

# The Stone and Ancient Quarries of Montjuïc Mountain (Barcelona, Spain)

---

Álvarez, Aureli

*Source / Izvornik:* **ASMOSIA XI, Interdisciplinary Studies on Ancient Stone, Proceedings of the XI International Conference of ASMOSIA, 2018, 693 - 698**

**Conference paper / Rad u zborniku**

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

<https://doi.org/10.31534/XI.asmosia.2015/05.09>

*Permanent link / Trajna poveznica:* <https://um.nsk.hr/um:nbn:hr:123:236138>

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

*Download date / Datum preuzimanja:* **2024-07-23**



*Repository / Repozitorij:*

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



# 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 Ruppiniè 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

# THE STONE AND ANCIENT QUARRIES OF MONTJUÏC MOUNTAIN (BARCELONA, SPAIN)

Aureli Álvarez

Institut Català d'Arqueologia Classica (ICAC), Tarragona, Spain (aalvarez@icac.net)

## Abstract

The sandstone known as Montjuïc stone has been used throughout history in the city of Barcelona. However, it was during the Roman period that the quarries were extended considerably to supply the stone needed to build the city and its walls, as well as to use for its cultural manifestations (architecture, epigraphy, sculpture, etc.). Montjuïc stone is an easily recognisable sandstone with properties that make it suitable for a wide range of uses. The two varieties used for building, *blanquet* and *rebuig*, have very similar properties and can be distinguished mainly by their colouring (light grey in the case of *blanquet* and reddish ochre for *rebuig*).

## Keywords

Montjuïc sandstone, *Blanquet* variety, *Rebuig* variety, Roman quarries, temple of Augustus, wall of the *Barcino Colonia*



Fig. 1. Remains of Roman quarries in the area of El Fossar (now a mass grave) (photo: Archive MUHBA)

## Introduction

*Barcino* was built by the Romans on the coastal strip of Iberian *Laietania*, between the mouths of the Rivers *Llobregat* and *Besós* on so called *Mount Taber*, to the east of *Montjuïc Mountain*. Emperor *Augustus* was the true founder of Roman *Barcino* (15-13 BC).

The find on the south-western side of *Montjuïc Mountain* of a large area of quarrying, with signs of stone extraction during Roman times (Fig. 1), attests its use for the construction of Roman *Barcino* from the time it was founded during the reign of Emperor *Augustus*.<sup>1</sup> It was the building material for the first city walls and for the other public buildings; it was also frequently used for sculptures and inscriptions.<sup>2</sup>

The proximity to *Barcelona* and the urban requirements of the city led to the proliferation of quarries

all over *Montjuïc Mountain*.<sup>3</sup> Some were exploited and abandoned in ancient times while others were worked until more recently.<sup>4</sup>

In preparation for the 1992 Olympic Games, large faces of the Roman quarries facing the sea were excavated and studied.<sup>5</sup>

The *Montjuïc sandstone* was used outside the city of *Barcino* in other towns and settlements in the *Laietania* area, such as *Iluro* (modern-day *Mataró*) and the *Vallès* area.<sup>6</sup>

1 GUTIÉRREZ 2009, 89-101.

2 GRANADOS 1991, 141-201.

3 FAURA I SANS 1917, 155.

4 ÁLVAREZ 1988, 22-25; ÁLVAREZ 1988b, 34-39; ÁLVAREZ, MAYER 1983, 303-310; ÁLVAREZ, MAYER, RODÀ 1993, 145-151; ÁLVAREZ *et al.* 2009; ROCA I BLANCH 1999, 79-220; VOLTES 1960.

