

WP4

Platy limestone as cultural heritage

Supplement 3.1

Cultural heritage and limestone. – General overview

Appendix 3.1.5

Final report for the project area in Croatia (North Dalmatia)

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THE USE OF A PLATY LIMESTONE IN THE ZADAR REGION THROUGH THE HISTORY - Exploitation, processing, transport and construction

Summary

Limestone is a fundamental building material on the east Adriatic coast, as well as in the Zadar region. Thanks affluence, the easy and cheap exploitation and marine transportation platy limestone is the most widespread type of stone used in the building in the Zadar region. It is used in a representative architecture (sacral and public buildings and fortifications) and especially in the traditional profane building. Historically dominated island quarries in the supply of Zadar, but today the exploitation of the plate stone is present only in the Zadar hinterland.

Introduction

Through the long historical development, from prehistory to the early 20th century, limestone is the dominant building material in the whole Mediterranean. Therefore the history of the Mediterranean (and also the Adriatic), is unimaginable without the presence of stone in construction use. Zadar, located at the central point of the eastern Adriatic coast, is part of the Mediterranean ecumenism and share that common heritage. The eastern coast of the Adriatic Sea is marked by the use of limestone in construction as western is marked with using of brick. All of our coastal cities, villages in hinterland and island villages, were erected in the limestone. Mainly is a traditional, anonymous, profane building. These monuments are rapidly disappearing under the weight of modern construction based on the use of reinforced concrete. By now, most of our traditional profane architecture has disappeared. Preserved are only the most representative stone buildings inside the historic nucleus of the Adriatic towns which are protected by conservation institutions. However, one should keep in mind that this is only a small remnant of the former stone building. All profane building, from prehistory to the early 20th century, whether in cities or in the countryside, was used the stone as the main building material. The eastern coast of the Adriatic was built almost entirely from sedimentary limestone rocks, so limestone is almost only rock used in construction.

Metamorphic and magmatic rocks are almost none, so few buildings constructed or decorated with different kinds of marble or granite are exclusively import.¹

Among the limestone there are big differences, and on the east Adriatic coast in building is the most common use of three types: white rudist limestone in blocks, platy limestone and coloured limestone *breccia*.²

White, rudist, limestone are used as architectural stone due to its good workability and density. From it are carved valuable structural and decorative elements of buildings (columns with capitals, architrave, portals, profiled cornices, massive shaped blocks on facade, ashlar). Because of a lack of marble and granite, coloured limestone *breccia* was used for decorative parts of buildings.

Historically, in the Zadar region, the mostly was used reddish breccia from the island of Rab.

The third type of stone used in the building on the eastern Adriatic coast is a platy limestone. This type of stone was the main building material on the east coast from Prehistory to the early 20th century. Because of its natural layering can be easily separated from the rock mass and chopping at the desired thickness.

Thickness could vary from one meter to several millimetres. Layered rock emerges on the surface and does not require expensive quarries exploitation. It relatively easily separated with wedges, bars and picks.

In Zadar region platy limestone was used in four ways:

1. Use of common irregular broken stones and stone rubble as aggregate in masonry mortars.
2. The use of homogeneous, less layered, limestone shaped with mason tools in completely regular geometric shape, semi ashlar and ashlar- *priklesanci* and *klesanci*.
3. The use of proper stone slabs, chipped by layers, for paving and roofing.
4. The use of a plate of stone in the construction of dry walls construction

However, a characteristic of all Karst area should be mentioned, that is, the clearing of stones to give cultivable land. The stone was removed for centuries to form small cultivated soil. Parcels of land were fenced with dry walls- *ograde* built with large stone, while little rocks were deposited in large piles known as

¹ Ward Perkins, John Bryan, Dalmatia and the Marbel Trade, *Disputationes Salonitanae*, Split, 1976., str.

