

# The Remains of Infrastructural Facilities of the Ancient Quarries on Zadar Islands (Croatia)

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# THE REMAINS OF INFRASTRUCTURAL FACILITIES OF THE ANCIENT QUARRIES ON ZADAR ISLANDS (CROATIA)

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## Abstract

The paper provides an overview of recent discoveries of infrastructural facilities in ancient quarries on the Zadar islands. The facilities are located in the immediate vicinity of ancient quarries: communications from the quarries to the coast in the form of exit corridors carved in bedrock, paved tracks for transport of stone to the harbor, harbor installations for loading and shipment of stone blocks. The sites are located on Molat, Sestrunj and Dugi Otok islands. The remains of other buildings featured in quarrying complexes were also recorded: a foundry and a water cistern. Some of the infrastructural facilities contain archaeological finds that can be used to date the adjacent quarries. It is important to emphasize that, owing to their favorable geographical position, these sites are well preserved which is quite unique a situation in the entire Mediterranean region. It should be noted that the zones featuring quarries also feature communications to the sea, harbor facilities and auxiliary buildings. Such sites are rarely represented in the archaeological record and it is extremely important to preserve them from modern devastation.

## Keywords

infrastructural facilities, quarry harbor, ancient quarry, Zadar islands

Palace<sup>1</sup>. Several scholars made the connection between Brač quarries and Roman period public building. P. Didolić emphasized in several discussions of quarrying at Brač that it was the Romans<sup>2</sup> who introduced stonemasonry proper to the area and concludes that stone loading and export were conducted at Splitska harbor for the purpose of building Diocletian's Palace<sup>3</sup>. Several other papers are important for issues related to Brač quarrying such as D. Vrsalović<sup>4</sup>, B. Kirigin who discussed Roman inscriptions and reliefs found at Škrip<sup>5</sup>, N. Cambi whose seminal contribution includes the issues of late Roman period sarcophagus production at Brač<sup>6</sup>.

M. Katić discussed the Greek colonization period quarries of Srebrena bay on the island of Vis.<sup>7</sup>

The quarrying tradition at Korčula was discovered by M. Gjivoje<sup>8</sup>, while S. Dokoza discussed medieval documents in connection with stone use and trade<sup>9</sup>. Lately, B. Russell and K. Glicksman<sup>10</sup> have discussed quarrying at Brač and Korčula. Sara Popović<sup>11</sup> has made a notable contribution to the knowledge of stone quarrying on Hvar.

J. Jeličić<sup>12</sup> and D. Maršić<sup>13</sup> have discussed archaeological finds which can be directly related to quality Trogir stone quarrying at St. Ilija hill.

Several scholars were concerned with Zadar area. M. Suić has pinpointed the islands of the Zadar

The eastern Adriatic coast abounds in prehistoric buildings definitely connected with extraction and collection zones of stone material. However, it is only after the establishment of Roman authority that building activities accelerated, on an unprecedented scale, resulting in an increased demand for quality stone products. The period in question did not go unnoticed but unfortunately, quarrying and problems related to stone acquisition remained at the fringes of the interests of scholars.

The most notable quarrying center is the island of Brač, or to be more precise, the area between Splitska cove and Škrip. F. Bulić identified discarded stone elements in Splitska cove and assumed that the area was an export port for stone products headed for Diocletian's

- 1 BULIĆ 1900, 20.
- 2 DIDOLIĆ 1954, 210.
- 3 DIDOLIĆ 1957, 99.
- 4 VRSALOVIĆ 1968, 48.
- 5 KIRIGIN 1979.
- 6 CAMBI 2007, 105.
- 7 KATIĆ 2009, 33.
- 8 GJIVOJE 1970.
- 9 DOKOZA 2009.
- 10 RUSSELL, GLICKSMAN 2015.
- 11 POPOVIĆ 2012.
- 12 JELIČIĆ 1981.
- 13 MARŠIĆ 2007.