5 GRANADOS 1991.

6 GUTIÉRREZ 2009, 89-101; RODÀ 2009, 513-529.



Fig. 2. View of Barcelona with Montjuïc Mountain in the background (photo: A. Laborde 1806: “Voyage pittoresque et historique. Description de la principauté de Catalogne”, plate IV, Ed. Enciclopedia Catalana, SAU, Barcelona 2008, 6)

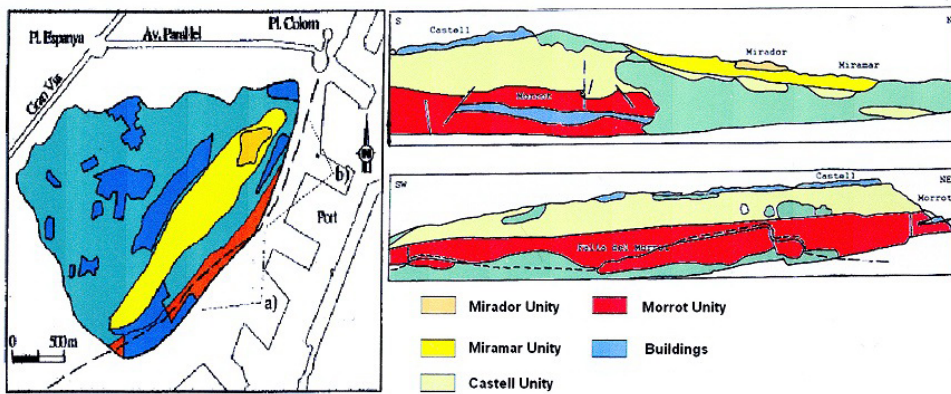


Fig. 3. Map and geological sections of the Montjuïc area (photo: GÓMEZ-GRAS 1993)

### Montjuïc Mountain

Montjuïc Mountain is situated to the south of the city of Barcelona, surrounded by Quaternary deposits and adjacent to the Barcelona graben. To the north and west it comes into contact with the Barcelona Plain. To the south it is bordered by the Llobregat Delta.<sup>7</sup> On the side facing the sea it is cut off by a fault that runs parallel to the coastline (Fig. 2).

The mountain can be considered a dome or anticline of dis-symmetrical branches, being the minor dip of the SW branch. On the lower part of the hinge it is possible to observe a slight tectogenesis originating from the silicification of more porous materials with the development of jaspers and chalcedony and the appearance in the fractures of minerals of hydrothermal origin.<sup>8</sup>

The silicified layers form compact, hard sandstone, passing locally to polygenic conglomerates.<sup>9</sup> The deposits are made up of alternating layers of conglomerates and

sandstones, with a lesser presence of mudstones. The vertical development of the layers is not homogeneous and there are numerous lateral changes of facies that make correlations difficult. The sediments that gave rise to the rocks of Montjuïc Mountain were deposited in a deltaic environment. Probably a large river that rose at Montseny Mountain crossed a terrain that descended slowly towards the coastal mountains we know today, flowing into the sea at Collserola. Villalta<sup>10</sup> differentiates 22 stratigraphic levels, which have recently been reduced to five units by Gómez Gras.<sup>11</sup> (Fig. 3).

The materials are dated to the Serravallian (Late Miocene).

### The sandstone

The first petrographic observation of Montjuïc stone was made by Jaime Almera in 1880, when he noted that it was made up of siliceous elements resulting from the erosion of granitic material from the coastal mountains.<sup>12</sup>

