

# Labour Forces at Imperial Quarries

---

**Russell, Ben**

*Source / Izvornik:* **ASMOSIA XI, Interdisciplinary Studies on Ancient Stone, Proceedings of the XI International Conference of ASMOSIA, 2018, 733 - 739**

**Conference paper / Rad u zborniku**

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

<https://doi.org/10.31534/XI.asmosia.2015/05.13>

*Permanent link / Trajna poveznica:* <https://urn.nsk.hr/urn:nbn:hr:123:265578>

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

*Download date / Datum preuzimanja:* **2024-08-27**



*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 Brillì 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. Peréx 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 Barancsuk, 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 Previato 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 Denктаş</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 Previato</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

# LABOUR FORCES AT IMPERIAL QUARRIES

Ben Russell

University of Edinburgh, Edinburgh, United Kingdom (ben.russell@ed.ac.uk)

## Abstract

This contribution focuses on manpower at imperially-administered quarries. Drawing on the evidence provided by the Mons Claudianus *ostraka* the range of workers at this site, their working practices and labour organization will be examined. These data will then be compared with what is known of quarrying elsewhere, notably at the major quarries at Dokimeion in Phrygia. While direct evidence for the individuals involved in the extraction of stone at these sites is not as forthcoming as for the Eastern Desert sites, certain conclusions can be drawn from the surviving quarry inscriptions and, in particular, the references to *officinae* and *caesurae*. This contribution touches on questions of quarry organization and the cost of the labour force at imperially administered quarries.

## Keywords

imperial quarries, manpower, Mons Claudianus

The Roman imperial state invested heavily in securing supplies of prestigious marbles from a range of major quarries around the Mediterranean. This investment was both financial and logistical, involving an extensive administrative framework and various forms of direct and indirect exploitation.<sup>1</sup> The *raison d'être* of imperial involvement in quarrying remains debated, as does the extent to which the quarried material was an imperial monopoly.<sup>2</sup> However, one key question relating to this issue that deserves to be explored in more detail is that of labour forces: how many individuals (quarrymen, carvers and others) did the state have to employ at these various marble quarries to ensure that sufficient supplies were produced? How did this financial investment compare with other demands on the imperial administration's resources? At most quarries we have no data about work forces, but at Mons Claudianus there is good evidence, albeit patchy, for the total number of individuals employed at different points in time. Although this site was clearly exceptional in many ways, the information provided by the Mons Claudianus *ostraka* offers

an insight into the functioning of a major quarry that can help us think about questions of manpower elsewhere. This contribution presents some thoughts on how we might go about calculating labour forces at imperial quarries.

## Workforce size and composition

Our best evidence for the workforces at imperial quarries is provided by the *ostraka* from Mons Claudianus, in the Eastern Desert of Egypt.<sup>3</sup> Of the approximately 9,000 *ostraka* recovered during excavations at this site between 1987 and 1993, the most important for our purposes is a water list (*O.Claud. inv. 1538*), published in full by H el ene Cuvigny, who dates it to the middle Trajanic period, c. AD 110.<sup>4</sup> This list documents all of the workers at the quarries on a single day, a total of 917, which Cuvigny breaks down into a series of groups (Table 1).

The other workers listed comprise a diverse band: a surveyor of stone, two doctors, two cobblers, a barber, a priest, assorted doormen and guards, a vet, a steward, camel- and donkey-handlers, among others. The exact status of the two main groups of workers at the quarries – παγανοί (*pagani*) and φαμελιάριοι (*familiares*) – remains obscure; the παγανοί are freeborn Egyptians mainly involved in quarrying, while the φαμελιάριοι were involved in auxiliary tasks and specialist jobs, only sometimes related to quarrying.<sup>5</sup> But all of these workers were paid employees.

This water list does not distinguish between types of stoneworkers (they are all described as σκληρουργοί or quarrymen/stoneworkers), nor does it tell us what the 400 φαμελιάριοι did, but other *ostraka* show that specialist quarrymen existed: quarry-pick wielders (ἀκισκλάριοι) and wedge-/feathers-men (παρασφενάριοι), for instance. Metalworking assistants are also attested, as are so-called 'hammer-men' (σφυροκόποι), some apparently working in quarrying, others at the furnaces, and stone-carriers/-transporters (λιθοφόροι).<sup>6</sup> These technical specialists were φαμελιάριοι not παγανοί like most of the other stoneworkers and metalworkers.