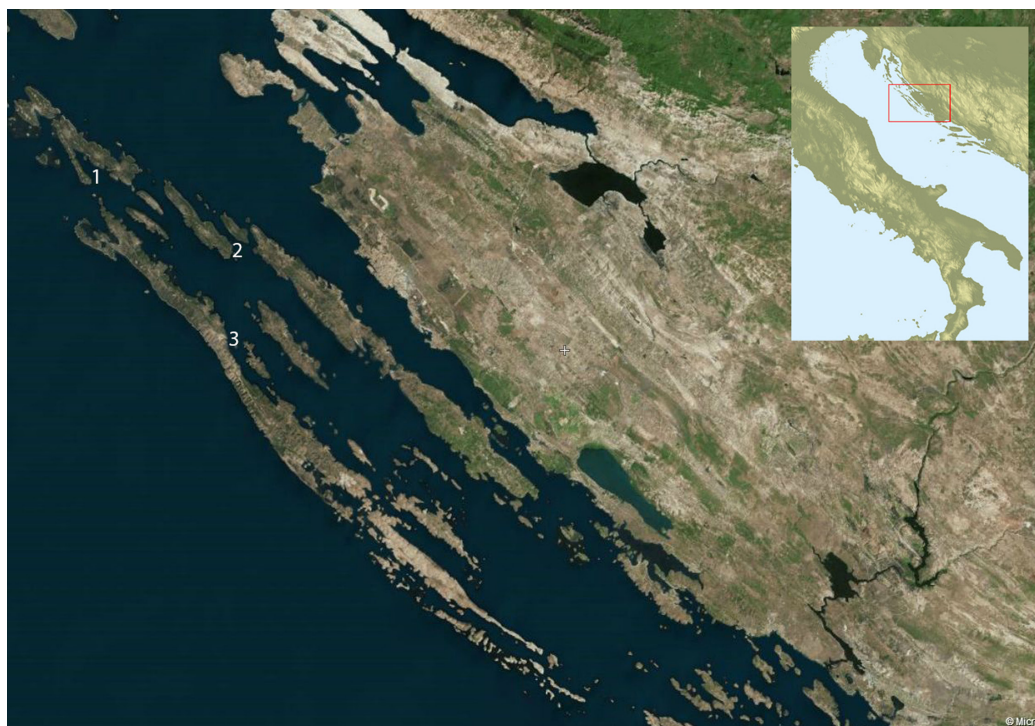


Fig. 1.  
Map of the Zadar archipelago with marked sites, 1- Molat, 2- Sestrunj, 3- Dugi Otok. (source: Flashearth)

archipelago as the source of stone for building projects in Roman-period Zadar<sup>14</sup>. D. Magaš and R. Filipi discuss the great Roman-period quarries at Sestrunj island<sup>15</sup>. Z. Brusić has mapped the most significant quarries in the Zadar archipelago<sup>16</sup>.

General matters related to stone quarrying on the Croatian coast and hinterland was discussed by the following scholars: R. Makjanić<sup>17</sup>, B. Crnković, Lj. Šarić<sup>18</sup>, S. Dunda<sup>19</sup>, N. Džaja<sup>20</sup>, A. Škegro<sup>21</sup>, R. Zlatunić<sup>22</sup> and M. Parica<sup>23</sup>.

Although the number of scholars who have at some point discussed quarrying is rather great, the information on the infrastructural facilities that were definitely a part of the Roman-period quarries is quite scarce.

Research into and field surveys of several Roman-period quarries have revealed a large number of archaeological remains that were an integral part of a

quarry complex. It is precisely these features that are the theme of this paper. The stone extraction zones are merely referred to by their location, followed by a short description. The main concerns are, however, the infrastructural facilities that accompanied such sites. First and foremost these include the remains of harbor facilities such as remains of stone piers used to load cargo and supply ships, ramps used to lower the blocks to the harbor facilities as well as the remains of several other buildings that were a part of a quarry complex.

Three quarries in the islands off Zadar are selected for the purposes of this paper. Apart from the extraction zones themselves, these sites include preserved infrastructural facilities that were a part of the quarrying complexes.

### Molat

Looking from north to south, the first site is located at Molat Island. The extraction zone is situated on the slope of Bonaster Hill, at an altitude of 70 m above sea level; the average height of the artificial cliff is 11 m. The quarry contains a small number of pick-axe tool marks which might be dated to the original Roman-period quarry. The majority of traces visible today are from the late medieval and early modern periods. Characteristic of the latter period is the large amount of spoil left. An exit corridor carved into the base rock is clearly visible on the northern side of the quarry (Fig. 2). This section was probably a part of the original Roman-period quarry. The argument to sustain such a claim is that the extraction from this corridor was carried out in the

14 SUIĆ 1981, 276.

15 MAGAŠ-FILIP 1983.

16 BRUSIĆ 1974.

17 MAKJANIĆ 1981, 71-76.

18 CRNKOVIĆ-ŠARIĆ 1992.

19 DUNDA 1997.

20 DŽAJA 1999.

21 ŠKEGRO 1999.