7 LLOPIS LLADÓ 1942, 321-383.

8 VILLALTA 1964, 99-105.

9 PARCERISA *et al.* 2001, v. 172, no. 6, 751-764.

10 VILLALTA 1964.

11 GÓMEZ-GRAS 1993, 115-161.

12 ALMERA 1880.



TEXTURAL PETROGRAPHIC DESCRIPTION		
CHARACTERISTICS	BLANQUET	REBUIG
TEXTURE	EPICLASTIC	
GRAIN SIZE	HETEROGRANULAR	
GRAIN DISTRIBUTION	LOW BADLY SORTED	
GRAIN FORM	SPHERICITY AND ROUNDNESS MIDDLE-HEIGHT OCCASIONALLY ANGULAR	
INTERGRANULAR RELATIONS	MANY PENETRATED GRAINS	A FEW PENETRATED GRAINS
MATRIX	LITTLE FILOSILICEOUS MATRIX	SIGNIFICANT AMOUNT OF FILOSILICEOUS MATRIX
CEMENT	LITTLE SILICEOUS CEMENT LITTLE ARGILLACEOUS CEMENT	SIGNIFICANT AMOUNT OF ARGILLACEOUS CEMENT
MINERALOGIC MATURITY	SUBMATURE	
MODAL CLASSIFICATION	SUBARKOSIC ARENITE	ARKOSIC GRAYWACKE

Table 1.

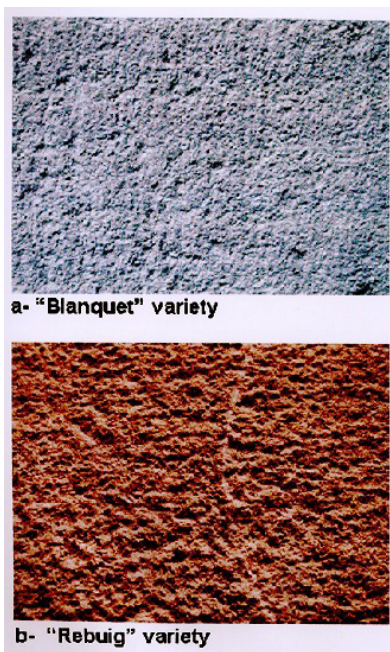


Fig. 4.  
The two varieties of stone found on Montjuïc Mountain:  
a) *blanquet*,  
b) *rebuig*  
(photo:  
A. Álvarez)

Faura I Sans (1917) gives us a petrographic description based on polarising microscope observation: “sandstone composed of rounded and perfectly cemented quartz grains”.<sup>13</sup>

The sandstone has a siliciclastic composition and can be considered a litharenite. Quartz monocrystals predominate over polycrystalline aggregates; the rock fragments correspond to granitoids, granitic porphyries,

quartzite, phyllites, schist, aplites, pegmatites and radiolarites. Associated minerals are biotite, muscovite, zircon, chlorite and tourmaline.

San Miguel and Masriera gave the first percentages of the different components of the rock, indicating a quartz content of more than 50%, accompanied by 10-25% of feldspars (orthoclase, plagioclase and microcline), with the remainder made up of muscovite, biotite and chlorite.<sup>14</sup>

This group of petrographic facies has traditionally been known as Montjuïc stone and includes two varieties. We could consider building stone: the grey-coloured variety (*blanquet*) (Fig. 4a) and a variety with a predominately ochre colour (*rebuig*) (Fig. 4b). They were used without distinction in the construction of buildings and monuments in Barcelona. The grey-coloured variety has the greatest degree of silicification, while the ochre variety owes its colour to the presence of iron minerals (sulphurs, oxides and hydroxides).

The matrix is sparse –less than 15% in volume– and is composed of micas, quartz and clay minerals. In more silicified varieties the remains of chalcedony and quartz can be found. The silicification process removed any presence of carbonated elements, especially in the *blanquet* variety, whereas in the *rebuig* variety the remains of residual calcareous cement may be found.

Table 1 shows a textural petrographic description and a comparative exposition of the two varieties, *blanquet* and *rebuig* (Table 1).