1 HIRT 2010, 290-331; RUSSELL 2013, 38-52.

2 FANT 1993; PENSABENE 2013, 197-218.

3 PEACOCK, MAXFIELD 1997.

4 CUVIGNY 2005.

5 CUVIGNY 2000, 331-333.

6 B ULOW-JACOBSEN 2009, 11-12.

Profession	Total
Architect	1
-----	
παγανοί	
Stoneworkers	349
Supervisors	7
Blacksmiths	40
Bellowsmen	25
-----	
φαμελιάριοι	400
-----	
Soldiers	
Officers	2
Infantry	29
Recruit	22
Cavalry	6
Unknown role	1
-----	
Other workers	35

Table 1.  
Groups of workers  
recorded on *O. Claud.*  
inv. 1538

As well as simply listing all the workers needing water, the water list recorded on *O. Claud.* inv. 1538 also gives breakdowns for the numbers of workers per extraction site (Table 2).<sup>7</sup> These can be supplemented by data from additional *ostraka* from Mons Claudianus published by Adam Bülow-Jacobsen (Table 3).<sup>8</sup> Among the individuals who are not classed as either stoneworkers or metalworkers in Tables 2 and 3 are soldiers, guards of various types of supplies, foremen, carpenters, knot-makers and sawyers, all attested in small numbers.

These totals provide an insight into the size and composition of different working parties. Some of the workforces in specific quarries are enormous (higher totals appear in some of the incomplete *ostraka*), presumably reflecting the importance of the project being worked on: the so-called Trajan quarry was the largest, with the Mese and Myrismos quarries following. Of the workers employed in the quarries, 70-80% of them can be identified as quarrymen or other types of stoneworkers. Most of the rest of the workers present were employed at the

furnaces, each operated by a three-man team comprising blacksmith (χαλκεύς), bellowsman (φουσητής) and temperer (φαρμαζάριος). The ratio between stoneworkers and those involved in tool sharpening averages out at about 4:1, with one blacksmith for every twelve stoneworkers.<sup>9</sup> This high ratio is probably not representative: the granodiorite (*granito del Foro*) is exceptionally hard and evidence from more recent periods suggests that carvers working it could go through six chisels in an hour.<sup>10</sup>

#### Fluctuations in the size of the workforce

The Trajanic *O. Claud.* inv. 1538 provides a glimpse of the quarries at the height of their operation but other *ostraka* show that these enormous numbers were not maintained. Using the names of individuals requiring chisels recorded on a series of documents from the early 140s AD (*O. Claud.* 832-6), Bülow-Jacobsen proposes that around 110 stoneworkers were active in the quarries in this period, equivalent to a possible total

7 CUVIGNY 2005, 314-315, 322.

8 BÜLOW-JACOBSEN 2009.

9 BÜLOW-JACOBSEN 2009, 14.

10 *Pers. comm.* Stephen Cox.



Quarry name	Stoneworkers	Smiths	Others	Total
'Trajan'	137 total		?	>137
'Mese'	105-111?	11	?	>116/122?
'Myrismos'	36 total		8	44
'Large platform'	30	2	?	>32
'Oracle-Sarapis'	18	2	5	25
'Apis'	12	1	3	16
'Hera'	33 total		6	39
'Dioscuri'	16 total		2	18
'Platform of Hera'	23 total		3	26

Table 2.  
Labour groups at  
particular quarries listed  
on *O. Claud. inv.* 1538

Quarry name (with <i>O. Claud. no.</i> )	Stoneworkers	Specialist stoneworkers	Smiths	Other metalworkers	Others	Total
Apollo (634)	17	1	2	4	2	26
Dios (638)	11	3	1	2	3	20
Kanopos (641)	7?	7	1?	2	1	18
Mese (644)	36	1	3	6?	3?	49
Myrismos (647)	30	2	3	6	4	45
Myrismos (648)	70	2	4	8	5	89
Column of Chresmoserapis (657)	25		2	4		31
? (652)	-	78?	-	?	?	78
? (659)	61	1	4	4	7	77
? (660)	61	1	4	8	5	79
? (673)	25		2	2	3	32
? (686)	60	4	4	8	5	81

Table 3.  
Labour groups at  
particular quarries  
listed on other *ostraka*  
from Mons Claudianus  
(complete lists only)

workforce of 286.<sup>11</sup> Using a different set of documents, Bülow-Jacobsen and Cuvigny identify 150 or so *παγῶνοι* at the site in the late 130s and early 140s AD, though this total evidently includes stoneworkers and most metalworkers too.<sup>12</sup> Year to year, in practice, the workforce could have been very different depending on the nature of demand.