22 ZLATUNIĆ 2006, 185-206.

23 PARICA 2014.





Fig. 2.  
Exit corridor at the  
Bonaster site extending  
towards the harbor



Fig. 3.  
Aerial view: quarry and the  
related harbor marked with  
arrow. (photo: D. Vujević)

southerly direction. Recent interventions in the quarry only continued this movement towards the south while the use of the exit corridor continued.

The exit corridor is, in fact, the beginning of a trackway i.e. a ramp used to lower stone blocks. The track can be followed several dozens of meters, only to fade away into the thick forest.

The beginning of the ramp track used to lower stone blocks is determined by the exit corridor carved into the bedrock. The termination of the track, on the other hand, can be followed to the sea shore where the Roman period harbor structure begins to emerge. These structures were related to the activities at the quarry.

In the vicinity of the spot where the pier is joined with the coast, a refashioning or rather an adjustment of the bedrock is clearly visible. This feature forms the ramp leading to the pier itself. This refashioning continues under the sea level as well, where it is clear that the irregular bedrock is missing which is the case on both sides of this communication (Fig. 4.) This is, in effect, the termination of

the lowering ramp leading from the quarry to the pier. The feature is discernible at the sea shore because the sea has degraded the bedrock along the sea shore making it easier to determine the remains of the lowering ramp. It is clearly visible that the ramp-road terminates precisely at the stone pier.

The area between the quarry and related harbor is extremely overgrown with thick vegetation. However, the aerial photo clearly displays vegetation marks representing the road. Likewise, it is impossible to determine without excavation whether the road was paved or the bedrock was merely adapted for the purpose. The entire harbor assemblage and the communication terminus are below sea level today. The sea level has risen since the Roman period, when it was about 1.6 to 2 m below contemporary sea level (Fig. 5), suggesting the facilities were built in the Roman period.<sup>24</sup>

24 For a more detailed elaboration on changing sea levels see: SURIĆ 2009; LAMBECK *et al.* 2010; ANTONIOLI *et al.* 2007; FAIVRE *et al.* 2010.





Fig. 4.  
The marked zone of refashioned bedrock, representing a road to the pier itself and used for loading stone blocks

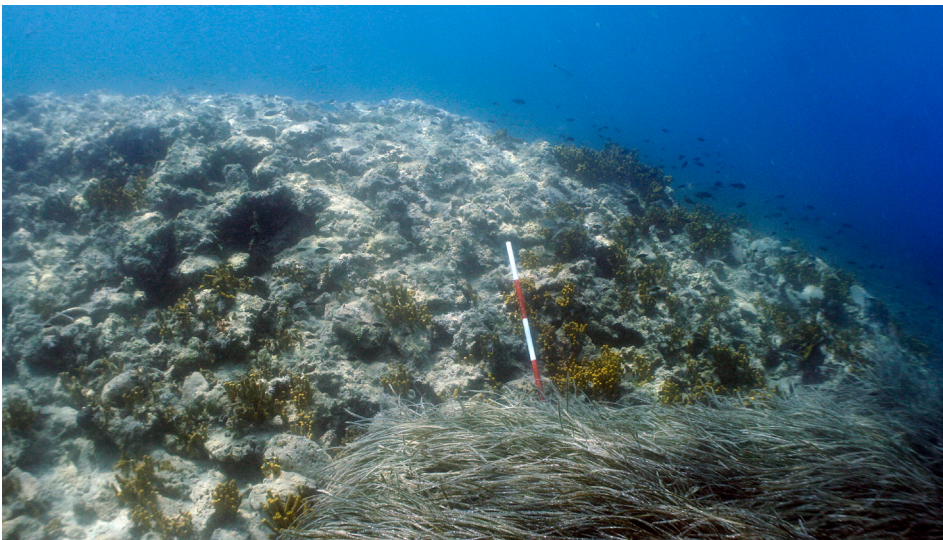


Fig. 5.  
Stone bank-pier at Molat; nowadays the structure is submerged

The harbor pier, which was used for loading stone blocks on the ships, is located at M. Zaganj cove. It is 12 m long and the structure is positioned perpendicular to the shore line. The structure is built from amorphous uncut stones, 60 cm in diameter. A large number of Roman amphorae fragments, as well as several ballast stones were found on the bank surface. The selection of the building site for the harbor is quite curious. It would have probably been better to build the harbor in the V. Zaganj cove, 250 m south-west of the M. Zaganj cove i.e. just below the quarry. The actual harbor site was probably chosen for the protection from the southern winds it provided. Perhaps the gradual descent of terrain towards M. Zaganj cove also played a part, making it ideal for building a ramp for lowering the stone blocks.