13 FAURA I SANTS 1917.

14 SAN MIGUEL, MASRIERA 1970, 11-34.

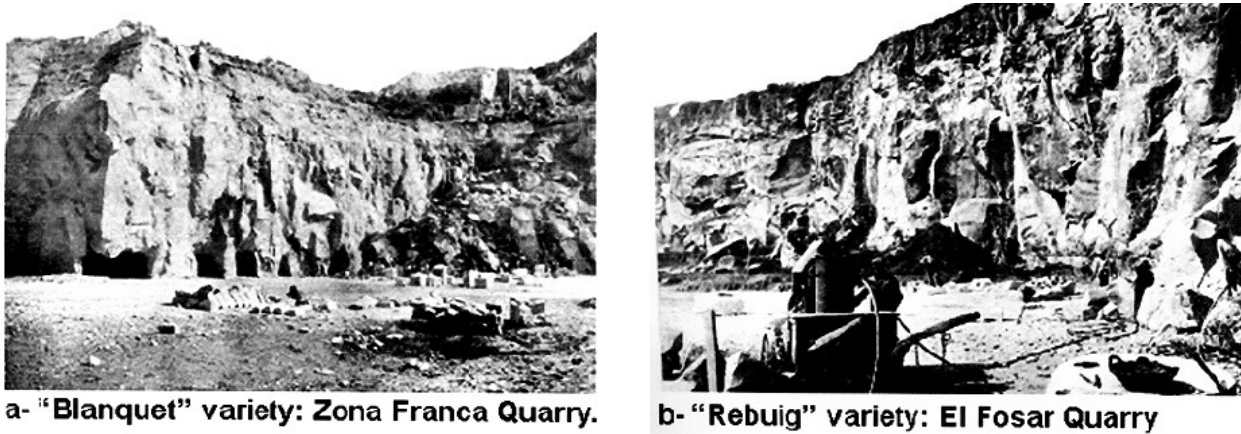
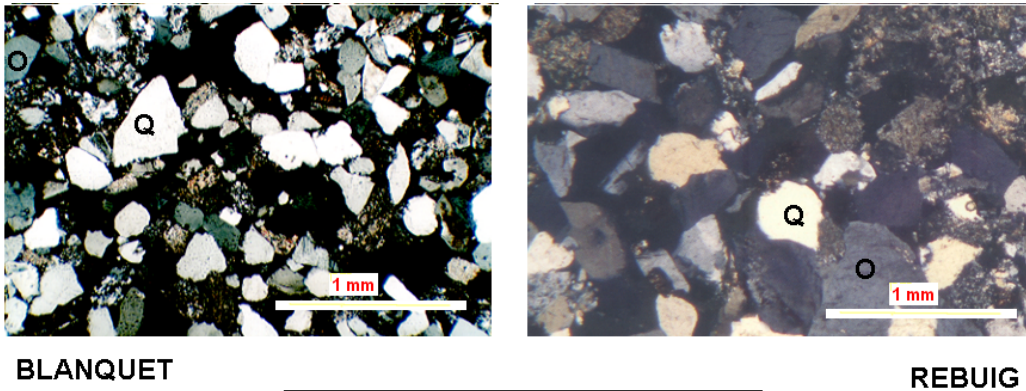


Fig. 5. Photographs of the two main quarries at the beginning of the 20<sup>th</sup> century: a) the Zona Franca quarries, b) the El Fossar quarries (photo: VOLTES 1960)



X-RAYS DIFFRACTION		
BLANQUET		REBUIG
75.0	QUARTZ (Q)	69.0
14.0	ORTHOCLASIS (O)	18.0
5.0	PLAGIOCLASE (P)	8.0
6.0	MICA-ILLITE (M)	6.0

Fig. 6. Microphotographs of the two varieties (*blanquet* and *rebuig*) with their respective mineralogical compositions (photo: A. Álvarez)

**Mineralogical composition**

The mineralogical composition of Montjuïc sandstone was first analysed using polarised light microscopy. A second stage using X-ray diffraction allowed for a semi-quantitative evaluation of the diverse mineral phases. The results were compared and completed with an elemental analysis using X-ray fluorescence and, in some cases, a scanning electron microscope (SEM).

