EUROLITHOS European Ornamental Stone Resources

Eurolithos case study

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

Thematic focus: Ornamental stone resource value assessment

Responsible partner(s): HGI-CGS

Author(s): Željko Dedić, Marija Horvat, Vlatko Brčić

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Executive summary

Quarry landscapes change because they are the expression of the dynamic interaction between natural and human forces in the environment. They are the result of continuous reorganizations of the land in order to adapt its use and spatial structure better to changing societal demands. But landscapes can also be related to cultural issues and traditions that mark the character of a community. Ever since ancient times stones have been excavated at the stone excavation sites on the island of Brač. At present, 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 which have been under World Heritage (UNESCO) protection. The natural stones from the island of Brač have been used for building some of the well-known world structures too. The White House in Washington, the Parliament House in Vienna and Budapest were built from stones originated from the island of Brač.

This case study will include specific research on quarry landscapes in the vicinity of Pučišća, the island of Brač, particularly for developing a general, multidisciplinary methodology of documentation and evaluation of such sites.

The subjects will be focus on:

- Identification and description of features of quarrying (stone resource, quarry site)
- Interpretation of such features and visualization of them (finding time depth, micro-level analysis, visualizing a quarry landscapes).

Based on mentioned analyses on quarry landscapes, this case study will provide a system of best practice in identification, description and interpretation of features of quarrying.

They should serve to prepare recommendations for promotion and sustainable use of natural stone as a building material, which will help to protect and to preserve both natural and cultural heritage.

Keywords Quarry landscapes, stone resource, Ornamental stone

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Description of case study

This case study includes a specific research on quarry landscapes from few quarries, some in the vicinity of Pučišća and some from ancient quarries at the hamlet of Škrip both from the island of Brač, Republic of Croatia (Figure 1).

During Antiquity, the quarries of Brač were ran and, according to epigraphic evidence, owned by the Empire. The majority there of were situated between Splitska and Škrip, and those of the greatest significance were Plate, Stražišće and Rasohe. Stone was transported from these quarries to the port of Splitska, where they were shipped to the final destinations.

The island was probably named after a deer – brenthos in Illyrian, a cult animal of Illyrian tribes who inhabited the island. Greeks called it Elaphusa and Bretanide which derives from the world elaphos – deer. Findings in the Kopačina cave are the evidence of the presence of deer on Brač in the prehistoric period. Roman historian Polybius called it Bretia, Pliny the Elder Brattia whilst in the Antinoe itinerary from the 4th century it is mentioned as Bractia.

Brač, Italian Brazza, rugged, mountainous island in the Adriatic Sea that is part of Croatia. With an area of 153 square miles (395 square km), Brač is one of the larger islands in the Adriatic; it lies southeast of the mainland city of Split. Its maximum elevation, 2,559 feet (780 m), is reached at Vidova Mountain, the highest point in the Adriatic islands. The main occupations of the inhabitants are fishing and agriculture; crops include figs, olives, almonds, and wine grapes. With insufficient fresh water, the island must be supplied from the mainland in summer. Mechanized quarrying of marble provides a further export, and a small tourist industry has developed.

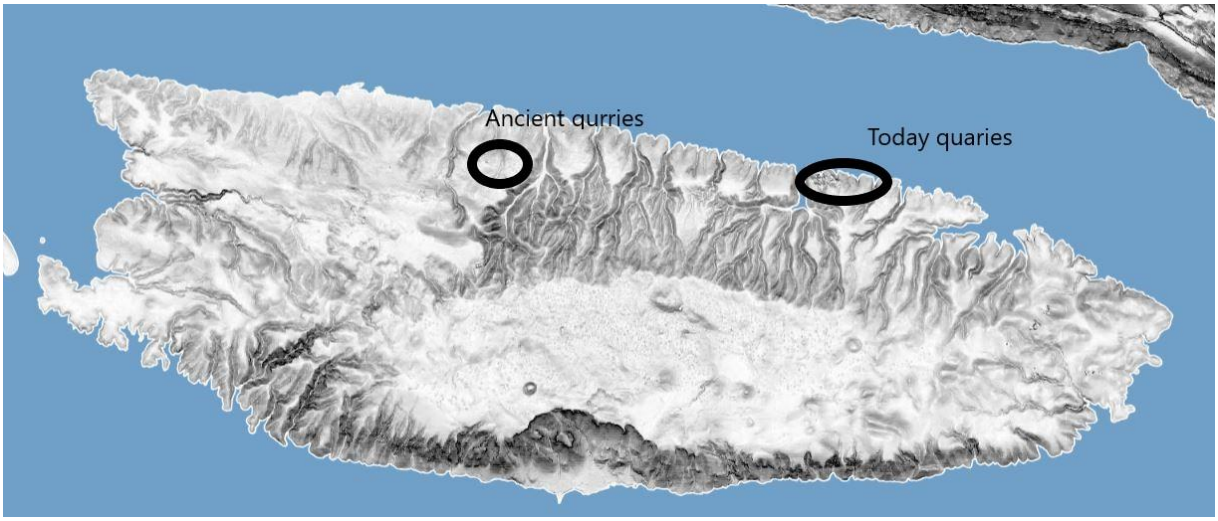

Figure 1 Location of the ancient and today quarries near Pučišća, the island of Brač, Republic of Croatia

The principal village is Supetar, and there is an ancient wall at the hamlet of Škrip, where stone was quarried to build (AD 295–305) Diocletian's palace in Split. The island was occupied by the ancient Greeks and Romans and then—following the power struggles in the Adriatic—in turn by pirates and the powers of Dubrovnik (the Ragusan republic), Venice, Bosnia, France, and the Austro-Hungarian Empire, with a brief period of autonomy. In 1918 it was incorporated into Yugoslavia. During World War II, Yugoslav partisans and Allied special forces took Brač back from the Germans in 1944. Today, island of Brač is part of Republic of Croatia connected by ferry to the regional center of the county, the city of Split.

We have explored two aspects of the quarry landscape identification and description of features of quarrying (stone resource, quarry site) and interpretation of such features and visualization of them (finding time depth, micro-level analysis, visualizing a quarry landscapes).Key stakeholders in the case study have been local stone producing company and the local Stone-mason's school in Pučišća as example of the interaction between stone resources and humans. One of hypothesis is that this work will provide a system of best practice in identification, description and interpretation of features of quarrying. They should serve to prepare recommendations for promotion and sustainable use of natural stone as a building material, which will help to protect and to preserve both natural and cultural heritage.

Methods applied

In this study, we have described and analysed ancient and today quarries landscapes near Pučišća, the island of Brač, Republic of Croatia.

