights on the overall functioning of Roman period quarrying complexes.

**BIBLIOGRAPHY**

ANTONIOLI F. et al. 2007: “Sea level change during Holocene from Sardinia and northeastern Adriatic (Central Mediterranean Sea) from archaeological and geomorphological data”, Quaternary Science Reviews 26, 2463-2486.


Dokoza S. 2009: Dinamika otočnog prostora, Split.


Džaja N. 1999: Tradicionalna obrada kamena klasičnim alatima, Umjetnička akademija Sveučilišta u Splitu, Split.

GJIVOJE M. 1970: "Antikni kamenolomi na korćulanskim otocima", Zbornik otoka Korčule 1, Zagreb, 68-75.

GUTIÉRREZ GARCIA-MORENO A. 2009: Roman Quarries in the Northeast of Hispania (Modern Catalonia), Tarragona.


PARICA M. 2014: Arheološki tragovi kamenerastva u Dalmaciji od prapovijesti do kraja srednjeg vijeka, doktorska disertacija, Zadar.


ŠKEGRO A. 1999: Gospodarstvo rimske provincije Dalmacije, Zagreb.