The polarised light microscope allowed us to identify the minerals and to determine their shape, size and distribution, while with X-ray diffraction we were only able to identify the mineral phases and not their shape and distribution. In some cases the elemental

analysis (X-ray fluorescence and scanning electron microscope (SEM)) did not allow the result of a specific mineral phase to be assigned.<sup>15</sup>

For the study of the *blanquet* variety a sample (CRM4) was selected from the quarry located in the Zona Franca (Duty Free Zone) (Fig. 5a). The *rebuig* sample (CFM2) came from the El Fossar quarry (Fig. 5b).

Figure 6 shows the comparative mineralogical composition of the two varieties.

15 WILSON, PITTMAN 1977, 3-31.

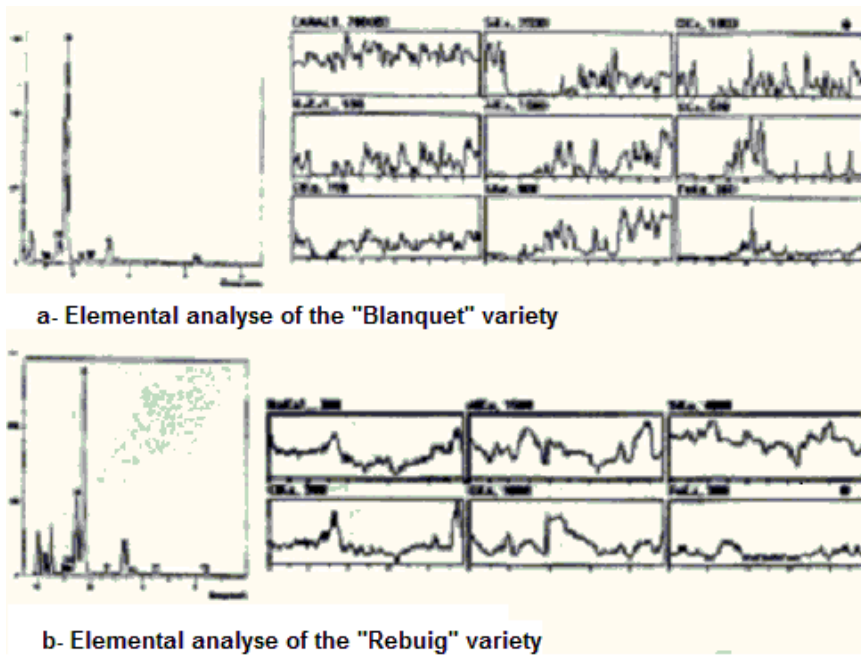


Fig. 7.  
Elemental analyses of  
the two varieties made  
with a scanning electron  
microscope (SEM) (UAB)

### Elemental analysis

The elemental analysis, which was carried out with a scanning electron microscope equipped with an EDAX detector, confirms the presence of the minerals detected using polarised light microscopy and X-ray diffraction.

The main elements found in the *blanquet* variety are, in order of importance, aluminium (Al), silicon (Si) and potassium (K). There are slight traces of sodium (Na), sulphur (S), chlorine (Cl) and iron (Fe). The predominance of silicon over aluminium indicates large quartz content (Si+O) compared to feldspars (Si+Al). A linear analysis (Fig. 7a) shows the superposition of the constitutive elements of the feldspars (Si, Al, O, Na, and K). The coincidence of sulphur and iron could indicate the presence of pyrite (an abundant mineral in the area).

The *rebuig* variety has the same elements as the *blanquet* except that it also contains titanium (Ti), which can be linked to the presence of iron forming a new mineral, ilmenite, which would have replaced the pyrite found in the previous samples. The linear analysis shows the same coincidences as before in the components of the feldspars (Si, Al, Na and K) (Fig. 7b).

### Applications

Montjuïc sandstone had numerous applications and, since it is such a characteristic stone, it is easy to identify.

One of the first Roman inscriptions carved on it was mentioned to the duumvir Caius Coelius (IRC IV,57), who was in charge of building the first walled enclosure of the *Barcino Colonia*.

The Temple of Augustus, with capitals in the Triumvirate period style dates from the foundation period.

