

EUROLITHOS European Ornamental
Stone Resources



European Ornamental Stone Resources

Project number GeoE.171.017

Deliverable D5.1

Eurolithos case study collection

Authors and affiliation:

**Željko Dedić (HGI-CGS), Tom
Heldal (NGU), Jorge Carvalho
(LNEG), Valentina Cetean (IGR),
Christodoulos Hadjigeorgiou
(GSD), Javier Martínez Martínez
(IGME), Mauro Lucarini (ISPRA),
Mirka Trajanova (GeoZS)**

[Affiliation, PP acronym]

E-mail of lead author:

zdedic@hgi-cgs.hr

Version: 30-01-2020

This report is part of a project that has received funding by the European Union's Horizon 2020 research and innovation programme under grant agreement number 731166.



Deliverable Data		
Deliverable number	D5.1	
Dissemination level	Restricted	
Deliverable name	Case study presentation	
Work package	WP5 ORNAMENTAL STONE HERITAGE	
Lead WP/Deliverable beneficiary	HGI-CGS	
Deliverable status		
Submitted (Author(s))	15/01/2020	X
Verified (WP leader)	20/01/2020	X
Approved (Coordinator)	30/01/2020	X

The involved Eurolithos team

<i>Geological Survey of Norway</i>	NGU
<i>Geological Survey of Slovenia</i>	GeoZS
<i>Geological Institute of Romania</i>	IGR
<i>Italian Institute for Environmental Protection and Research</i>	ISPRA
<i>Croatian Geological Survey</i>	HGI-CGS
<i>Cyprus Geological Survey Department</i>	GSD
<i>Geological Survey of Spain</i>	IGME
<i>The National Laboratory of Energy and Geology</i>	LNEG

Version

Version	Description
Final	Final version for delivery



LIST OF CONTENTS

1	INTRODUCTION	2
2	MAIN SUBJECT AREAS OF THE CASE STUDIES	3
3	STAKEHOLDER INVOLVEMENT	6
4	ORNAMENTAL STONE RESOURCE VALUES	8
4.1	Assessment of large quarry landscapes	8
4.2	Heritage assessment of historical quarry: Magura Calanului, Romania	9
4.3	Heritage assessment of quarry landscapes: Quarries near Pučišća, the island of Brač, Croatia	10
5	STONE AND BUILT HERITAGE	12
5.1	Open data solutions for linking ornamental stone resources with buildings....	12
5.2	Built heritage of Nicosia, Cyprus: the use of calcarenite as built stone from antiquity to recent times, Cyprus.....	12
5.3	Linking natural stone from the island of Brač, with built heritage.....	13
5.4	Stone and built heritage: the Carrara Marble (Alpi Apuane District)	14
6	STONE AND INTANGIBLE HERITAGE	15
6.1	Traditional crafts in modern stone production	15
6.2	The Pučišća Stonemason School	16
7	SUSTAINABILITY AND ORNAMENTAL STONE	17
7.1	Sustainable stone production	17
8	CASE STUDY COVERING SEVERAL SUBJECTS	19
8.1	Best practices of natural stone valorization for the preservation of stone-built heritage: the case of platy limestone as characteristic element of cultural landscape along the Eastern Adriatic coast	19
8.2	Synergistic effect of quarry landscapes with overlapping active and historical quarries: the study case of Macael (SE of Spain)	19
9	FROM CASE STUDIES TO GUIDELINES	22
10	REFERENCES	23



1 Introduction

In Eurolithos, WP5 defined three main subjects of case studies in the Project Description, suggesting at least 2 case studies in each group:

- Ornamental stone resource value assessment – including a framework for description and characterization of stone quarries and quarry landscapes, defining the best methodological practice to assess the values of such
- Stone and built heritage – develop methods for practical inventories of stone resources and built heritage, including a framework for assessing the importance of stone types for maintenance, restoration and new construction.
- Stone and intangible heritage (crafts) – focused on the unitary designation and description of the immaterial crafts in a way that can be used in the heritage stone assessments.

In our consortium meeting in July 2019, we, furthermore, decided to include one or several case studies in an additional new subject – sustainable ornamental stone production. This was mainly reasoned in the increased urgency in finding sustainable solutions along the range of raw materials, and due to recent innovative developments in the industry. We will primarily focus 1) zero waste, 2) environmental footprints (life cycle) and 3) sourcing of ornamental stone products.