For geological interpretation we use 4 sheets of the official Basic Geological Map of the former Yugoslavia, scale 1:100,000 (available on www.hgi-cgs). In the middle of the 70's of the 20th century, teams from the Institute of Geology in Zagreb (today Croatian Geological Survey), along with colleagues from Slovenia, Bosnia and Herzegovina, and Montenegro, produced a comprehensive geological maps that cover island of Brač (Basic Geological Map; Jelsa, Vis, Omiš and Split). We also used and new Basic Geological Map of the Republic of Croatia scale 1:50.000 – sheet: Brač Island) - Croatian Geological Survey, Department of Geology.

For the history of the quarrying have used written sources from multiple sources predominantly Joško Belamarić, Stone of the eastern Adriatic (2016), Donelli, Ancient quarries on the Eastern Adriatic Coast with specific reference to the island of Brač (2009) and for the use in buildings we have used some written sources (exhibition Mramore lavdata Brattia, 2015), some web sites and in addition own observations.

For the interpretation of quarrying have in addition used own observations in historical buildings and quarries. In the latter, we have applied guide to ancient stone quarry landscapes: from documentation to statement of significance developed in the FP7 project QuarryScapes and other methods provided in the guidelines of that project, some of it published in Heldal (2009). In addition, a documentary made by Television Zagreb (1988), **U kamenu kretanja** is very useful, giving an insight in the crafts and processes of stone exploitation at that time.

For the more physical description and analyses of the quarry landscapes we used multiple web services from the Croatian mapping authorities (https://www.geohrvatska.hr/, https://geoportal.dgu.hr/), and checks in the field for making a rough characterization on how to recognize quarry features.

Geological setting of the ornamental stone from the island of Brač

The External Dinarides are fold-and-thrust belt, part of the Alpine orogenic system, characterized by generally SW verging structures, and can be considered as the detached, back thrust and highly deformed upper crust of the Adria during subduction to the NE. The belt, along with the related part of the Adriatic foreland (Figure 2) is geographically situated within the Dinaric Karst region. Differing opinions about the geologic evolution of the system in the NE Adriatic region highlight its complexity (Aubouin et al., 1970; D'Argenio et al., 1971; Chorowicz, 1975a, b; Herak, 1987; Buser, 1989; Cati et al., 1989a; Jelaska et al., 1994; Lawrence et al., 1995; Grandić et al., 1997; Pamić et al., 1998; Grandić et al., 1999, 2001; Picha, 2002; Tari, 2002; Marton et al., 2003; Vlahović et al., 2005).

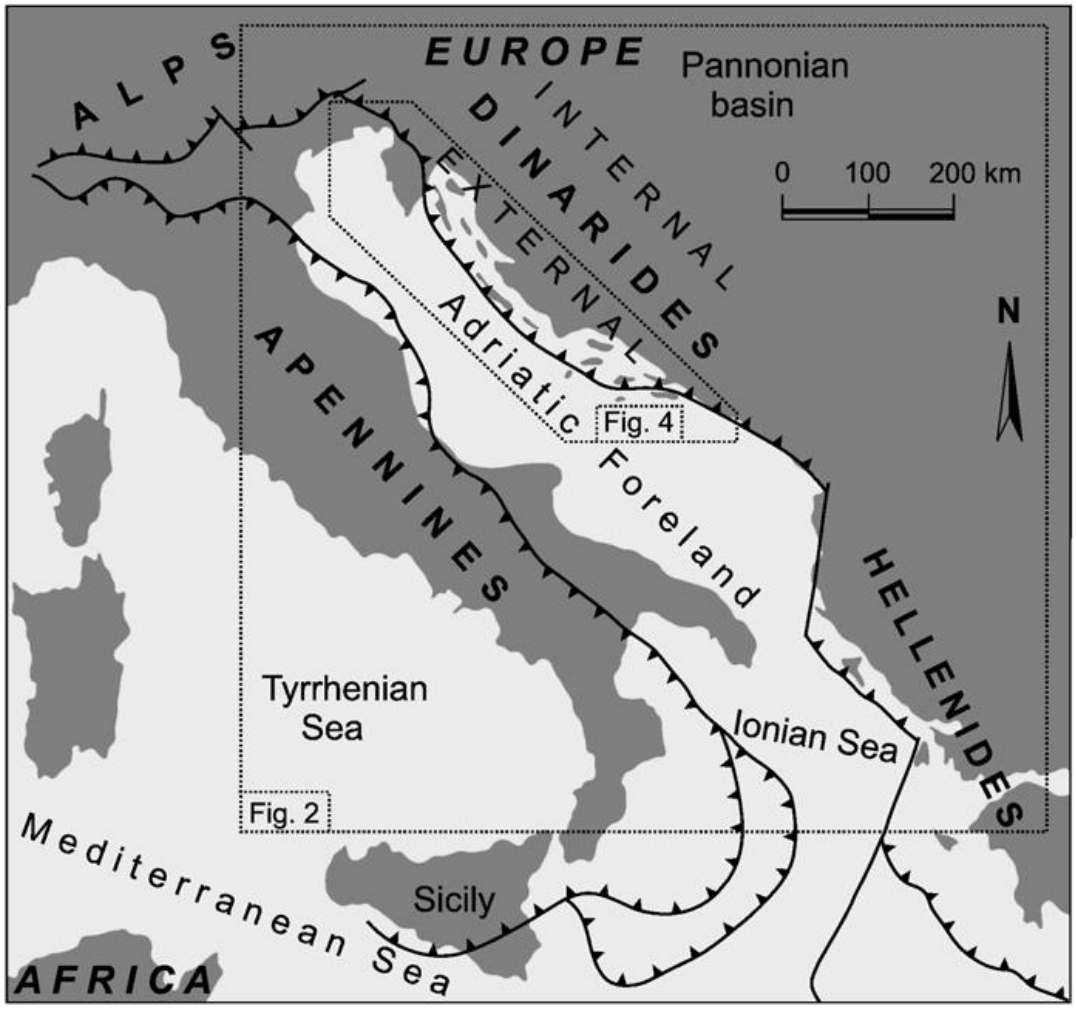

Figure 2 Tectonic map of the Adriatic region showing the deformation fronts of the major Alpine orogenic belts.

One of the earlier paleogeographic models of the region is based on a clear tripartite paleogeographic subdivision in its southeastern part (D'Argenio et al., 1971). The model comprises two carbonate platforms — Adriatic and Dinaric, and the intervening Budva–Cukali Basin (BCB). The idea was followed by Chorowicz (1975a), who suggested NW prolongation and termination of the BCB (NW end of the NEAT on Figure 3).

The second early model considers the region as a more or less unique carbonate shelf of the External Dinarides (Grandić, 1974) characterized by maximal subsidence in the central zone and intrashelf troughs that developed during the Late Cretaceous.