² Crnković, Branko, Građenje prirodnim kamenom, Zagreb, 1992., str. 1-13

gromače, mocire or *gromile*. This centuries-old process created a specific Karst landscape covered with a network of dry stone walls.³

Historical overview

The use of stone is as old as the human presence in the area. However, it became the dominant phenomenon on the east coast during the Iron Age Illyrian settlement. This is an Illyrian (in the case of Zadar Liburnian) hill fort settlements, *gradine*, that occur during the late Neolithic and Eneolithic when it comes to moving settlements from flat fields to sublime and easily defended sites. Many of their settlement are generally built on hills and determine them with stonewalls, masonry wall technique was without using any mortar. Specified time settlements represent the first real stone structure in the wider area of Zadar. In general, they are circular structures built with irregular stone. Larger settlements have walls built with massive blocks.⁴

Except for large blocks, Liburnians used the platy limestone. Plates were extracted near the settlements itself, and was used for sidewalks, graves, and probably roofing.

Zadar area is rich with platy limestone and is to date the most widespread stone exploitation. It is just simple and cheapest method of separating stones in layers. Tools were simple: wooden wedges, generally made of precious hard oak wood, were beaten with stone or iron hammers, or layers are separated with a pickaxe. This allowed the Illyrians to quickly and efficiently build their fortified settlement and necropolis below them. When possible, drywall structures were built on the natural stone barriers and cliffs. Limitation of Karst landscape Liburnian masons, and builders always turn to their advantage.

As we've already mentioned, stone from the nearest possible area is used.

Quarries have not been opened and there was no systematic exploitation. Mining, processing and building of stone was limited to every tribal community that lived in an area.

With the arrival of the Illyrians under the final Roman rule in the 1st century AD, began the systematic exploitation of stone. They open a number of smaller and

³ Orbančić-Sapundžić, Nada, Suhozid-ruralna arhitektura, Histria Antiqua, sv.3, Pula, 1997., str. 115-116

⁴ Suić, Mate, *Antički grad na istočnom Jadranu* (2.izmjenjeno i dopunjeno izdanje), Zagreb, 2003., str.80-81

larger quarries from which the stone was extracted for raising colonies along the coast. In the vicinity of each of the Roman settlement a quarry were opened.⁵

On the site of Liburnian hill fort settlement Romans built a colony *Iader*, today Zadar. Ancient *Iader* was built with local stone extracted from quarries in the nearby islands. The largest of these were in the islands Lavdara, Sestrunj, Dugi otok, Kornati, Žut, Rava, etc.

Croatian name Lavdara comes from the Latin *lapidaria* – quarry. This relatively bare and uninhabited island, because of high quality of hard rock, was ideal for exploitation. Although traces of exploitation found along the coast of the island, the largest concentration is on the southwest side. The Romans drew rock by the shores of Lavdara, and the depth of the sea is allowed landing to stone ships (*naves lapidariae*) next to the quarry. It's guarantee to masons low costs of transportation and enormous time savings.⁶

On the island of Žut roman quarry was located at *Petrara*, at the island of Sestrunj *Padrara Gornja and Padrara Donja*. Quarries on Sestrunj are the largest platy limestone quarries from the Roman period.

Quarry *Ovča* near Savar on Dugi otok was also open during the Roman period, but it only developed to its full potential during the the Middle Ages. In all three cases quarries are at a height of over 100 meters above sea level and a little farther from the coast. Unlike Lavdara, slides – *sklizne svoznice* or sleigh – *smuk* had to be used for semi-worked stone blocks, with bullock cart to push down the slope to the docks. There are using cranes to boarded stone in the ship. All the technology of extracting, transporting and processing of stone has been known in classical Greece. Rome took it over and standardized the craft in the first century after Christ. Vitruvius processed this topic in his famous treatise *De Architectura Libri Decem*.⁷ In Zadar hinterland, roman limestone quarry existed on the site Otavac (village Popovići at Benkovac).