In total, we are carrying out 12 case studies distributed on the four subject areas. These case studies will collectively form the scientific foundation for making guidelines describing how to assess values of ornamental stone resources.



2 Main subject areas of the case studies

In this chapter we will describe the four main subject areas of case studies.

1) Ornamental stone resource value assessment: ornamental stone has been employed since the dawn of civilization in shaping our cities and architectural heritage. Quarry landscapes are the result of continuous reorganizations of the land in order to adapt its use and spatial structure better to changing societal demands. They are also related to cultural issues and traditions that mark the character of a community. Quarries and quarry landscapes may form direct or indirect parts of UNESCO World Heritage Sites, extended parts of our historical cities or unknown needs for future restoration of listed buildings.

As expressions of dynamic interaction between natural and human forces through time, quarry landscapes and the stone resources they occur in, may contain significant values: economic (for future exploitation), architectural (as authentic source of building material), historical (as places of industrial change and evolution), archaeological (as remains of ancient industries) and cultural (as contributors to cultural landscapes). All these values may collectively or individually influence land management and future exploitation of resources (see Pereira et al. 2015, Pereira and Pratt 2016, Pereira and Van den Eynde 2019, Pereira et al. 2019).

This group of the case studies will include specific research on quarry landscapes, for developing a general, multidisciplinary methodology for documentation and evaluation of such sites. The subjects will be focus on:

- Identification and description of features of quarrying on micro and macro level (stone resource, quarry site)
- Interpretation of such features and visualization of quarry landscapes (including time depth and interpretations) (Heldal 2009)
- Assessing values along several axes for such sites

This group of the case studies will lead to a guidelines and best practices in identification, description and interpretation of features of quarrying and quarry landscapes, and how this may be used for assessing values.

2) Stone and built heritage: ornamental stone is one of few commodities that has been applied in the same way (for construction) since Antiquity until today. Society and technology applied have changed, but we are still using stone basically in the same way as in the Greek and Roman periods. In addition to the vast number of historical and modern buildings in which ornamental stone were used, the tradition of producing and using stone has become an inseparable part of many countries' identity. Numerous quarries throughout Europe that were applied in ancient times, are still in use. Others were abandoned centuries ago, and yet others are recently closed or at risk for being closed within a short time.



The impact of a massive scale loss of access to important European stone resources is poorly known. However, knowledge of the use through history and geography of particular resources may have a great impact on how such resources are valued (i.e., for promotion of the importance of stone resources from their use in stone-built heritage).

This group of case studies will explore tools for linking ornamental stone resources with built heritage and other constructions. The case studies will focus on: Tools for linking spatial data (quarry/resource location with use in construction), examples of the importance of linking stone resources with constructions, and examples of needs for linking authentic resources to built heritage.

3) Stone and intangible heritage (crafts): even in a high-tech world, traditional crafts are vital for proper production of ornamental stone. Yet, many places such traditions, learned through centuries, are in danger of extinction. This is the reason why Stone-mason's school exists in many countries, successfully maintaining tradition of precious procession of stone. Some schools are known for having specific knowledge of i.e. ancient Roman hand tools in stone dressing, and thus receiving an increasing number of queries from foreign countries for student enrolment. In other countries, industries are maintaining ancient crafts for profit reasons.

This group of case studies will explore the importance of crafts and traditional skills, both from an industrial point of view and from a public one – the need for education.

4) Sustainable ornamental stone production: sustainable ornamental stone production is not widely addressed, but it should be. Too much stone with heavy environmental footprints, particularly related to transportation, is traded around the globe. In this group of case studies we will primarily focus on: zero waste production, environmental footprints (life cycle analyses) and sustainable management of ornamental stone resources. One of the reasons for creating this topic was increased urgency in finding sustainable solutions along the range of raw materials, and due to recent innovative developments in the industry.

The main obstacles in this group of the case studies are in the rigid legislation and in the lack of guidelines for stakeholders in spatial planning, urbanization and cultural and natural conservation. Firm guidelines are needed for sustainable use of natural stone as building material, then for conservation of the stone as heritage and finally for conservation of stone-built cultural heritage.