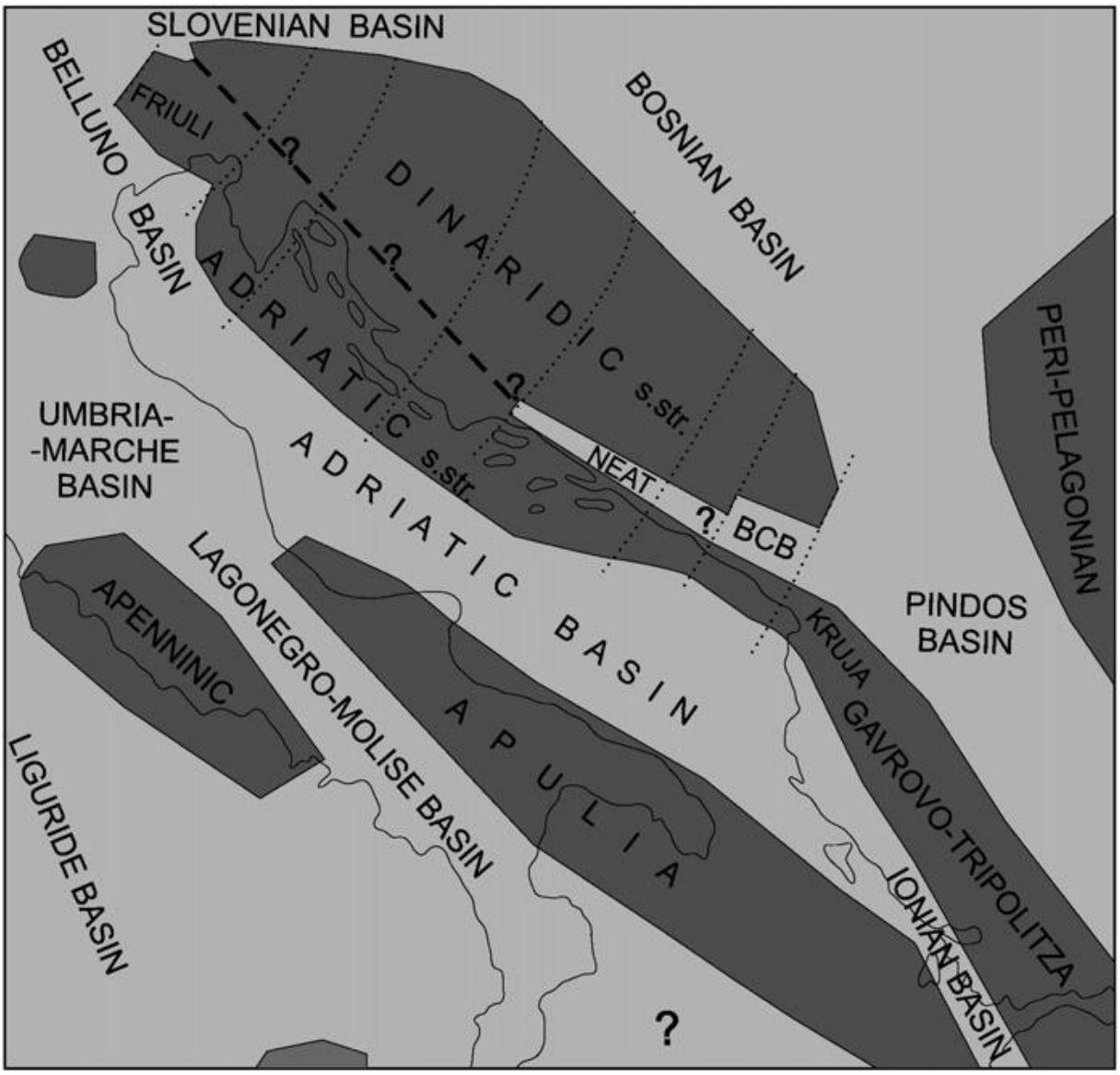

Figure 3 Conservative paleogeographic map of the Adriatic region for the Late Cretaceous time (some present-day geographic lineaments are indicated, see Fig. 1; redrawn and simplified after Dercourt et al., 2000; Bosellini, 2002). The Adriatic–Dinaridic carbonate platform (s. lato) is split into the Dinaridic and Adriatic platforms (s. str.) by the supposed continuous NE Adriatic trough (NEAT, thick dashed lines). Hypothetical transform faults (thin dotted lines). Basins on the continental and oceanic crust — light grey. Carbonate platforms and shelfs — dark grey. BCB — Budva–Cukali Basin.

The Adriatic–Dinaridic carbonate platform existed as an isolated ('intraoceanic') carbonate platform, from the Late Triassic to the Mid Eocene, and reached its maximum extension in the Late Cretaceous (Jenkyns, 1992; Gušić & Jelaska, 1993). The Island of Brač, situated along the central part of the Croatian Adriatic

coast, although only a small part of the **large Adriatic– Dinaridic carbonate platform**, shows a rather complete, relatively undisturbed, and well-exposed Upper Cretaceous succession. This succession has,

therefore, been taken to be a representative example of Upper Cretaceous deposits of that part of the Adriatic– Dinaridic carbonate platform (Figure 2). Palaeogene deposits are also present (Figure 4).