Along this local stone, marble and granite from distant imperial quarries in Greece, Asia Minor and Egypt were imported. Zadar island quarries were not under direct imperial, but in municipal ownership. The imperial quarries were

⁵ Šarić, Ivan, Antički kamenolom u Prozoru, *Materijali, tehnike i strukture predantičkog i antičkog graditeljstva na istočnom jadranskom prostoru*, Zadar, 1976., str. 115-120

⁶ Filipi, Amos Rube, Otok Lavdara, *Geoadria*, vol.6, str. 146-147

⁷ Vitruvius, *De Architectura Libri Decem*, preveo Matija Lopec, Zagreb, 1999., str. 40-45

aesthetically most valuable. They are mainly white and coloured marbles from Greek and Asia Minor and granites from Egypt. On the eastern coast of the Adriatic, the imperial quarries on the island of Brač (Škrip, Rasohe, Stražišće, Plate) at the beginning of the 4th century Diocletian possessed. These quarries have been supplied stone for the construction of Diocletian's Palace in Split.⁸ Romans as well as the Illyrians before them, used in the construction of *Iader* platy limestone, due to easy availability and workability to the desired thickness. Buildings in residential quarters of *Iader* also are made with platy limestone, but modest in size and minimally processed in a rectangular form. Except for masonry, Romans used this stone for paving streets and squares. The market square was paved in the 2nd century with private donation. A memorial inscription is preserved which states that the widow *Meliae Anianae* donated 600,000 *sesterces* for raising the arch and paving market square.⁹

Mostly, used platy stone was extracted at island Lavdara. The brownish-pink stone was chosen because of the high wear resistance due to pedestrian traffic. Even today, on the former *Forum Romanum*, it can be seen plates of Roman pavement harvesting on Lavdara. Romans used platy stone for roofing of buildings, but a far less than tile (*tegula* and *imbrex*).

In the fourth century ancient *Iader* begins to transform into a Christian city. At the Roman Forum builds Episcopal Complex and Cathedral. In The town has erected a number of basilicas. Although, traces of early Christian architecture, has been preserved by modest remains, it can be concluded that they were built with semi-worked stone. They had a semi-circular apses covered with a platy limestone, but the naves were covered with half-round tiles-*kupa kanalica*.

With the fall of the Roman Empire comes to stagnation and vanishing stone exploitation in the Zadar area. City survived inside its walls and is slowly recovering through the Early Middle Ages. A numerous of modest pre-Romanesque churches was built, using crushed stone mixed in plentiful lime mortar. Roofs of these churches were usually covered with stone slabs. They were cheaper and more accessible building materials then tile. Of all the pre-Romanesque churches in Croatia the most monumental was church of St. Donatus

⁸ Didolić, Petar, Historijski brački kamenolomi, *Brački zbornik*, sv.3, Split, 1957., str.99

⁹ Ilakovac, Boris, Kada je popločan i uklašen emporij rimske kolonije Jader, *VAZM*, 3.s., XXXII-XXXIII, Zadar, 1999-2000., str. 93-103

(formerly dedicated to St. Trinity) in Zadar. The rotunda was built with subsequently, irregular stone, partly platy stone and partly ancient remains of Forum-*spolia*. Large pieces of Roman columns and cornices were used for building the foundations of the church.

Zadar region is characterized by small pre-Romanesque churches with central plan (in the form of a cross or circle).¹⁰ They are built with rubble stone and have roof covered with stone slabs. The stone slabs are thin (up to two centimetres), small in size and overlap together in two-thirds of the surface. Regularly, found them on vaulted parts of the building: apses, domes, vaults. They are often joined with lime mortar, and sometimes without mortar.

In the late Middle Ages the demographic and economic recovery of European cities came about which reflected in the construction industry. In Zadar great architectural momentum occurred during the 12th, 13th and 14th centuries. Travel writers highlight the beauty of the white stone city.¹¹

Re-open the former Roman quarries at the islands around Zadar (Lavdara, Sestrunj Dugi Otok, Ugljan), and opens a new (quarries Zapuntel, Kamenjak, Zagračina on island Molat). Beside use of white block limestone and platy limestone, in Zadar was imported famous reddish breccias from Rab (*lapide rubeo* or *mandolato*). The specialty of Zadar Romanesque is combining white stone with reddish breccia.¹²

We should also mention another type of stone, essential for medieval vaulted construction, travertine- *sedra*. It is a lightweight porous rock formed at Karst barriers on Dalmatian rivers. Because of the simple workability, ease and good construction quality it was used for the reduction of arches, vaults, domes and apse. For the needs of Zadar, travertine was extracted on the river Zrmanja and from the port of town Obrovac transported in Zadar with ships.¹³