The Catalonia Museum of Archaeology (MAC) and the Museum of History of Barcelona (MUHBA) have numerous finds from the excavations and many samples are published in our publications.<sup>16</sup>

16 ÁLVAREZ, MAYER, RODÀ 1993; ÁLVAREZ *et al.* 2009, *op. cit.*, 86-93.

## REFERENCES

- ALMERA J. 1880: De Montjuïc al Papiol a través de las épocas geológicas, Barcelona.
- ÁLVAREZ A. 1988: "Las canteras de Montjuïc (Barcelona) II", *Rev. Mineralogistes de Catalunya* 4(1), 22-25.
- ÁLVAREZ A. 1988b: "Las canteras de Montjuïc (Barcelona) III": *Rev. Mineralogistes de Catalunya* 4 (II), 34-39.
- ÁLVAREZ A., DOMÈNECH A., LAPUENTE P., PITARCH A., ROYO H. 2009: "Marbles and stones of Hispania", in *ASMOSIA IX*.
- ÁLVAREZ A., MAYER. M. 1983: "Materiales lapídeos de origen local utilizados en época romana en la costa sur del litoral catalán. Unidad y pluralidad en el mundo antiguo", *Actas del VI Congreso Español de Estudios Clásicos* (Sevilla, 1981), vol. II, Madrid, 303-310.
- ÁLVAREZ A., MAYER M., RODÀ I. 1993: "La pedra de Montjuïc i la seva utilització en època romana", *Actes del III Congrés d'Història de Barcelona*, Barcelona, 145-151.
- FAURA I SANS M. 1917: "Montjuïc: Notes geològiques", *Pub. Soc. de Atracció de Forasteros*, Barcelona.
- GÓMEZ-GRAS D. 1993: "The Permo-Triassic of the Catalan coastal cordillera facies and sedimentary petrology, part 1". *Boletín Geológico y Minero* 104(2), 115-161.
- GRANADOS O. 1991: "Estructura urbana de la ciudad romana", in *Historia de Barcelona*, Barcelona, 141-201.
- GUTIÉRREZ A. 2009: *Roman Quarries in the Northeast of Hispania (Modern Catalonia)*, Tarragona, 89-101.
- LLOPIS LLADÓ N. 1942: "Tectomorfológia del macizo del Tibidabo y valle inferior del Llobregat", *Estudios Geográficos* 3, 321-383.
- PARCERISA D., THIRY M., GÓMEZ-GRAS D., CALVET F. 2001: "Proposition d'un modèle de silicification superficielle des grés néogènes de Montjuïc, Barcelone (Espagne); Paragenèses minérales, environnements géochimiques et circulation des fluides", *Bulletin de la Société Géologique de France*, Novembre 2001; v. 172; no. 6, 751-764.
- ROCA I BLANCH E. 1999, "Montjuïc, la muntanya de la ciutat, Barcelona", chapter IV, Barcelona, 79-220.
- RODÀ I. 2009, "Los talleres de la ciudad de Barcino (Barcelona)", *Actes du X<sup>e</sup> Colloque International sur l'Art Provincial Romain (Arles-Aix-en-Provence 2007)*, Arles, 513-529.
- SAN MIGUEL A., MASRIERA A. 1970: "Contribución al estudio petrológico de los niveles de areniscas de Montjuïc (Barcelona)", *Instituto de Investigaciones Geológicas de la Diputación Provincial de Barcelona*, vol. XXIV, Barcelona, 11-34.
- VILLALTA J. F. 1964: "Montjuïc, Geología de los alrededores de Barcelona. Itinerario VI", Barcelona, 99-105.
- VOLTES P. 1960: "Historia de Montjuïc y su castillo", Ayuntamiento de Barcelona, Barcelona.
- WILSON M. D., PITTMAN E. D. 1977: "Authigenic Clays in Sandstones: Recognition and influence Reservoir Properties and Palaeoenvironmental Analysis", *Journal of Sedimentary Petrology* 47, 3-31.