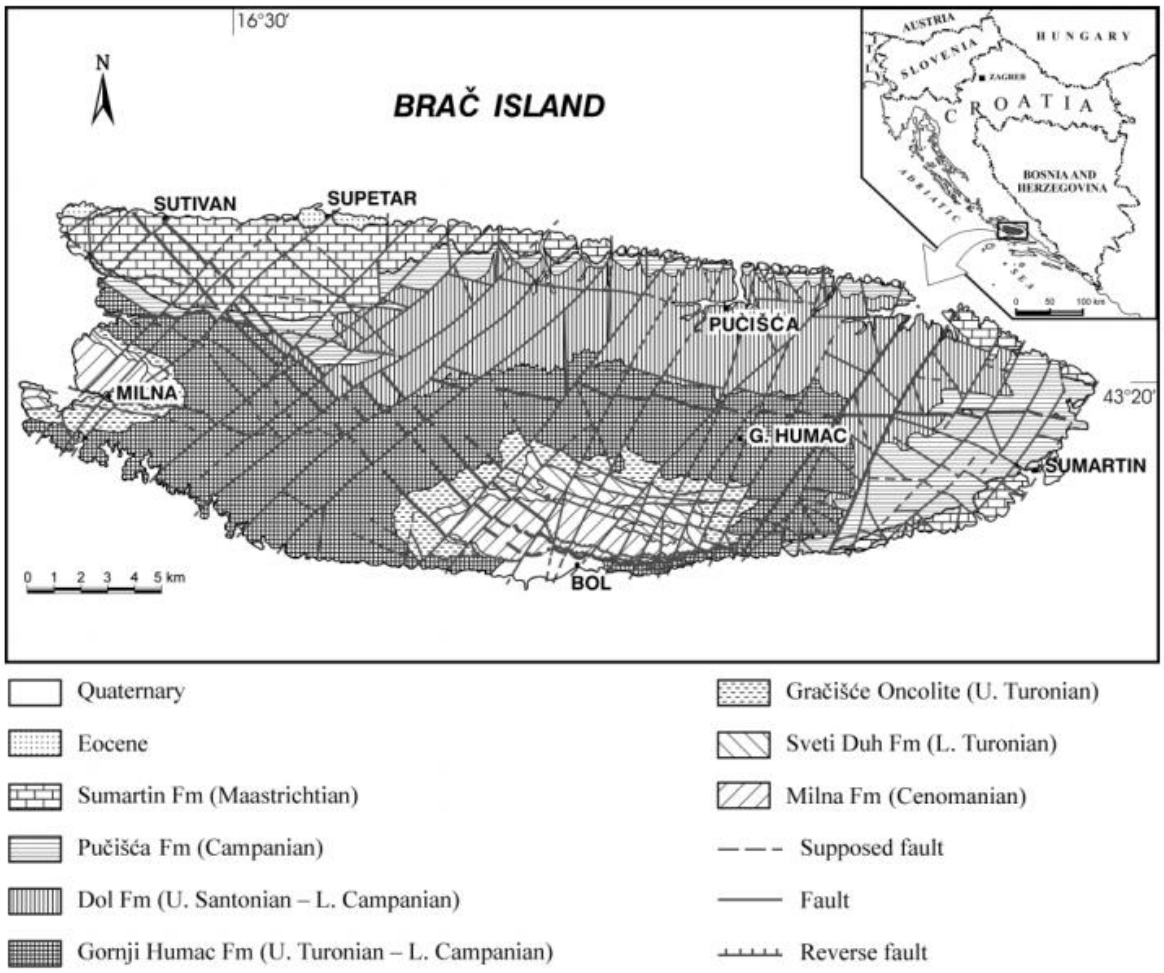

Figure 4 Maps showing location of Brač Island and its geology (simplified after Prtoljan, 1989 and Gušić & Jelaska, 1990).

The island of Brač is a small part of the **large Adriatic–Dinaridic carbonate platform**, mainly built up of Upper Cretaceous and, to a lesser extent, Palaeogene deposits. The Pučišća Formation (Campanian) is one of the six lithostratigraphic units of the Upper Cretaceous succession (the Brač Group) which includes carbonate deposits ranging in age from the Mid Cenomanian to Maastrichtian.

Stratigraphy of platform carbonates

Typical Upper Cretaceous succession (Fig. 3) has been described in detail from the island of Brač (Gušić and Jelaska, 1990; Cvetko Tešović et al., 2001) and has been subdivided into the following informal

lithostratigraphical units: Milna formation (Cenomanian) — platform interior, Sveti Duh formation (uppermost Cenomanian to lower Turonian) — pelagic incursion over the platform, Gornji Humac formation (Turonian to Coniacian) — platform interior, Dol formation (Coniacian to Campanian) — intra-platform basin indicating a second Late Cretaceous pelagic episode, Pučišća formation (Santonian to Campanian) — rudist-bearing margin of intra-platform basin, back margin and platform interior, and Sumartin formation (Upper Campanian to Maastrichtian) — platform interior, equivalent of the lower part of the Liburnian

formation (Vreme beds) of the Kras area (Stache, 1889; Bignot, 1972; Jurkovšek et al., 1996 and references therein). The succession is referred to as the Brač group (Figure 5). Early to Middle Eocene Foraminiferal limestone (Marjanac et al., 1998; Ćosović et al., 2004) unconformable overlay the Sumartin formation over a clearly expressed emergence surface (hiatus) (Korbar,2012).

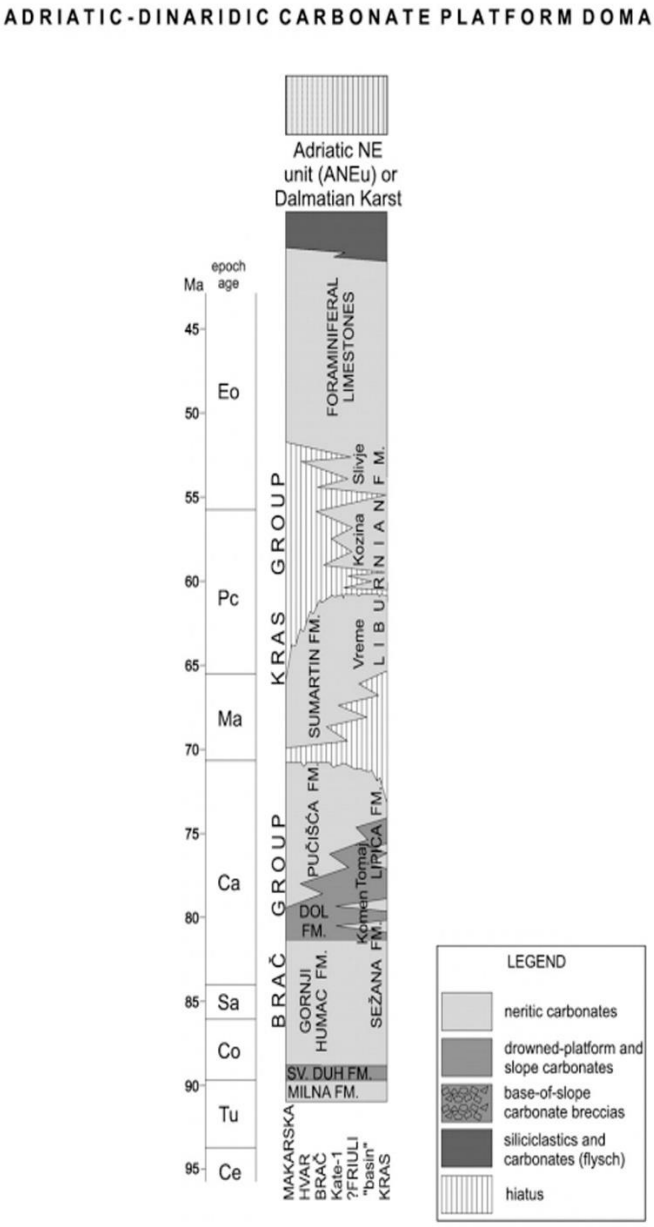

Figure 5 Chronostratigraphic correlation of Upper Cretaceous to Paleogene carbonates of Adriatic–Dinaridic Carbonate Platform (ADCP) domain in the present-day NE Adriatic region.