By the later Antonine period there are suggestions that the workforce dropped to very low numbers. Complaints about insufficient supplies become more common, as does evidence for staff shortages.<sup>13</sup> In a letter addressed to the prefect Antonius Flavianus (*O. Claud.* 850), dating to the late Antonine period, a group of quarrymen working on a pair of columns request both more supplies and protection from harassment by nomads so that they can finish the job more quickly.

### Productivity and potential output

*O. Claud.* inv. 1538 dates to the middle Trajanic period, and if to AD 110, as has been proposed, to exactly halfway through the building of the Forum of Trajan. This project made use of *granito del Foro* for a total of 108 column shafts in the lower order of the Basilica Ulpia (8.84 m in height (c. 30 Roman feet))<sup>14</sup>. Further material was used for wall revetment and paving, a total of no more than 40 m<sup>3</sup>. Indeed *granito del Foro* use at Rome reached its zenith in the Trajanic and Hadrianic periods and is also used in abundance in the Pantheon, Temple of the Divine Trajan, Temple of Venus and Roma, as well as at Hadrian's Villa.<sup>15</sup> Elsewhere I have used the water list *ostrakon* from Mons Claudianus (*O. Claud.* inv. 1538) in conjunction with later nineteenth-century building manuals to estimate the potential output of the Mons Claudianus quarries at the peak of their operation.<sup>16</sup> Pegoretti's labour figures for the working 'Dioriti della massima durezza'/'Granito duro', suggest that to quarry and rough-out just one of the shafts used in the Basilica Ulpia would take 1115 man-days.<sup>17</sup> For the 108 shafts required we are looking at a total of roughly 120,420 man-days, to which a further 3000 man-days for the blocks for paving should be added. What these totals indicate is that the

workforce of 349 stoneworkers (comprising quarrymen and carvers) attested in *O. Claud.* inv. 1538 would have required approximately 350 days to produce all of the *granito del Foro* required for the Forum of Trajan. An excess of material would always have been produced to cover any damage during transport so this total should be pushed up slightly, but since, as argued above, the actual total number of stoneworkers (including specialist members of the *φραμελιάριοι*) was probably closer to 400, the overall figure does not change significantly. Turning these totals around, a workforce comprising 350-400 stoneworkers could probably have quarried and roughed-out 94-108 shafts of c. 30 Roman feet in a working year (i.e. of c. 300 days) or a total of around 1500 blocks of 1 m<sup>3</sup>.

These totals relate to the quarries operating at their peak. The use of *granito del Foro* drops off after the Hadrianic period, even if it is found in the Antonine theatre at Sessa Aurunca, the later second-century phase of the theatre at Teano, the Baths of Caracalla, the Baths of Diocletian and his palace at Split.<sup>18</sup> Reduced demand led to the situation outlined above, in which far fewer workers were employed at Mons Claudianus.

### Calculations for the quarries at Dokimeion

Detailed evidence of the kind provided by these *ostraka* is limited to the Eastern Desert, but some of the evidence outlined above is relevant to understanding potential workforce totals at other quarries under imperial oversight.