### Sestrunj-Padrare

An extremely large complex of Roman period quarries located in the southern part of Sestrunj Island (under local place names Donje and Gornje Padrare). The quarries exploited the slab-like stones, sedimented in thin layers, up to 70 cm thick. This kind of stone can be used to build walls, pavements and the thickest layers are quite adequate for building ramps. The initial information on this complex is provided by A. Filipi and D. Magaš<sup>25</sup>. They have dated the quarries to the Roman period, based on surface archaeological finds.

Gornje Padrare quarry is located on the eastern slope of Gračina Hill. The assumed altitude is 60 – 80 m above the sea level. The extraction zone plan is semicircular in shape, maximum width is 400 m, and the area covered is 2,34 ha. The average height of the artificial cliff is measured at 2.5 m in the area under survey.





Fig. 6. Aerial view: the beginning of Donje Padrare extraction zone (photo: D. Vujević)



Fig. 8. Submerged part of the harbor construction

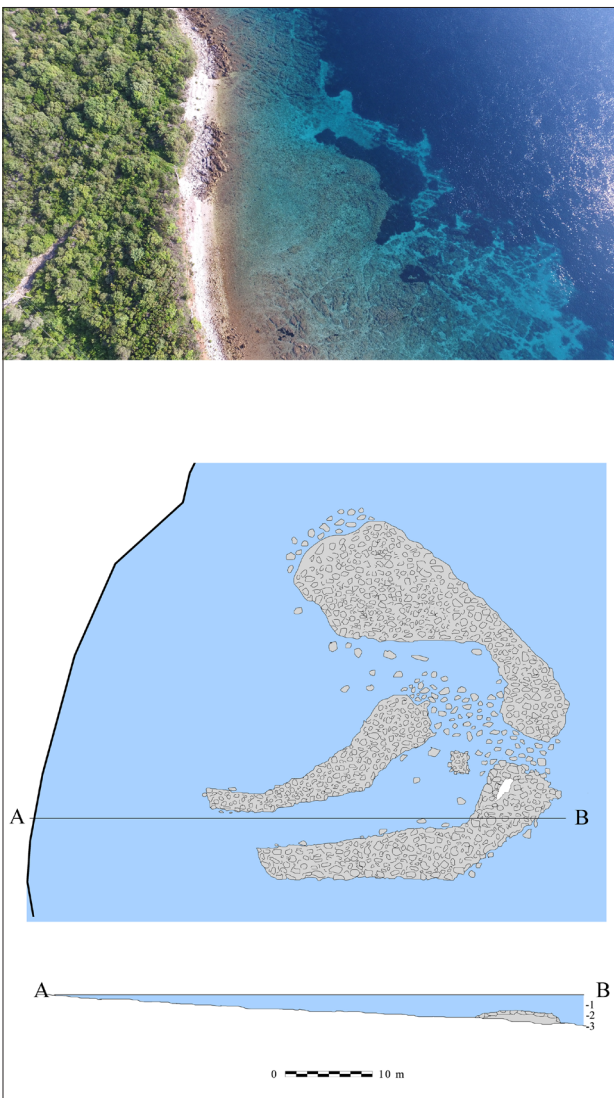


Fig. 7. Aerial view and plan of Karanke harbor (photo: D. Vujević)

The Donje Padrare extraction zone consists of 11 quarries stretching one kilometer in length. The quarries are open pits, stretching in the northwest-southeast direction, forming a line at an altitude of 120 m above the sea level. The quarry pits are rather narrow but also extremely deep. The height of the artificial cliff is 9 m.

The area around the quarry is extremely overgrown with vegetation. Therefore, the beginning of the ramp track for lowering stone blocks is not visible. However, it can be assumed that the transport of extracted stone was conducted through a natural gully at the hill slopes' junction. This natural communication is the most plausible arrangement because this zone consists of small eroded gravel and it requires the least intervention in the bedrock. The assumed track is covered in thick vegetation and it stretches from the center of Gornje Padrare quarry to the sea, terminating at Karanke, a Roman-period harbor. Some smaller interventions are visible, such as refashioning of the natural rock at certain rather inaccessible sections of the track in order to form an unobstructed communication through the lowering ramp.