Table 1 gives an overview of case studies.



Table 1. Case studies, subject areas and responsible partners

<i>Case study</i>	<i>Lead partner</i>	<i>Subject area</i>	<i>Stone type</i>
<i>Assessment of large quarry landscapes</i>	NGU	1	Granite
<i>Heritage assessment of historical quarry: Magura Calanului, Romania</i>	IGR	1	
<i>Heritage assessment of quarry landscapes: Pučišća, Brač, Croatia</i>	HGI-CGS	1	Limestone
<i>Open data solutions for linking ornamental stone resources with buildings</i>	NGU	2	Multiple
<i>Built heritage of Nicosia, Cyprus: the use of calcarenite as built stone from antiquity to recent times</i>	GSD	2	Limestone
<i>The linking ornamental stone from island Brač with buildings</i>	HGI-CGS	2	Limestone
<i>Stone and built heritage: the Carrara Marble (Alpi Apuane District)</i>	ISPRA	2	Marble
<i>Traditional craft used in modern stone production</i>	NGU	3	Schist, limestone
<i>The Pučišća Stonemason School</i>	HGI-CGS	3	
<i>Sustainable ornamental stone production</i>	NGU/-LNEG	4	Monzonite, limestone, schist
<i>Best practices of natural stone valorization for the preservation of stone-built heritage: the case of platy limestone as characteristic element of cultural landscape along the Eastern Adriatic coast</i>	GeZS	1+2	Limestone
<i>Synergistic effect of quarry landscapes with overlapping active and historical quarries: the study case of Macael (SE of Spain)</i>	IGME	1+2	Marble



3 Stakeholder involvement

Behind the selection of case studies was the intention that they collectively should cover a range of stakeholder groups, from industry to cultural heritage authorities. The roles of the stakeholders are:

- Contribute in the selection and planning of case studies
- Contribute in the discussions and with information/data during case study work
- Contribute to comment and review final product

In some cases (particularly those involving industry) the stakeholders have been involved since early planning, since they are expected to contribute with company-specific data. In other cases (typical regarding local authorities and heritage authorities) they will play more active roles towards the end of case studies. **Table 2** provides an overview of case studies and stakeholders.

Table 2. Case studies and stakeholder groups involved at some stage.

<i>Case studies</i>	Industry	Land-use and environmental planning	Education	Government agencies	Local/regional authorities	Heritage authorities and institutions
<i>Assessment of large quarry landscapes</i>	X	X			X	X
<i>Heritage assessment of historical quarry: Magura Calanului, Romania</i>			X		X	X
<i>Heritage assessment of quarry landscapes: Pučišća, Brač, Croatia</i>		X	X		X	X
<i>Open data solutions for linking ornamental stone resources with buildings</i>					X	
<i>Built heritage of Nicosia, Cyprus: the use of calcarenite as built stone from antiquity to recent times</i>					X	X
<i>The linking ornamental stone from island Brač with buildings</i>			X		X	X



<i>Stone and built heritage: the Carrara Marble (Alpi Apuane District)</i>	X				X	X
<i>Traditional craft used in modern stone production</i>	X		X			X
<i>The Pučišća Stonemason School</i>	X		X		X	X
<i>Sustainable ornamental stone production</i>	X	X		X	X	
<i>Best practices of natural stone valorization for the preservation of stone-built heritage: the case of platy limestone as characteristic element of cultural landscape along the Eastern Adriatic coast</i>		X	X		X	X
<i>Synergistic effect of quarry landscapes with overlapping active and historical quarries: the study case of Macael (SE of Spain)</i>	X	X			X	X



4 Ornamental stone resource values

4.1 Assessment of large quarry landscapes

Eurolithos partners: NGU

Throughout Europe, there are large industrial and cultural landscapes originating from the exploitation of ornamental stone through history (**Figure 1**). Such landscapes may contain a range of potential values; as cultural and industrial heritage, as areas for recreation and tourism, as geological heritage, and as areas for future exploitation of stone. The Iddefjord granite, SE Norway (Pedersen and Maaløe 1990), has been exploited since the middle ages, but the main phase came with the industrial revolution. During the last half of the 19th Century, the granite industry here grew to a considerable size, culminating around the turn of the century when more than 5000 people worked in the quarries, producing paving and building stone (Oxaal 1916). At present time, only one active natural stone quarry remains, but the quality of the granite should encourage some further future developments. The study summarizes the geology and evolution of quarrying and quarry technology and provides an insight in the economic and non-economic values within the quarry landscape.