Like the quarries at Mons Claudianus, the Dokimeian quarries were placed under enormous strain in the early second century AD, even if their peak production probably occurred in the Hadrianic and Antonine periods.<sup>19</sup> *Pavonazzetto* from the site was again used extensively in Trajanic building projects at Rome, notably the Forum of Trajan. This structure used 184 *pavonazzetto* column shafts, in five different sizes ranging in length between 3.53 and 8.83 m, as well as 40 pilaster shafts of 7.05 m and a total of approximately 70 m<sup>3</sup> of material for sawing into veneer (enough to cover 2788 m<sup>2</sup>).<sup>20</sup> Using Pegoretti's totals for the working of a hard marble, we can estimate that to prepare all of this material at the quarries would have required 19,055 man-days for the column shafts, 1986 man-days for the pilaster shafts, and 1890 man-days for the additional blocks. To extract and rough-out all of this material in the same timeframe in which the Mons Claudianus quarries

11 BÜLOW-JACOBSEN 2009, 263.

12 BÜLOW-JACOBSEN 2009, 264.

13 *O. Claud.* 876-8, 882, 887, 889, 890-1, 895; BÜLOW-JACOBSEN 2009, 257-259.

14 PACKER 1997.

15 PEACOCK *et al.* 1994, 214-15, table 1; CLARIDGE 2007, 74; CASSATELLA, PANELLA 1990.

16 RUSSELL 2013, 228-232.

17 PEGORETTI 1843-1844, 78, 240-245.

18 CASCELLA 2009, 39; SIRANO, BESTE 1999; DELAINE 1997, 259-263; PEACOCK *et al.* 1994, 214-15, table 1.

19 FANT 1989.

20 PACKER 1997; MILELLA 2002.

were able to turn around their allocation, would have required a total of at least 65 stoneworkers. In addition to these, further stoneworkers would have been needed to work on any additional columns or blocks needed as spares (10% in excess would have been sensible) and on the material used for the series of statues of Dacian captives that adorned the Forum of Trajan. An overall total, therefore, of up to 80 stoneworkers is more reasonable.

To this total we should add all of the additional workers that the Mons Claudianus *ostraka* reveal were involved in quarrying. At Mons Claudianus these other individuals outnumbered the listed stoneworkers at a ratio of roughly 2:1 but at Dokimeion their numbers would not have needed to be so great, partly because the sites was not nearly so remote.<sup>21</sup> Administrators would have been required, as well as workmen for carrying water, clearing rubble and transporting quarried material. Metalworkers would also have been needed, albeit in lower numbers given the relative softness of the marble being extracted; a total of perhaps one for every 12 stoneworkers is more plausible. Fewer soldiers would have been present, however, while the infrastructure needed to supply the site with food and equipment would not have been as complicated as in the Eastern Desert. Nevertheless, it seems likely that in order to complete their task, this team of 65 stoneworkers would have required at least the same number again of support staff. In addition, it is crucial to remember that while a significant portion of the workforce at Dokimeion might have been allocated to a single project for an entire year, *pavonazetto* was used so widely and in such a range of projects that it seems more likely that further projects were being catered for at the same time as the material for the Forum of Trajan was being produced. This being said, there are few major building projects of the same date as the Forum of Trajan that employ *pavonazetto* in substantial quantities: the earlier Forum of Nerva used *pavonazetto* columns as do a range of Hadrianic buildings in Ephesos, Smyrna and Athens, while elsewhere in Asia Minor and in North Africa much of the *pavonazetto* belongs to Antonine or later projects.<sup>22</sup> It does not seem unreasonable, therefore, to argue that a total workforce at the quarries of 150-200 individuals in the Trajanic period could have handled most of the demand placed on them.

Considering the pattern of demand for *pavonazetto* observed in building projects it is possible this workforce increased later in the second century AD, but this is also a period when private contractors become visible at the site. These individuals paid for the right to quarry stone (probably white marble in the main) by extracting a certain

amount of material for the state.<sup>23</sup> The inventory numbers on quarried blocks dating to after the 130s, therefore, provide some vague indication of output, but only of material belonging to the state, which must have been under 50% of the total output. The highest of these inventory numbers from the quarries is 433, on a block dated to AD 147.<sup>24</sup> The average size of the quarried blocks recovered from the Dokimeian quarries is roughly 0.8 m<sup>3</sup> and to quarry and square even 450 such blocks in a year would have necessitated a workforce of only around 30 stoneworkers. Since, in practice, the inventory number provides a minimum total for the imperial products, and in any case should be doubled to account for non-imperial output, a labour force of 70-100 stoneworkers could be reconstructed. The way in which the quarry personnel were divided after the 130s into groups working in the quarries (*caesurae*) and workshops (*officinae*) also suggests a relatively large and highly articulated workforce.<sup>25</sup> The numbers of these groups varies annually but in AD 198, for instance, the directors of four *caesurae* are named (Iulius Neophytus, Ostillius Elpidophorus, Ulpus Yacinthus, and Aurelius Theophilus) alongside five *officinae* (Urania, Bassiana, Herculiana, Severiana, Mart(is/ialis)).<sup>26</sup> At Mons Claudianus, most of the teams assigned to specific quarries consisted of 30 or more individuals, and even though the situation at Dokimeion is likely to be different, it is conceivable that this number of working groups indicates a workforce of again at least 70-80 stoneworkers.