Karanke Cove is located to the north of the Gornje and Donje Padrare quarry complex. A well preserved harbor installation is found at this site. It was built, beyond any doubt, as an integral part of Roman-period quarries, since the natural channel stretching from the direction of the quarries (used for transportation) terminates at the very Karanke harbor<sup>26</sup>.

The harbor installation includes several stone banks, built from amorphous stone, 30-60 cm in diameter. Two larger stone banks are discernible, nearly joining in the middle section of the construction, making a large, horseshoe-shaped harbor. The outer bank sections are at an average depth of 2.5 m beneath contemporary sea level. A clear break in the bank is visible, resembling an

26 The harbor installation is discussed in detail in PARICA 2012.



Fig. 9.  
Aerial photo: Ovča Cove  
(photo: V. Glavaš)



Fig. 10.  
Ramp for lowering  
stone blocks

opening. This feature is located at the point where the banks are nearly joined. The break in the construction is interpreted as a narrow entrance for ships, providing complete protection<sup>27</sup>. Larger ships for stone transport must have docked at the outer sides of these banks. The track between two parallel banks, in the direction of the profile A-B probably represents the remains of the original communication proceeding from the quarry (Fig. 7). This claim is supported by the fact that the terrain descends regularly and gradually at this section and also by the lack of base rock rising from the surrounding area.

Several fragments of amphorae and tableware were found in the harbor installation area. Amphora fragments with preserved typological characteristics can be designated as Dre.ssel 6b types. This type is dated to the first half of the 1<sup>st</sup> century AD, based on mouth form<sup>28</sup>.

27 MAGAŠ-FILIP I 1983, 76.

28 JURIŠIĆ 2000, 6; STARAC 1997; CIPRIANO 2009.

### Dugi Otok

The central part of Dugi Otok Island features two groups of quarries, which in fact comprise a single large quarrying complex. The northern quarry group is located in the vicinity of Ovča Cove while the southern group is positioned at the Padrare site, about two kilometers to the south.

The Ovča Cove (Fig. 9) is located roughly two kilometers south of Savar village. Four quarries are visible in the immediate vicinity of the cove and several other locations where trial stone block extraction is clearly discernible. Some of the quarries were in use during the late medieval and early modern periods. The largest quarry displays traces of early modern exploitation using wedges and gunpowder. However, a section of the original Roman period quarry is preserved in the central part of the quarry complex. The pits are regular in shape and a trench is visible, excavated using a heavy pick-axe. A layer of Roman period amphora fragments is clearly visible in the profile



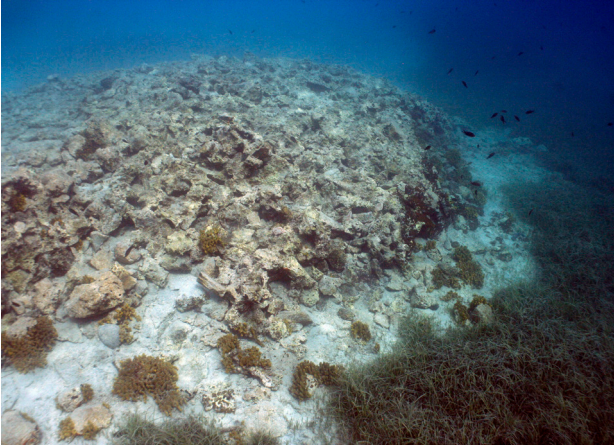


Fig. 11. Submerged stone bank-pier at Ovča Cove

of this particular quarry section. The layer stretches above the base rock and spoil is deposited above it.

A lowering ramp is clearly visible in precisely this, central, part of the quarry, descending in the direction of the cove. (Fig. 10) Spoil heaps are formed on either sides of the track. Even the early modern period spoil did not cover the track, so it was definitely used in this period, as well as the communication towards the sea. The track can be followed in its entire length. The 4-meter-width is visible in the field because on both sides a small bank was formed while the track was being cleared. The bedrock springs around the track so it is reasonable to assume that the bedrock on the track itself was refashioned. However, only archaeological excavations could confirm such a claim.