This case study seeks to enlighten the following generic aspects of historic quarry landscapes:

- Provide a framework for the description and characterization of quarry landscapes (i.e. geology, history, technology, landscape and stone use)
- Develop a toolbox on how such a characterization can be applied for assessing important values related to the quarry landscape
- Explore the influence of other land uses and land use planning on quarry landscapes
- Propose a framework for best practice in quarry landscape assessment

The following quarry landscapes in Europe will be used for this study: The Iddefjord Granite, Norway.

Stakeholders: local granite industries, cultural heritage authorities, regional/local administration



Figure 1. 19th Century granite quarries scattered along the coast of SE Norway

4.2 Heritage assessment of historical quarry: Magura Calanului, Romania

Eurolithos partners: IGR

Other participants: Dacica Foundation, Local Council

The historical use of the dimensioned stone for constructions (walls of military enclosures, civil or religious buildings, access roads, places of worship) has often been determined by practical requirements (as good workability, durability, distance from the source area, the required quantity) and only secondary to aesthetic - ornamental ones. In such cases, the source-area of the stone associated with historical monuments defining even national identity, has itself heritage value, deserving the scientific recognition of its importance for the world culture and civilization.

The proposed case study refers to the ensemble of fortresses and fortifications from Sureanu-Orastie Mountains erected by the Dacians during the 1st century BC and destroyed by the Romans at the beginning of the 2nd century AD. The monumental structures of the Sarmizegetusa Regia, the capital of the Dacian Kingdom (226 anthropogenic terraces, inhabited probably by more than 5000 people) and other 5



fortresses overlap a schistous or a hard limestony geological substratum, non-suitable to be used as ashlar (dimension) stone.

At present, it is admitted that all these fortresses were almost exclusively built with limestone that originates from Măgura Călanului quarry (30-50 km away). However, while the above mentioned fortresses has been inscribed on the World Heritage List 20 years ago, the Măgura Călanului historical quarry has never been systematically studied, nor the geosite protected or valued. It was only exploited during the building of the Dacian fortresses and it is well preserved, being probably one of the most spectacular ancient monuments of its kind outside the Greek-Roman world.

Hypothesis: Including of this cultural site in the list of historical monuments or other evidence which can ensure proper preservation and administration; Facilitating the starting of meta-disciplinary research for this global heritage stone resource.

Potential stakeholders: local community + administrative bodies (2 Local councils); scientific – cultural responsible units (County Directorate for Culture, 2 Museums); 1 Foundation, 1 NGO; scientific community and tourists, being in the proximity of an UNESCO Global Geopark (Dinosaurs [Geopark Tara Hategului](#) - 10-20 km away).

4.3 Heritage assessment of quarry landscapes: Quarries near Pučišća, the island of Brač, Croatia

Eurolithos partners: HGI-CGS

Ever since ancient times stones have been excavated at the stone excavation sites on the island of Brač. At present time, the most important stone excavation place is situated near town of Pučišća.

The high quality natural stone enabled building a number of famous constructions in Croatia. The most significant are the [Palace of Diocletian](#), the [Cathedral of St James](#) in Šibenik and the Cathedral of [St Lawrence in Trogir](#) (Crnković and Šarić 2003), all of which are UNESCO World Heritage sites.

The natural stones from the island of Brač have also been used for some other, well-known monumental buildings other places in the world, such as The White House in Washington, and the Parliament Houses in Vienna and Budapest (Maksimović, 2006).

This case study will include specific research on the quarry landscapes in the vicinity of Pučišća, at the island of Brač (**Figure 2**), particularly for developing a general methodology for documentation and evaluation of such sites. The study will focus on:

- Identification and description of features of quarrying (stone resource, quarry site)
- Interpretation of such features and visualization



Based on the mentioned analyses on quarry landscapes, the case study will explore a system of best practice in identification, description and interpretation of features of quarrying, i.e. defining and delineating the quarry landscape. Furthermore, how this can be applied in the value assessment and prepare recommendations for sustainable use and management of the natural stone resource.