History of quarrying and use of the ornamental stone from the island of Brač

On Brač, there are nearly a hundred known quarries today, be it in operation or abandoned. Each of them has a story of its own, involving people who have since time immemorial lived with, for and from the magnificent stone. In fact, stone is etched into every aspect of the island's life: it can be found in old noble residences, shepherd huts and farmers' roofs alike; in wells and bollards, in moulded doorposts, windowsills, dormers, and so forth.

Stone is everywhere, whether the grey, hundred-year-old kind covered in ivy, moss or caper, the hand-processed one, or a freshly extracted stone of dazzling whiteness. In this insular setting where stone is still quarried, people possess the valuable knowledge of stone, passing it from generation to generation, keeping the tradition alive. Brač has been losing its stone, very much like its inhabitants, steadily through centuries, to various parts of the eastern Adriatic coast and beyond.

In Antique times it was used for a great number of reliefs, statues and sarcophagi, now scattered across many sites, places and museums. Stone from Brač's quarries has been mined since the Ancient Greek and Roman times and stone used for the construction of important buildings.

However redundant it might seem here to list all the edifices, historical and contemporary alike, built using Brač limestone, there are a few deserving of special mention: the Parliament and **Hofburg Palace** in Vienna, the **Parliament in Budapest**, the **White House** in Washington, and the **Regent's Palace** in Trieste, Italy.

Figure 6 Rasohe, one of the Romanquarries on Brač, nearby the Splitska cove (photo: M. Miliša, 2008.)

The most famous of these is located in the vicinity of **Diocletian's Imperial Palace** in Split. Apart from some imported varieties that were primarily used for decorative purposes, the Late-Antique imperial palace was constructed using almost solely the stone from Brač quarries. Piles of unpolished stones layered as walls alongside field paths are a real attraction on the island. According to some estimates, they are equal in quantity to the existing Egyptian pyramids (although uncut), totalling approximately 7 million cubic meters. These stones were collected for centuries by shepherds and labourers who worked to clean the karst soil to turn it into arable land. The extracted stone was used not just for the local buildings but was exported to various places in the ancient world. Such practice has continued till today: plenty of buildings in Croatia and abroad were built with beautiful stone from the island of Brač. Having such long and valuable tradition in stone excavation and stone masonry means that many stone buildings, sculptures and beautifully carved small items found their place on Brač which makes this island a place of lovely architecture that combines with deep blue sea and green pine forests in the back ground to create magnificent scenery. Stone houses,

luxury villas and other buildings made from the Brač stone add to the beauty of the island and to the harmonious look of its small towns and places with pebble and sand beaches. Even if stone exploitation and the method of work in Antique quarries have been discussed thoroughly, there are still many uncertainties surrounding the matter.

It is our firm belief that the solution to these quandaries lie in these little-researched Antique quarries. Figure 6) Systematic research, or at least a field survey, would surely lead to new discoveries about the artefacts or fragments of carved stone from Late Antiquity, or signatures of quarry workers – which would complement what is already known about the life of stonemasons in the past. (Marmore lavdata Brattia; Split, 2015)

In the areas along the sea, close to sheltered bays, below the hills, the Romans were establishing the lordships and suddenly developed viticulture and olive culture. Their newly developed settlements (villae rusticae) were inspired by ancient culture and civilisation. It had significantly changed Brač landscape and existing cultural habits of the population. Construction and stone processing culture was subject to particular change. Namely, the most important economic activity which developed on the island of Brač in Roman times was stone carving. Rich limestone sites were attractive for Roman authorities as useful resources needed in development of the Empire and the Province of Dalmatia. The quarries were opened, and stone carving craft was flourishing. The area between Škrip and Splitska, at the central part of the north coast of Brač, exactly opposite to Split, became the very centre of stone industry. The labour force in the quarries consisted of Roman slaves (conquered local population, arrested soldiers and convicts), under the surveillance by state officials or soldiers. Škrip became the settlement for accommodation of workers, and Splitska – the port for export of stone from the island of Brač. Mass production of sills, capitals, sarcophagi, grape and oil presses, storage stone basins/ “kamenice” for conservation of liquids and other stone products required in Roman civilisation was developing in the stone carving workshops. Products with defects could not be sold, and therefore many of them remained on the island, and can be found even nowadays.

The architecture of Roman buildings was different from the architecture applied by the native population of Brač. The facades were built from cautiously cut stone, and the houses were significantly larger and higher, since it was enabled by new building technology. The lime production also started, and the lime mixed with land or with crushed brick was strong binding material. Therefore, Romans could build pools for water, baths and other buildings which are true testimony of huge civilisation progress. The art of stone exploitation and dressing, which starts in Roman period of Brač history, has remained until nowadays the most important peculiarity of this island. Today on island you can see a lot of handmade drywalls and bunches of stone that testify to the heavy weight of the burden but also their skills of making dry stone constructions who became shrivelled cultural good. If you visit today stone quarries, you witness modern techniques of extracting this valuable material that is today used for souvenirs, art and building material.

Civilisation on the island of Brač is characterised by centuries of tradition dating back to Roman agricultural farming and Renaissance construction, the builders and architects of which were inspired by the island's landscapes and aesthetics.

Figure 7 Pustinja Blace on the island of Brač

To cultivation of Brač's land is also related to an important decree from the time of the Venetian rule when no man from Brač was allowed to marry until he planted one hundred olive trees. The most prominent Dalmatian builders and sculptors of the Renaissance, such as Juraj Dalmatinac, Andrea Alessi and Niccolo Fiorentino, applied their creative genius to Brač stone. The tradition of using stone to build with has become an inseparable part of Brač's identity. Settlements have arisen on the island, centring around early Romanesque basilicas built on the grounds of former Roman estates and medieval Brač churches of modest dimensions, each with its own story of how it came to be, how it developed and how it stepped into the rhythms of contemporary life (Figure 7).

One place on Brač island is devoted to stone in particular. Pučišća, a small coastal town on the north-east part of Brač, has a long tradition of stone exploitation and stone masonry. 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. The only stonemason high school in Croatia is located in Pučišća where students from all over the country come to learn this beautiful craft and produce stone masterpieces. There are tours that take you to the school where the visitors can learn all about stone, the history of its excavations on the island of Brač and in Pučišća, about the masonry and witness the students working with the stone. There are various stone sculptures scattered across the town so taking a stroll can feel as a visit to a museum. Many smaller stone carved items can be bought as souvenirs.