### Wages

How much did those stoneworkers who needed to be directly employed (i.e. who were not contractors) cost the state? A series of *ostraka* from Mons Claudianus dated to AD 136 and 146 show that most of the *παγανοί* (88% on the relevant *ostraka*) were paid 47 drachmas per month, though some junior workers were paid either 37 drachmas and 4 obols or 28 drachmas.<sup>27</sup> Rations were paid on top of this. The *παγανοί* received 1 artaba of wheat per worker plus wine, while they had to buy other goods from the Nile valley, the cost of which was deducted from their wages. The *φαμελιάριοι* received a more generous ration of lentils, oil and clothes but it is not clear what wage they received. Considering the average market price for 1 artaba (c. 39.5 litres) of wheat in Egypt in this period was 9.2 drachmas and, when the other rations are taken into account, this could mean that the *παγανοί* at the top end of the scale

21 RÖDER 1971.

22 PENSABENE 2010, 79.

23 HIRT 2010, 290-331; RUSSELL 2013, 45-49.

24 FANT 1989, no. 90.

25 FANT 1989; HIRT 2010, 293-299.

26 HIRT 2010, 392-393, no. 310-319.

27 CUVIGNY 1996.

were paid the equivalent of 70 drachmas per month.<sup>28</sup> This is higher than was typical for labourers in the Nile valley, who in this period were paid on average 25 drachmas and rarely above 40 drachmas.<sup>29</sup> However, 70 drachmas per month translates to just a little over 2 drachmas per day and this sits at the lower end of daily wages recorded in other areas of the empire, which typically range from 2-4 sesterces.<sup>30</sup> Interestingly, these wages seem to be about the same as those paid to miners in Dacia in the same period, indicating some level of central control.<sup>31</sup> We have no information on how many months these workers were employed each year at Mons Claudianus. Scholars working on ancient labour often use a figure of between 200-250 working days per year as an average.<sup>32</sup> This would equate to seven or eight months of full-time employment. However, it is very unlikely that rest days were not built into the monthly schedule at Mons Claudianus. Indeed Cuvigny notes that when daily wages are attested on the *ostraka* they are in the region of 4 drachmas, perhaps suggesting that built into the monthly rates was an understanding that only half the days of the month were working days.<sup>33</sup> Since there was little seasonal variation in temperature or rainfall in the Eastern Desert, there is no reason to assume that these workers could not have been employed all year round. Cuvigny, in fact, has argued that the monthly wages attested at Mons Claudianus are actually based on annual salaries broken down in monthly instalments.<sup>34</sup>

To put these wages in context, a worker at the top end of the pay scale was paid 564 drachmas annually or roughly half what a legionary was paid following Domitian's reforms (1200 sesterces).<sup>35</sup> However, since the workers at Mons Claudianus were also provided with some rations on top of their wages, they did much better than this comparison suggests; Serafino's monthly estimate of 70 drachmas would equate to an annual pay of 840 sesterces. Since the annual subsistence requirement has been estimated at 115-200 sesterces for the same period, with a sestertius and a drachma being broadly equivalent, it is clear that the workers at Mons Claudianus were paid a reasonable wage.<sup>36</sup>

From the perspective of the state, just to pay the 421 *παγαβοί* listed in *O. Claud. inv. 1538*, therefore, would have cost around 230000 drachmas (assuming that 88% of the workers were on the highest rate, 8% on the middle rate and 4% on the lowest rate). To this total we need to add roughly 46000 drachmas in wheat, plus the cost of other rations, which could easily add up to the same again. To pay these specialist workers, therefore, would have cost the equivalent of the salaries of approximately 270 legionaries. To this total one needs to add the cost of the 400 *φαμελιάριοι* and the wages of the soldiers and other specialists at the site, which could easily have added up to more than the cost of the *παγαβοί*. In reality, of course, these wages would have constituted only a small portion (less than half?) of the total costs of running Mons Claudianus: no account here is made for the cost of food for the animals and the cost of equipment, in particular metal; transport of quarried material outside the quarry would also have been hugely expensive.