Stakeholders: land use planning, education, local authorities, heritage authorities



Figure 2. Quarry landscapes in the vicinity of Pučišća, Island of Brač, Croatia



5 Stone and built heritage

5.1 Open data solutions for linking ornamental stone resources with buildings

Eurolithos partners: NGU

The connection between geological stone resources and the built environment in which they are used, is of great value for the overall assessment of importance for the particular resources. The longevity of use (time depth) relates to the historic importance of the stone resource, whilst the geographical extension of use adds arguments for national or international significance. It is probably not viable to make yet another European database on buildings and constructions made of stone. Thus, we try to explore how open solutions can be applied as a “crowdsourcing” opportunity for linking with stone resources through European mineral resource platforms. In particular, this case study will explore the use of wiki-solutions (such as [Open Streetmap](#)) as tools for such interactions.

Stakeholders: Trondheim municipality

5.2 Built heritage of Nicosia, Cyprus: the use of calcarenite as built stone from antiquity to recent times, Cyprus

Eurolithos partners: GSD

Throughout Europe, there is significant built heritage with the use through history of unique ornamental stones in a single house to the whole cities. These buildings or monuments or sites stand in time for centuries even sometimes for thousands of years. Even though many built heritage sites usually are touristic attraction, no information is provided about the stone that it is made of and how it is related to its history. This case study seeks to:

- Record the legal framework for the protection and conservation of the built heritage (antiquities law, town planning and housing law etc.)
- Record the best practices in the conservation of these sites but also record bad practices that they should be avoided
- Identify and characterize the ornamental stone in the selected built heritage landmarks and connect it with locations (quarries) that it came from (i.e. geology, history, landscape and stone use)
- Develop a photo album of significant built heritage sites providing relative information.



The following places with built heritage in Europe will be used for this study: The City of Nicosia, Cyprus (**Figure 3**).

Stakeholders: local authorities, cultural heritage authorities



Figure 3. Stone use and ancient/old quarrying, Nicosia. Presidential Palace in Nicosia and calcarenite quarry in the Mammari village west of the City of Nicosia.

5.3 Linking natural stone from the island of Brač, with built heritage

Eurolithos partners: HGI-CGS

The natural stone from the island of Brač, quarries has been exploited since the Ancient Greek and Roman times and used for the construction of important buildings. The tradition of using stone to build with has become an inseparable part of the island of Brač's identity (Plastić 2006). To maintain the stone-built heritage, the original sources of stone must be available, or at least, stones of similar quality and appearance.

This case study will establish linkage between the natural stone resources at the island of Brač, with the built heritage (buildings) where these have been applied through various periods. There are numerous quarries on Island of Brač. Some are still in use, while others were abandoned centuries ago.



The case study will investigate a range of buildings made of Brač stone and explore how these can be sourced to various parts of the limestone resources.

This will provide tools for 1) assess the importance of the stone resources from their use in the built heritage, and 2) identify future needs for stone in the maintenance of the built heritage and implications for stone resource management.

Stakeholders: education, local authorities, heritage authorities

5.4 Stone and built heritage: the Carrara Marble (Alpi Apuane District)

Eurolithos partners: ISPRA

Through millennia, ornamental stone resources have provided materials for construction, for several thousand years. The numerous sites where stone resources have been exploited represent a "cultural heritage", carrying evidence of ancient technologies, trade and anthropic development.

To maintain the stone-built heritage and the cultural landscapes, the original sources of stone must be available, or at least, stones of similar quality and appearance: this entails very important links between built heritage and stone resources.

Besides, the interaction between humans and stone resources has produced, historically, a rich and diversified immaterial heritage, namely crafts and skills.

This case study will be focused on:

- A synopsis ranging from geology and history to technology (and stone use) and landscape;
- The creation of a practical inventory of stone types for better calibrating maintenance, restoration and new construction;
- The realization of a short-list of monument categories built using [Carrara Marble](#) (and a mention to the great sculptors);
- The drawing up of best practises and guidelines on how to do inventories of links between stone resources and built heritage.