After centuries of neglecting, begins with active communal maintenance in Zadar. Once again, they are paving the main streets and squares, as well as important public and private buildings, and churches. Residential architecture of medieval

¹⁰ Vežić, Pavuša, Dalmatinski trikonhosi, *Ars Adriatica*, sv. 1, Zadar, 2011., str. 27-66

¹¹ Skok, Petar, *Tri starofrancuske hronike o Zadru u god. 1202.*, 1951., Zagreb, str. 91-93

¹² Petricoli, Ivo, Dva priloga povijesti zadarske katedrale, *Peristil*, sv.22., 1979., Zagreb, str.5

¹³ Fisković, Cvito, *Zadarski sredovječni majstori*, Split, 1959., str. 15

Zadar is mostly gone but we learn from the documents that were usually modest in size, built in wood, stone (*lapidae*) or a combination of stone and wood (*partim lapidea, part de lignamine*). Roofs were mainly covered with stone slabs (*plancha*) or less often with tiles (*cuppa*).¹⁴ Numerous medieval churches in Zadar hinterland and islands are also usually covered with stone slabs.

Almost regularly, platy stone covering the semicircular apses. Naves of churches are with brick or stone roofing. The stone was cheaper, but because of the weight it was appropriate for vaulted parts of Churches (apse, dome), but not for the flat wooden roof as well. In the 13th century stonemasons craft was at its peak, so there is specialization within the profession. Masons employed at the separation of stone slabs in quarries medieval documents referred *smaratori*, while the masters who paving street called *salizator stratorum*.

Because of the quality, white limestone was exported to the Italian cities on the opposite coast (Fermo, Marche).¹⁵

Side by side with the local masons, masters from Italy operated in Zadar. Due to strong economic, political and cultural relations, largest number of them came from region of Marche (especially from the small town of Fermo) and Veneto. There is no historical mention of the export of platy limestone from Zadar because it is always treated as ordinary construction material (like sand, lime, iron, or timber). And as we have already said, the west coast of the Adriatic is marked with brick like East Coast is marked with stone.

In the documents, is very rare to mentions origin of the stone, except in the case of the highest quality architectural building material. Mainly thick block limestone was called "white" (*lapide albo; piera bianca, pietra bianca*), a platy limestone was called "dark" (*pier nigra*). Plate stone is so common that it considers simple construction materials.

The Early Modern time brings economic decline as a result of exhausting wars over centuries between Venice and Turkish Empire. Stonemasonry is slowly dying and is subject to defensive purposes. In addition to the aforementioned quarries, platy limestone at the beginning of the 15th century has been extensively exploited from the islands of Iž and Ugljan (Lukoran).¹⁶

¹⁴ Klaić, Nada/Petricioli, Ivo, *Zadar u srednjem vijeku do 1409.*, Prošlost Zadra-Knjiga II, Zadar, 1976., str.

¹⁵ Petricioli, Ivo, *Srednjovjekovnim graditeljima u spomen*, Split, 1996., str. 193-194

¹⁶ Fisković, Cvito, *Zadarski sredovječni majstori*, Split, 1959., str.14

The technique of masonry and stonework, as well as the use of a platy stone remained the same as well as in Middle Ages. It continues to pave the streets of Zadar and the main square (*platea magna*) paved on the 1467th year joint contributions of all citizens (commoners and nobles).¹⁷ Because of the constant attacks of the Turks, Venetian Republic sent military engineers to Zadar in the 16th and 17th century to rearrange the medieval walls into a modern fortress. The city has experienced a radical change. Many churches and buildings have been destroyed and their material was used to build the fortifications. From the mid-16th century, increasing the use of imported stone from quarries of central Trogir, Korčula and Brač. This was due to the slow disappearance of Zadar workshops due to falling orders of stonemason.¹⁸ Urban reorganization of the city in a Renaissance fortress demanded huge financial and logistical efforts. The plan is effectively spent Venetian officer, condottiere Sforza Pallavicino. He tore down the medieval burg *Varoš* 1567th year, and stone used as building material for the fort. He introduced the work obligation for all segments of the population. Especially important were masons, and stonemasons. With the help of all citizens and hired craftsmen from Istria (blacksmiths, carpenters and the brick masters) massive fortifications *Forte* was built in just a few years.¹⁹ Venetian administration, and later her Hapsburg, for public works (repairing the walls, harbours and docks, communal maintenance) introduced a work obligation (*per servizio pubblico*) to stone masons for extracting and breaking of stone. They worked without pay, at their own expense - *a spese proprie*. Besides the stone-workers, obligations are affected by the islands ship owners. They were obliged to transport prepared platy limestone in Zadar. This obligation on Lavdara quarries were especially affected people of Sali (Dugi otok) in the 16th, the villagers Ugljen (island Ugljan) in the 17th and Kukljica (island Ugljan) from 18th until the early 20th century.²⁰