The ramp for lowering stone blocks, described above, terminates at the bottom of Ovča Cove. A harbor installation or rather a stone pier was built in the immediate vicinity. It is very well preserved because the cove is well protected. The structure is submerged about two meters below contemporary average sea level. (Fig. 11). Visible remains of the structure are 11 m long and 5 m wide. The pier fill consists of pieces of mid-sized amorphous stone. The average size of stones is about 15 – 30 centimeters in diameter. A rather large quantity of various archaeological finds was discovered in the pier fill and around the structure, such as pottery fragments, amphorae, tegulae, dolia and several pieces of ballast stone. Several brick fragments with hydraulic mortar were found at the cove bottom, near the modern artificial shore line. Roman period cisterns were built using such material, so the existence of such a structure in the immediate vicinity seems quite plausible. The harbor construction can be dated to the Roman period, based on portable archaeological finds.

The second group of quarries is located in the Pa-drare area, about two kilometers south of Ovča Cove. The group consists of several quarries, including four larger and several smaller operations. Some of the larger quarries



Fig. 12. Stone pavement at the lowering ramp

display trackway traces passing through the refuse material and descending towards a natural small gully between two hills. Stone pavement is visible on a lowering ramp section (Fig. 12). The structure is visible in the length of about 10 meters. However, eroded soil and stones have covered this communication way so one can assume that excavations would reveal a significantly larger portion of the ramp. All the lowering ramp tracks from the multiple quarries are finally joined in a single track which follows a small natural dale terminating at a small harbor.

A small harbor is visible at this site. It is in fact a small cove cut into the shore line. The southern side is a natural promontory extended with a small stone bank about 3 meters long. Therefore, the natural promontory and the stone bank extension together make up a docking zone capable of receiving a ship. Archaeological finds were discovered in the docking zone area including several amphorae body shards, bricks and a well preserved amphora neck. The latter is hard to determine, due to the poor preservation. The concentration of archaeological finds is significantly smaller than in the Ovča Cove.

In the immediate vicinity of the docking construction described above, where the sea heavily erodes the shore, a profile is documented featuring traces of architecture and large quantities of iron slag. The slag could

be connected to a foundry in which stonemasonry tools would have been repaired.

The three quarrying complexes presented in this paper feature, apart from stone block extraction zones, additional infrastructural facilities. The Molat quarry is an example of an exit corridor carved in the bedrock, often featured in the eastern Adriatic such as Sv. Ilija – Kučićeva kava<sup>29</sup> and Voluja – Vinišće. Mediterranean examples include Gölemezli, Turkey<sup>30</sup>, Angera, Italy<sup>31</sup> and Sant Juliá, Spain<sup>32</sup>.

The featured quarries also include visible remains of a lowering ramp. It is in fact a communication between the quarry and the harbor facilities. Practically all quarries feature some form of ramp, though with varying degrees of preservation and ineligibility. The quarries utilize natural gullies as block lowering ramps i.e. the track descends gradually in a straight line from the quarry to the gully and then all the way to the sea. Refashioning of the bedrock is recorded at certain locations, facilitating unhindered movement of stone blocks. The ramp at Padrare on Dugi Otok is the only site recorded thus far featuring a stone pavement, such as that featured at the Pentelic quarry<sup>33</sup>. It is possible that other quarry tracks on Zadar islands feature pavements but this is hard to sustain without archaeological excavations.

All the sites presented in this paper feature harbor installations. Their importance lies in the fact that they are well preserved. The cause of such a state of affairs is the environment protected by the islands, the rising of the sea level and, finally, the lack of aggressive building interventions. Harbor installations can be well dated because all feature surface finds on the banks, visible without archaeological excavations. On the one hand, harbors were used to ship stone blocks and on the other as a logistical support for quarry facilities. Harbor installations at Molat and Sestrunj display a truly amazing feature: the termination of the communication ramp i.e. the road which ends at the pier itself. The excellent preservation of these features is unique in the entire Mediterranean.

The sites at Zadar islands are interesting for the information they provide on the auxiliary facilities within quarrying complexes such as foundries for stonemasonry tool repair and the remains of a water cistern and other architecture.

The remains presented in this paper demonstrate that the quarrying complexes at Zadar islands were fully

capable of operating autonomously because they probably featured all the necessary facilities to be self-sustainable.

The most intensive stone exploitation operations can be dated to the 1<sup>st</sup> century AD, based on pottery fragment finds at harbor installations. These activities can be related to major public building projects in Romanized coastal towns. However, there is much to be gained by systematic archaeological excavations in these areas. The features and facilities are well preserved, which makes this area uniquely important and holding a promise of major insights on the overall functioning of Roman period quarrying complexes.

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