Stakeholders: industry, cultural heritage authorities, local authorities



6 Stone and intangible heritage

6.1 Traditional crafts in modern stone production

Eurolithos partners: NGU

Other participants: schist companies Oppdalsten AS and Minera AS

Although new technology has been heavily introduced in the stone quarrying and processing in the same manner as for other mining industries, traditional crafts are still needed in many cases (**Figure 4**). This case study will explore how traditional crafts are used in modern stone production, and in particular look at production processes where high-tech and traditional crafts live together in a symbiotic relationship. It will further explore the vulnerability of such crafts and possible solutions for maintaining such knowledge also in the future.

The case study will provide examples from the the Oppdal schist, South-Central Norway: the schist is produced applying traditional crafts with roots 1000 years back combined with state-of-the-art technology. We look closer at the value chain in the production and how technology and crafts interact in the different stages.

Stakeholders: industry and cultural heritage authorities



Figure 4. Traditional breaking of schist slabs, Oppdal, Norway



6.2 The Pučišća Stonemason School

Eurolithos partners: HGI-CGS

The [Stone-mason's school in town Pučišća](#) (**Figure 5**) on the northern part of Island of Brač, successfully continues tradition of precious procession of stone, somewhat backward as regards to advanced technology (Klesarska škola Pučišća 2009). It recently celebrated the 100th anniversary of work whilst in the school workshop, apprentices' young hand are making real masterpieces in stone. The school is known for using ancient Roman hand tools in stone dressing, is receiving an increasing number of queries from foreign countries for student enrolment. Stone has played a major part of this small town's economy and has been a major part of its self-image. The quarries are situated to the east of the town and some of them date back to the Roman times (Vitruvius Pollio, 1st century AD) and the school is the only place in Croatia and EU where one can obtain a professional qualification in stonemasonry.

The tools used are made of wrought iron and are designed for the rough and fine dressing of medium-hard limestone available in the island of Brač, quarries, which was used in building such landmarks in Croatia and around the world.

In this study case we will present the Stone-mason's school in Pučišća as example of the interaction between stone resources and humans has produced a rich and diversified immaterial heritage, namely crafts and skills.

Stakeholders: industry, education, local authorities, heritage authorities



Figure 5. Stone-mason's school and student work (lion), Pučišća, Island of Brač, Croatia



7 Sustainability and ornamental stone

7.1 Sustainable stone production

Eurolithos partners: NGU, LNEG

Other participants: Lundhs AS, Minera AS

This case study seeks to collect and explore how “sustainability” can be applied to ornamental stone production. In particular, concepts related to “zero waste”, land use, carbon footprints and societal license to operate. The case study will collect existing data from industry and research and make a systematic compilation and interpretation that can lead to definition of best practise and guidelines.

The following areas and subjects will be used for this study:

- The larvikite ornamental stone production in SE Norway¹: Numerous quarries operate (**Figure 6**) in iridescent, monzonitic rocks named “larvikite” in this area, a famous rock used for facades, floors, tabletops and other ornamental purposes all over the world. Until recently, 90-95% of the exploited rock was deposited as waste. At present time, this number has been reduced to zero in parts of the area. The case study will explore how this was made possible, and discuss technical, industrial and market aspects of importance.
- The Oppdal schist in South-Central Norway is an important resource for the production of schist for floors, facades and other building stone. In recent years, the waste from the schist production has gradually decreased due to exploration of new market opportunities. Most recently, technical innovation projects and collaboration between the industry and R&D institutes has opened more opportunities by providing technical solutions for improving aggregate qualities of the schist. The case study will discuss how a step-by-step innovative approach can provide new solutions and opportunities for utilising quarry waste.
- Ornamental limestones from MCE, 150 KM north of Lisbon, in Portugal, are exploited in some tens of quarries grouped in five main exploitation centers. They are located in a Natura2000 site and widespread over four municipalities, each with their own land use management plan. This brings complexity and difficulties for the management of the extraction activity by the public authorities and quarry owners. This case study will discuss how national and regional public authorities, the geological survey, private consultants and the industry involved together to implement a rational management of the extractive industry for each exploitation center considering the protection and conservation of the natural values.