After the fall of Venice, there was short period of French and then the finally Austrian government in Dalmatia. Austrian administration declares in 1868th year

¹⁷ Raukar, Tomislav, Zadar u XV. Stoljeću-ekonomski razvoj i društveni odnosi, Zagreb, 1977., str. 59

¹⁸ Borić, Laris, Renesansna skulptura i arhitektonska plastika u Zadru, doktorski rad, Zadar, 2010., str.423

¹⁹ Peričić, Šime-Petricioli, Ivo- Raukar, Tomislav-Švelec, Franjo, Zadar pod mletačkom upravom : 1409-1797, Prošlost Zadra 3, Zadar, 1987., str.280

²⁰ Filipi, Amos Rube, Otok Lavdara, *Geoadria*, vol.6, str. 147-148

open city of Zadar. They begin with an extensive public works. Zadar, once a medieval fortress, became a classical open city with many parks, wide promenades and regulated shores. In the town were raised numerous of classicist palaces and residential buildings.²¹

To ensure an adequate supply of stone from the island's quarries, the government introduced a work obligation to ships owners on the islands. Hard work of extracting and ships transporting of platy stone from Lavdara obliged the inhabitants Kukljica (Island Ugljan). Although in the first half of the 20th century Kukljica had, for platy limestone transportation, 30ships-*leut*, labour cost was very low. Between the two World Wars, value of the platy limestone loaded on one *leut* was about 20-30 dinars which could buy 7-10 kilograms of bread.²²

Besides on the Lavdara, residents of Kukljice extracted stone on the island Kobiljak (at the southern entrance to the bay Telaščica), Petrare site on the island of Žut, on the islands Gustac, Gornja and Donja Aba and Tukošćak (north of Sali, Dugi otok), in the bay of Dobra in Božava on Dugi otok, on the Sestrunj and small island of Paranak near Sestrunj.²³

During the Austrian government in Zadar streets and squares was finally paved with Lavdara reddish stone, of which one part retained to this day. Since that time, stone roofing was completely stopped, but the use of platy limestone is still dominant in rural building (in the islands, and especially in the hinterland).

After WW1 quarrying is still largely concentrated on the islands and it is in further declining. In the sixties of the 20th century quarrying are completely turned off. So today for the first time in recorded history, there is no active quarrying in the Zadar islands. The low cost of labour, emigration of the insular population in the first half of the 20th century and the occurrence of tourism as a major economic branch in the islands resulted such situation.

Also, the modern exploitation with the road transport enabled the competitiveness of quarries in the hinterland. So that stone from Benkovac area became, from the second half of the 20th century, a symbol of the platy limestone for entire Croatia. Mostly exploits around the villages Popovici, Pridraga, Benkovačko selo and Lisičić. Stone was excavated here since Roman times.

²¹ Stagličić, Marija, Gradnje i projekti od 1997. do 1914. Godine u Zadru, katalog, Zadar, 2003.

²² Filipi, Amos Rube, Otok Lavdara, *Geoadria*, vol.6, str. 149

²³ Isti, str.149

Today, exploitation of architectural stone does not exist in the Zadar County. The last quarries on the southern Velebit (decorative, colored breccia and conglomerate *tulovac*, *romanovac*, *marić*) are also in front of closing.

Therefore, it remained only fragmented platy limestone industry in Benkovac area (a series of small, private, delphs and quarries). It is mainly based on the production of plates and slabs of different thicknesses -cleaved or sawed. It is used for pavements and facade panels.