There are many stories and myths regarding this precious material. One says that the US White House was built (or at least a part of it) from Brač stone as one Hungarian merchant allegedly bought large amount of stone from the quarries and sold it to the construction company that was building it. Unfortunately, there is no proof for this story but it is still nice to think about it. On the other hand, stone from the island of Brač indeed was used at United Nations headquarters in New York – in the vestibule of the main building and in front of it as a base of the Peace monument, the work of Croatian sculptor Antun Augustinčić.

Stone is just one part of Brač island identity but it is a very important one. It makes the island perfect for satisfying one's cultural appetite and learning about the noble craft of stone masonry while having a great holiday as well. And you are bound to find at least one lovely souvenir

Ornamental stone from the island of Brač

Ornamental stone in Pučišća Stone was the basic building material in the old architecture of Brač. The stone has been used as a building material since prehistoric times on the island. Drywalls, cottages, and walled settlements were built. The Romans opened quarries near Škrip and Splitska, using the stone for construction of Diocletian Palace (Figure 8 and 9).

Figure 8 Illyrian walled settlement

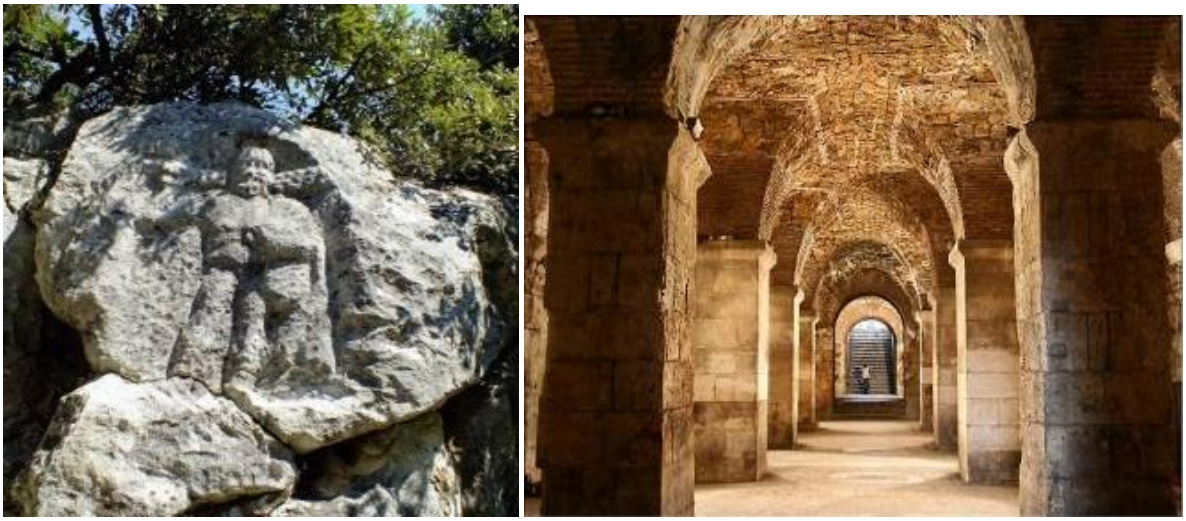

Figure 9 Roman times

During the Renaissance new quarry opened in Pučišća, from which stone was excavated for the construction of Šibenik cathedral. Several stonemasons from Pučišća were famous: Trifun Bokanić, Nikola Radojković, Ivan Puljizić and Nikola Lazanić (Figure 10).

Figure 10 Renaissance times

Brac stone is limestone, formed by deposition of marine organisms. There are several types, and in Pučišća quarry Veselje and Sivac are "harvested". Sivac is punctuated by blotches or veins, and Veselje contains smaller or larger shells' remnants (Figure 11).

Figure 11 Types of limestones from island of Brač

An approach to value assessment of the quarries landscape from the island of Brač

When viewing the **ancient and today quarries landscapes from the island of Brač** as a hole, it has became clear that one of the key problems with quarry landscapes is not the lack of such sites but how to point at the historical importance of them and thus make selection of sites and parts of sites for protection.

Also, it is rather obvious that there are numerous values connected to it: **economic, historic, morphologic and even aesthetic**. The challenge is to view the multiple values in the quarry landscapes as connected.

There are numerous historical remains of quarrying that can be appreciated, but there is also a rich architectural heritage that will need maintenance, and thus newly quarried stone.

We followed guide with special attention to the need for multidisciplinary approaches; for instance, the **geological characterisation** of the **stone resources** is equally important as the documentation of the **archaeology**, in order to reach an understanding of not only how quarrying was done but also why

The guide follows a scheme presented in Figure 12, starting with the empirical characterisation (*identification of features, micro-level analysis and how to construct a quarry landscape*), moving to the macro-level interpretation and finally to constructing **a statement of significance**. Of particular importance is a methodology on how to view quarry landscapes in relation to different key perspectives – their place in **socially constructed landscapes**; the contact between quarry landscapes and others such as the places of consumption; the projection of key historical events in the quarry landscapes; and, quarry landscapes as dynamic landscapes.

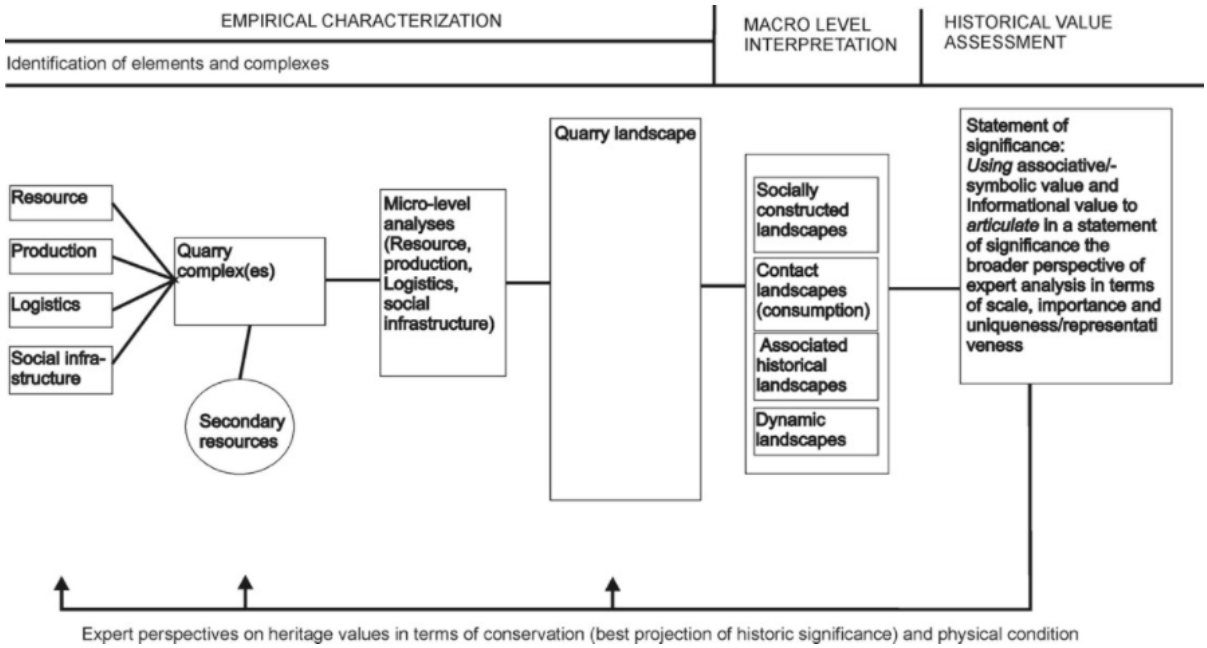

Figure 12 A procedure for "building a case of conservation" for quarry landscapes