In the future, also the stone industry needs to adapt to documentation of environmental footprints and ethical standards for being able to supply stone products to many customers. On the other hand, such procedures may strengthen the European stone



industry, since they emphasize the need for other criteria than strictly economic in tenders. The case study provides examples of the use of EPD (Environmental Product Declaration) for ornamental stone, and explores the various aspects of this.

Stakeholders: industry, government agencies, local authorities, Land use and environmental planning



Figure 6. One of many quarries in Larvikite, SE Norway



8 Case study covering several subject areas

8.1 Best practices of natural stone valorization for the preservation of stone-built heritage: the case of platy limestone as characteristic element of cultural landscape along the Eastern Adriatic coast

Eurolithos partners: GeoZS, HGI-CGS

One of the key issues of cultural landscape and stone-built heritage preservation along the Eastern Adriatic coast and its karstic hinterland is the access to traditionally used autochthonous building material, i.e., platy limestone. The main obstacles are in the rigid legislation and in that stakeholders in spatial planning, urbanization and cultural and natural conservation lack firm guidelines for sustainable use of natural stone as building material, then for conservation of the stone as natural heritage and finally for conservation of stone-built cultural heritage. As consequences, building stone is often used incorrectly or inappropriately, it is often replaced with non-autochthonous stone or other materials, and characteristic architectural elements of many buildings are often damaged, destroyed or falling into decay.

An interdisciplinary study in countries of the Eastern Adriatic region addressed these problems from all aspects, i.e., from geological characterization of platy limestone, its occurrence and excavation potential to its use in architecture, natural and cultural heritage preservation, and legislative framework.

As the loss of stone-built cultural heritage is a significant problem in Europe and worldwide, we will provide a system of best practice protocols in identification, valorization, promotion and sustainable use of natural stone as a building material. They should serve to prepare recommendations for legislation changes that will help to protect and to preserve both natural and cultural heritage.

Stakeholders: land use planning, education, local authorities, heritage authorities

8.2 Synergistic effect of quarry landscapes with overlapping active and historical quarries: the study case of Macael (SE of Spain)

Eurolithos partners: IGME

Usually, the development of big active quarries over (or close to) historical quarries is perceived as a negative or risky situation from a conservative point of view. Indeed, the uncontrolled development of active fronts can lead to the complete disappearance of historical extraction areas and the consequent loss of geo-archaeological and ethnologic information. Consequently, the declaration of future new extractive areas should consider the presence, location and importance of pre-existent quarries in order to avoid irreparable losses.



However, the current situation in many active quarries is that they are associated with historical fronts (more or less old). Instead of facing this reality as an unfortunate development of industrial activity, this dual reality (modern-ancient works) can provide an excellent opportunity to increase the interest and the heritage value of the quarry landscape.

The synergy between historical and modern realities can be raised from different aspects:

- The modern quarry fronts usually offer smooth and regular surfaces where to study and to explain the geology of the outcrop at meso-macro scale, being able to extrapolate this geological background to the historical fronts.
- The development of active quarry fronts near (or on) historical fronts may offer the possibility of a controlled exploitation of the same varieties of rock used in the architectural heritage. This option brings the possibility of obtaining a perfect compatibility between both replacement and original stone in the monument. This is especially important in those quarries with complex geology and/or lithological heterogeneity.
- From a didactic and touristic point of view, the co-existence of both types of stone works makes it possible to compare and to explain the evolution of the stone work methodology along the time, increasing the global interest of the landscape.

The Macael Region is located in the SE of Spain and it is locally known as “the Marble Region”. It is one of the most important quarry provinces of Spain. From a geological point of view, in this region outcrops the formation of schists and marbles situated in the upper part of the Nevado-Filabride lithological succession (the lowest metamorphic complex of the Internal Zone of the Betic Cordillera).

Marble from this region have been systematically exploited (**Figure 7**) since Roman period, although there is evidence of marble extraction activities for 5000 years. Nowadays, the most typical commercial varieties from Macael Region includes both calcitic and dolomitic marbles (White Macael, Grey Macael, Anasol, Yellow Macael) as well as serpentinites (Green Macael). These dimension stones are produced in tens of active quarries distributed throughout the region.

A countless number of historical buildings uses Macael marbles. Some of the most representative are: Cathedral-Mosque of Cordoba (8th century), Palace of Medina Azahara (Cordoba, 10th century), the Alhambra and Cathedral of Granada (13th-15th century), Monastery of El Escorial in Madrid (16th century), Cathedral of the Almudena (Madrid, 19th-20th century).