It is the stone used in the conservation for roofing of architectural monuments.

The Benkovac platy limestone separated from the rock mass has yellowish or greyish colour. By influence of the atmosphere soon gets gray primary patina.

Therefore conservators elected plates on the surface of delphs or take old plates from ruinous buildings and reuse them.

The traditional architecture

Profane architecture of Zadar hinterland and islands did not change anything for centuries. Therefore, it is very difficult to determine the age of the particular structures. Basically, it is a house with single-cell space covered with gabled roof. The walls are built of raw (*lomljenci*), or semi-worked stone (*priklesanci*).

Because of static only a stone at the corners (*uglaci*) of the house was more carefully processed. Rural houses in the northern part of the Dalmatia, particularly in Bukovica, were not plastered.

The walls are a minimum dissolved. Besides the door, it has opened up one or two small windows. Doors and window frames are more carefully carved. The only perforation of inner walls is shallow niche called *ponara*. It was used for storing small supplies or candles.

The centre of the interior was an open fireplace-*ognjište* or *komin*. Fireplace was built by stone. Only firebox was made of brick. It is situated at the centre of the room or in the corner of the walls. Fireplace smoke was passed freely between the stone slabs. In order to increase the draft, the big slab-*vidalica* at the top of the ridge is raised and propped herself up with a stone. In some places, it was built primitive chimney called *badža*. This method of construction is typical for rural housing on the entire eastern coast of the Adriatic Sea, and beyond.²⁴ Today it is

²⁴ Freudenreich, Aleksandar, *Kako narod gradi na području Hrvatske*, Zagreb, 1972., str. 179-189

simply called the *Mediterranean stone house*.²⁵ In rural architecture, except for housing, small farm's buildings such as barns, warehouses, pens for cattle etc. were built, always using modest drywall structure.

The roof was covered with stone slabs that overlap (two-thirds overlap). The slabs are massive and sometimes have a surface over 1 m². In Bukovica and Ravni Kotari, stones were laid in more or less diagonal rows.

It was a result of using of relatively large and thin pieces of stone slabs.

The roofing structures in Bukovica tip of traditional building were very simple. These are on the whole of wooden rafters and the roofs were not lathed. For rafters- *prlji* or *roženice*, round wood- *oblice* was most often used, meeting at the ridge pole on a board that braced them.

Because of the weight of stone slabs of fairly large dimensions, the rafters had to be at rather small distances from each other (about 40 cm). Every slab covered two to three rafters.²⁶

Maintenance of roofs was simple. Damaged stone slabs are replaced with new. The timbers are rarely changed, usually in a single generation. On their outside kitchen-*crna kužina*, *vatrenica* slabs were free of mortar. For residential buildings, the slabs were coated mainly with lime mortar and the entire roof surface is coated with limewash- *vapneno mlijeko*. This whitewashing- *bijeljenje* protect stone, and also disinfected surfaces on which rainwater collected. Across this type of roof rainwater was filling cistern- *gusterna*, *čatrnja*.

Conclusion

We can summarize that the platy limestone was the main construction material of Zadar region from prehistory to the occurrence of reinforced concrete in the 19th century (regardless of whether it is a city of Zadar, islands or inland). The reason is easy availability, workability and cheapness of these types of limestone.

Almost the only building material available to all it was destined for the traditional architecture of Zadar region. However, historical documents of this kind of stone are rare. It was not useful for fine stone carving, processing and is

²⁵ Šrajner, Filip, *Mediterranska kamena kuća- tehnika gradnje i obnove*, Zagreb, 2006., str. 20-36

²⁶ Živković, Zdravko, *Hrvatsko tradicijsko graditeljstvo*, Zagreb, 2013., str. 42

not valued as an architectural stone. In fact, it was considered as most ordinary construction materials, such as sand, water or lime. Basically, this stone was excavated on the surface in the vicinity of settlements, and very rarely in the quarries. Yet in the Zadar area quarry exploitation for platy limestone existed from the ancient times (Lavdara). Historically, the role of island stone was dominant, but today only exploits in the hinterland (Benkovac) persevere. Plate stone now lost its original function of construction and takes just a decorative one. The original purpose of the plate was kept in stone conservation practice.



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