1. Characterising the stone resource

We have already identified in previos chapters **quarries from Brač** as sedimentary rocks as main class and carbonate subclaass or limestones of different types. These stone resources should be investigated as evidence of consumption (geological characterisation): the rocks can link the quarries with the places and products where the stones have been used, being buildings, tools or other items. Also, stone resources can be divided into principal commodities reflecting the purpose of use, such as building stone (used for constructing buildings), utilitarian stone (used for everyday utensils) and ornamental stone ("rare" resources used for embellishment of buildings, sculpture and elite/exclusive objects). Stones resources from **quarries from Brač** have commodity as building stone (masonary) and as ornamtenatal stone (decorative):Uses of building stone can be**: rubble walls, ashlar walls, architectural elements, roof floor paving (funerary).** While ornamental stone (decorative) can be used as Sculpture cladding, floor, columns, funerary.

Key physical properties of rocks such as brittleness, hardness of the minerals and porosity decide the technology necessary for quarrying and processing. According to their physical properties (hardness, brittleness and cleavability) stone resources from **quarries from Brač can** characterize as **"Soft" rocks limestone.**

Secondary resources may have been important in the quarrying activities. Such resources include stone for buildings and other constructions at the quarry site, stone for tools, clay for pottery, etc. Such resources and their use are important to identify and characterise. In quarries from Brač, crushed stone aggregetes, created by exploitation of ornamental stone, will be crushed at the place of exploitation and transported to a temporary landfill, where will be used for constructions and roads. These construction material will be used localy or regional to Split or the nearest larger port to the quarries.

2. Identifying and describing features and material culture from quarrying

A quarry site may be visualised as the material remains from the various processes involved in the exploitation of it. Such remains include features related to the actual production (extraction and further working of stone products), the logistics (internal and external transport of stone objects) and the social infrastructure (features related to sustaining the people involved in the quarrying). Each of these elements of quarrying, alone or combined, provides important information about the timing, purpose and size of the quarrying activity. Production in a quarry can be described as a process in four steps (Figure 13).

1. The first is the extraction of rock from the bedrock, producing a stone block.
2. The second step involves the reduction of the size of the block producing a core.
3. This is further reduced/worked into one or several object blanks (or roughouts).
4. The final step involves the last finishing to the final product.

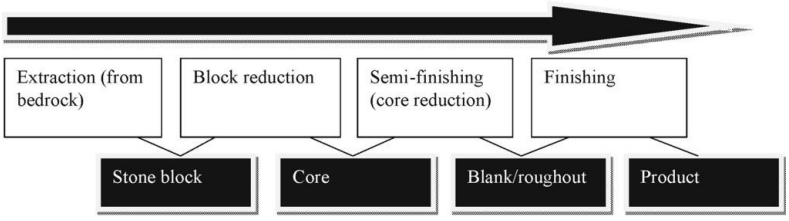

Figure 13 Quarrying defined as a process in several steps

The number of steps displayed at a quarry site, their spatial and technological connections and the start and end points of the process are important input for understanding **quarrying from a technological and**

organisational perspective. The material remains from the production process should be recorded and interpreted, and are divided into:

The **distribution and geometry** of the deposits of stone resources is the starting point of how landscapes are transformed by quarrying. The exposure of stone resources in the landscape is the result of multiple geological processes; from the formation of the rocks, through transformations of them through weathering and landscape forming processes. The geometry and outcropping pattern of the resource establishes the physical conditions of quarrying, to which quarrying methods to a large extent must be adapted. Stone resource geometries, as appearing in the bedrock in **quarries from Brač are** layered (sedimentary). Layered deposit geometries and the resulting quarry layout as open cast or open cast and gallery (Figure 14).

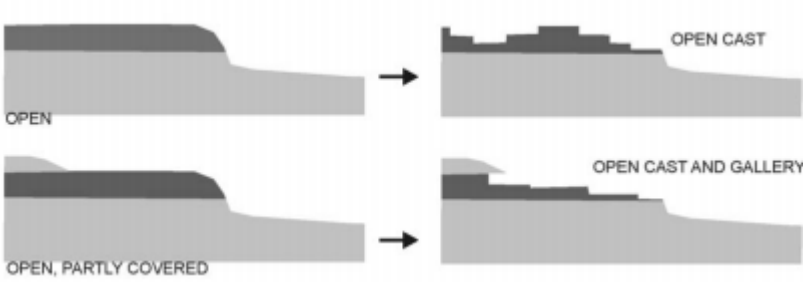

Figure 14 Examples of layered deposit geometries and the resulting quarry layout

In quarries from Brač the extraction phase is based on **channelling (carving)**; making channels in the rock by carving with hammer and chisel, pickaxe or stone tools, heating with fire, sawing or drilling. The existence of these quarries is supported by numerous inscriptions and recovered archaeological items on which quarrying marks are still visible (wedge holes known as “pašarini”). (Figure. 14.)

Figure 15 Trace of ancient notch in the rock – pašarin (photo: M. Miliša, 2015.)

The workflow at the quarry consists of a sequence of operations, starting with hand making of narrow „wedge holes“ in the rock deep up to 5 meters (pašarin), followed by the separation of block using wedges (kunji, punćoti i laštre) (Figure 15).

There is a wide assortment of specific tools, ranging from rougher to finer, known under their authentic Brač names of 'zubača' and 'martelina' (rock hammers), 'špica' (point), 'gradina' (claw), 'ravno lito' (flat chisel) and 'šćapadur' (chipper chisel), 'brusevi' (sanders), and so forth. The pattern is traced on the work surface. Depending on the complexity and symmetry of a given motif, templates may be used as a guide. Regardless of the carving phase, the larger sizes are used first, working through to the finer tools. As each tool leaves specific marks on stone surface, these marks alone are sufficient to identify the tool used (Figure 16).