The correspondence between the Mons Claudianus wages and those attested in Dacia indicate an agreed pay scale across imperial extractive operations, which is somewhat surprising considering the varying local economic conditions. If the workers at Dokimeion were paid the same during the construction of the Forum of Trajan (when the leasing system that developed later appears not to have operated) then the 150-200 workers required could easily have cost at least 100,000 sesterces and more if payments in kind (like the rations at Mons Claudianus) or equivalent incentives were also paid.

These totals provide an insight into the level of finances that the state invested in securing supplies of prestigious materials. Since the Forum of Trajan also used substantial quantities of *giallo antico* and *cipollino*, we might hypothesize workforces of 150 and 100 workers respectively in each of these quarrying districts just employed on this project. At Luna, meanwhile, where all of the white marble came from, a total of at least 200-250 workers directly involved in the supply of material to the Forum site can be estimated. These are extremely hypothetical totals, but within an order of magnitude that appears plausible based on the analysis attempted for Dokimeion. Just to secure enough material for the Forum of Trajan, therefore, the state may well have had to employ close to 2000 workers at quarries scattered around the empire. The costs involved in this process might explain why this direct system of exploitation was apparently replaced with a more indirect system, which utilised private contractors, at most imperial quarries where this was feasible. At Mons Claudianus, this was not possible and indeed overall investment in the site and its infrastructure seems to have declined after the Hadrianic period.