Current quarry landscape in Macael region alternates active quarry fronts with a few areas with remains of manual stone work. This situation, together with the high geological



complexity of the area, offers a great opportunity to face the case study from the following work lines:

- Location and analysis of historical quarries; developing systems of best practice protocols in identification, description and interpretation of features of quarrying in collaboration with other case study.
- Analysis of active quarries from a geological, divulgative and touristic point of view; analysis of their potential non-industrial interest.
- Analysis of the geographical-geological relationship between both active and historical extractive areas; analysis of the disappearance risk of historical areas.
- Compatibility analysis between current active and historical fronts from a petrological-petrophysical point of view.

Stakeholders: industry, land use planning, heritage authorities and local authorities



Figure 7. Marble quarry in the Macael area, Spain



9 From case studies to guidelines

The EuroLithos project addresses several aspects: identify and map the type and quality of ornamental stone resources and provide tools and protocols for the assessment and comparison of deposits.

EuroLithos will also address cultural heritage and building preservation aspects, since the maintenance of European heritage and a living stone industry are mutually dependent.

The main objective of WP5 is to establish tools that can facilitate and aid the process of valorization of stone resources. We believe that such tools will contribute to better maintenance of stone-built heritage, better conditions for SME's and better protection of stone resources in land-use planning.

These tools will address four aspects (subject areas) of ornamental stone resources; the intrinsic value of stone quarries and quarry landscapes, the value of stones from their use in stone-built heritage, the traditional crafts and sustainable ornamental stone production. This will result in four guidelines:

1. How to assess values of stone types, quarries and quarry landscapes
2. How to do inventories of links between stone resources and built heritage,
3. How to approach crafts for value assessments
4. Sustainable ornamental stone production

In first phase (from M1-till M18) of the EuroLithos project we adopted concepts and methodologies that will be addressed in the 12 case studies described in this report. These case studies will collectively form the scientific foundation for making the guidelines.

All the case studies will be finished before M24. Thereafter, guidelines will be extracted from the results of the studies, and published before M36. All the case studies will be published on the [Eurolithos web](#) when finished.



10 References

Crnković, B. & Šarić, Lj., (2003) Građenje prirodnim kamenom, IGH, Zagreb.

Heldal, T., Meyer, G. and Dahl, R. (2015) [Global stone heritage: Larvikite, Norway](#). In: Pereira, D., Marker, B. R., Kramar, S., Cooper, B. J. and Schouenborg, B. E. (eds) *Global Heritage Stone: Towards International Recognition of Building and Ornamental Stones*. Geological Society, London, Special Publications, 407, 21-34

Klesarska škola Pučišća, (2009) Klesarska škola Pučišća, 1909-2009

Maksimović, M., (2006) Eksploatacija ispitivanje primena arhitektonskog kamena, Valjevo-pres, Beograd.

Oxaal, J. (1916) [Norsk granit](#). Norges geologiske undersøkelse 76, 220 pp

Plastić, T., (2006) Natural stone exploitation management, Master of Philosophy Thesis, Faculty of Civil Engineering and Architecture, University of Split, Croatia.

Pedersen, S. and Maaløe, S. (1990) [The Iddefjord granite: geology and age](#). Norges geologiske undersøkelse Bulletin, 417, 55-64

Pereira, D., Marker, B. R., Kramar, S., Cooper, B. J. and Schouenborg, B. E. (eds) (2015) [Global Heritage Stone: Towards International Recognition of Building and Ornamental Stones](#). Geological Society, London, Special Publications, 407, 268 pp

Pereira D. and Pratt, B. R. (eds)(2016), [Heritage stones of the world](#). Geoscience Canada, 43, 1, 286 pp

Pereira, D. and Van den Eynde, V. C. (eds)(2019) [Heritage Stones and Geoheritage](#). Geoheritage, 11, 1, 215 pp

Pereira, L., Catarino, L. and Dino, G. A. (eds.) (2019) [Natural Stone and Architectural Heritage](#), Sustainability, Special Issue, 262 pp

Vitruvius Pollio, M., 1st century AD. De architectura libri decem.