Figure 16 Tool marks, carving details (photo: M. Miliša, 2015.)

Stone was transported from these quarries to the port of Splitska, where they were shipped to the final destinations. The stone blocks would subsequently be transported to the port on wooden rollers and loaded on the ships (Figure 17).

Figure 17 Structure of Antique quarry (drawings by M. Barišić, 2015.)

3. Interpreting and visualising quarry landscapes

Quarry landscapes are often composed of multiple layers of activities from more or less continuous activities through long time. Unlike settlements, the different time layers do not form well stratified layers, but rather a complex system of use, re-use and frequent re-location of material culture.

One of the most valuable methods of dating quarrying activities is through consumption of the rocks, being buildings in a city or other well-dated objects. From previous data from this study we can conclude that many buildings and sculptures were built from **quarries from Brač**, there are also records of a variety of tools used in the exploitation and processing of stone.

Micro-level analysis

Drawing together and characterising the micro-level data, as categorised above, allows us to build a composite picture of the ancient quarrying process and its social context. Multi-disciplinary perspectives are clearly key in this analytical phase, given that the objective is to define and characterise all the empirical data in terms of how it constitutes the material resources that make up a quarry landscape. This phase of expert analysis needs to describe and characterise the empirical data in terms of what insights can be made into how quarrying was undertaken in the past. Given that empirical data is always fragmentary comparative analysis with other ancient quarry sites, along with indirect evidence, is also key to interpretation of the micro-level.

When we interpret the production processes and the elements related to **quarries from Brač which** forms a basic platform of knowledge for "building" the larger concept of a quarry landscape and its significance, we can conclude that the rough blocks of limestone, quarried with rather simple means by channelling (carving) and exploiting natural fractures, were the "products" brought away from the quarries. The final shaping and fitting must have taken place there.

A key question is where the stone was transported. The q**uarries from Brač** from different periods and for different purposes are overlapping each other, and so the overall picture is complex. But when putting together the logistical elements that, through the detailed characterization, have been connected to each other, we see systems of logistics from different quarrying operations.

We have separated the Roman Period quarrying of ornamental stone for construction of Diocletian Palace from the period of the Renaissance when new quarry are opened in Pučišća, from which stone was excavated for the construction of Šibenik cathedral.

The blocks were brought from the quarries to a stockpile, from where they were transported overland 3 km to a harbour **Splitska** where they were loaded onto ships for the final transport to the place of use. The material culture in the quarry area indicates a small number of people involved in the quarrying and transport.

Visualising a quarry landscape

A **quarries from Brač** may be described as a unit of stone production, continuously exploited for a specific purpose in a specific period. A **quarries have** hiatuses in the production from Roman Period quarrying to the the period of the Renaissance. A ancient q**uarries on Brač; Plate, Stražišće and Rasohe** have start separate and later exploatation site was moved to the Pučišća and grow together into one large unit.

A quarry unit features a stone resource remains from the various steps of production, logistic features and remains of the social life around the quarrying. A **quarries from Brač have** evidence of exploitation of secondary resources. To a smaller or larger extent, the ancient q**uarries on Brač; Plate, Stražišće and**

Rasohe are a part of a larger organisation and social context. Quarry landscapes are multilayered and multifunctional. A ancient q**uarries on Brač; Plate, Stražišće and Rasohe in sense of** the definition of elements related to quarrying and the micro-level analyses of them, we can identified as groups or systems of quarries. A quarry complex **on Brač** may be visualised as a system of interconnected quarries sharing social infrastructure and logistics, input of labour force and secondary resources and output of products. The criteria on which a complex is defined depend on many factors, and may be one or combinations of the following:

1. Time/period (from Roman Period quarrying to the the period of the Renaissance to modern times)
2. Resource (limestone/ornamental stone)
3. Production (crafts)
4. Function/consumption (blocks)

A division by time/period from Roman Period quarrying to the the period of the Renaissance to modern times requires control and knowledge of the chronology, which may have been achieved directly by exact dating techniques or indirectly through i.e. consumption patterns. An indirect way of approaching chronology may be by defining complexes from production technology. A **quarries from Brač have** quarrying activities have been going on for 1700 years, illustrating unbroken human interaction with a specific resource through changing historical periods. Thus, it is particular interest to visualise such longevity of exploitation.

Fragmented values in play for land use management

The value assessment may provide arguments for land-use management. Knowing that the limestones **quarries from Brač** was applied for a number of constructions in the Republic of Croatia of national and international importance, and that it was applied abroad in numerous countries, should lead to an active and positive engagement into securing future ornamental stone production.

Figure 18 The island's regional museum

Today there is already progress in the valorization of such quarry landscape through outdoor museums walking paths protected quarry areas and space for the quarrymen in local museums.

The island's regional museum has made a perfect choice by taking Škrip for its location, a monument itself, being the oldest settlement on the island with an abundance of cultural monuments. The name Škrip originates from the Latin word scrupus, which denotes huge sharp stones that in those times were to be found at the back of Roman quarries. Among the houses that partly enclose the Illyrian buildings, the Roman mausoleum and the Croatian stronghold, there is a rich stone collection consisting of Roman, Late Antiquity and Early Medieval monuments and sculptures. The most prominent of these are the image of Hercules, the findings from Mirje and elsewhere and the copy of the Povlja lintel. Interesting ethnographic artefacts of this island are immersed in its agricultural, sheep-breeding and stone-masonry tradition, as well as in the valuable examples of its furniture which are to be found in the halls on the first floor. Above the Roman mausoleum is the projecting Radojković tower (kula Radojković) which was built in the 16th century, during the Venetian-Turkish wars (Figure 18).

It is certainly necessary to work on the further visibility and value of such quarry landscapes in other places on the island of Brač and in the whole Republic of Croatia.

Case study conclusions

A limestones **quarries from Brač** and its quarry landscape has been investigated and characterised along several axes: geology, historical evolution, evolution of crafts and technology and physical impact on the landscape. Such characterisation resulted in the definition of historical phases, or complexes.

On the basis of the characterization, we performed an attempt for value assessment of the limestone's **quarries** landscape using the method developed in the project Quarryscapes. We were able to make a rather clear statement of significance based on the extensive use of the limestones nationally and globally. The significance related to other concepts are still difficult due to fragmented information

The authors of the document want to draw attention to the importance of the preservation of renovation and management of quarries from Brač; **Plate, Stražišće and Rasohe** and its quarry landscape as cultural heritage and use of natural stone as a building material if the stone-built cultural heritage.

The knowledge of the value of ancient quarries as well as new quarries, we hope that the wider population will notice the importance of these areas for our ancestors as well as the possibility of further sustainable development and coexistence of quarries and their landscapes in modern modern times.

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