28 DUNCAN-JONES 1990, 151; SERAFINO 2009, 47.

29 DREXHAGE 1991.

30 DELAINE 1997, 119-121, 209; BARRESI 2000, 182, 345; DOMINGO 2013, 127-129.

31 NOESKE 1977, 396-404.

32 DUNCAN-JONES 1982; GOLDSMITH 1984, 269.

33 CUVIGNY 1996, 141.

34 CUVIGNY 1996, 143-145.

35 SPEIDEL 1992, 88, table 1.

36 GOLDSMITH 1987, 46; JONGMAN 2007, 599-600.

## BIBLIOGRAPHY

- BARRESI P. 2003: *Provine dell'Asia Minore: costo dei marmi, architettura pubblica e committenza* (Studia Archaeologica 125), Roma.
- BÜLOW-JACOBSEN A. 2009: *Mons Claudianus: Ostraca Graeca et Latina IV - The Quarry Texts: O. Claud. 632-896* (Documents de Fouilles de l'Institut Français d'Archéologie Orientale 47), Cairo.
- CASCELLA S. 2009: "Use del marmo nella decorazione architettonica del teatro romano di Sessa Aurunca (CE)", *Marmora* 5, 21-43.
- CASATELLA A., PANELLA C. 1990: "Restituzione dell'impianto Adrianeo del Tempio di Venere e Roma", *Archeologia Laziale* 10, 52-57.
- CLARIDGE A. 2007: "Hadrian's lost temple of Trajan", *Journal of Roman Archaeology* 20, 54-94.
- CUVIGNY H. 1996: "The amount of wages paid to the quarry-workers at Mons Claudianus", *Journal of Roman Studies* 86, 139-145.
- CUVIGNY H. 2000: *Mons Claudianus: Ostraca Graeca et Latina III - Les reçus pour avances à la familia: O. Claud. 417 à 631* (Documents de Fouilles de l'Institut Français d'Archéologie Orientale 38), Cairo.
- CUVIGNY H. 2005: "L'organigramme du personnel d'une carrière impériale d'après un ostracon du Mons Claudianus", *Chiron* 35, 309-353.
- DELAINE J. 1997: *The Baths of Caracalla: A Study in the Design, Construction, and Economics of Large-Scale Building Projects in Rome* (Journal of Roman Archaeology, Supplement 25), Portsmouth, RI.
- DOMINGO J. À. 2013: "The differences in Roman construction costs: the workers' salary", *Boreas* 36, 119-144.
- DREXHAGE H.-J. 1991: *Preise, Mieten/Pachten, Kosten und Löhne im römischen Aegypten bis zum Regierungsantritt Diokletians* (Vorarbeiten zu einer Wirtschaftsgeschichte des römischen Aegypten I), St Katharinen.
- DUNCAN-JONES R. 1982: *The Economy of the Roman Empire: Quantitative Studies* (2<sup>nd</sup> edition), Cambridge.
- DUNCAN-JONES R. 1990: *Structure and Scale in the Roman Economy*, Cambridge.
- FANT J. C. 1989: *Cavum Antrum Phrygiae. The Organization and Operations of the Roman Imperial Marble Quarries in Phrygia* (BAR International Series 482), Oxford.
- FANT J. C. 1993: "Ideology, gift, and trade: a distribution model for the Roman imperial models", in W. V. HARRIS (ed.): *The Inscribed Economy: Production and Distribution in the Roman Empire in the Light of Instrumentum Domesticum* (Journal of Roman Archaeology, Supplement 6), Ann Arbor, 145-170.
- GOLDSMITH R. W. 1983: "An estimate of the size and structure of the national product of the early Roman empire", *Review of Income and Wealth* 30, 263-288.
- GOLDSMITH R. W. 1987: *Premodern Financial Systems. A Historical Comparative Study*, Cambridge.
- HIRT A. M. 2010: *Imperial Mines and Quarries in the Roman World: Organizational Aspects, 27 BC-AD 235*, Oxford.
- JONGMAN W. 2007: "The early Roman Empire: consumption", in W. SCHEIDEL, I. MORRIS, R. P. SALLER (eds.): *The Cambridge Economic History of the Greco-Roman World*, Cambridge, 592-618.
- MILELLA M. 2002: "Uso del marmo colorato nel Foro di Traiano", in M. DE NUCCIO, L. UNGARO (eds.): *I marmi colorati della Roma imperiale*, Venezia, 124-127.
- NOESKE H. C. 1977: "Studien zur Verwaltung und Bevölkerung der dakischen Goldbergwerke in römischer Zeit", *Bonner Jahrbücher* 177, 271-416.
- PACKER J. E. 1997: *The Forum of Trajan in Rome. A Study of the Monuments, Volume 1*, Berkeley.
- PEACOCK D., MAXFIELD V. 1997: *Survey and Excavations - Mons Claudianus, 1987-1993. Volume 1: Topography & Quarries* (Fouilles de l'Institut Français d'Archéologie Orientale 37), Cairo.
- PEACOCK D., WILLIAMS-THORPE O., THORPE R.-S., TINLE A. G. 1994: "Mons Claudianus and the problem of the 'granito del foro': a geological and geochemical approach", *Antiquity* 68, 209-230.
- PEGORETTI G. 1843-1844: *Manuale pratico per l'estimazione dei lavori architettonici, stradali, idraulici e di fortificazione per uso degli ingegneri ed architetti* (2 volumes), Milano.
- PENSABENE P. 2010: "Cave di marmo bianco e pavonazetto in Frigia. Sulla produzione e sui dati epigrafici", *Marmora* 6, 71-134.
- PENSABENE P. 2013: *I marmi nella Roma antica*, Roma.
- RÖDER J. 1971: "Marmor phrygium. Die antiken Marmorbrüche von İschehisar", *Jahrbuch des Deutschen Archäologischen Instituts* 86, 253-312.
- RUSSELL B. 2013: *The Economics of the Roman Stone Trade*, Oxford.
- SERAFINO C. 2009: "Cave, miniere, salari: il caso del Mons Claudianus", in A. STORCHI MARINO, G. D. MEROLA (eds.): *Interventi imperiali in campo economico e sociale. Da Augustus al Tardoantico*, Bari, 43-53.
- SIRANO F., BESTE H.-J. 1999: "Studi sul teatro di Teano: rassegna preliminare", *Mitteilungen des Deutschen Archäologischen Instituts, Römische Abteilung* 112, 317-336.
- SPEIDEL M. A. 1992: "Roman army pay scales", *Journal of Roman Studies* 82, 87-106.