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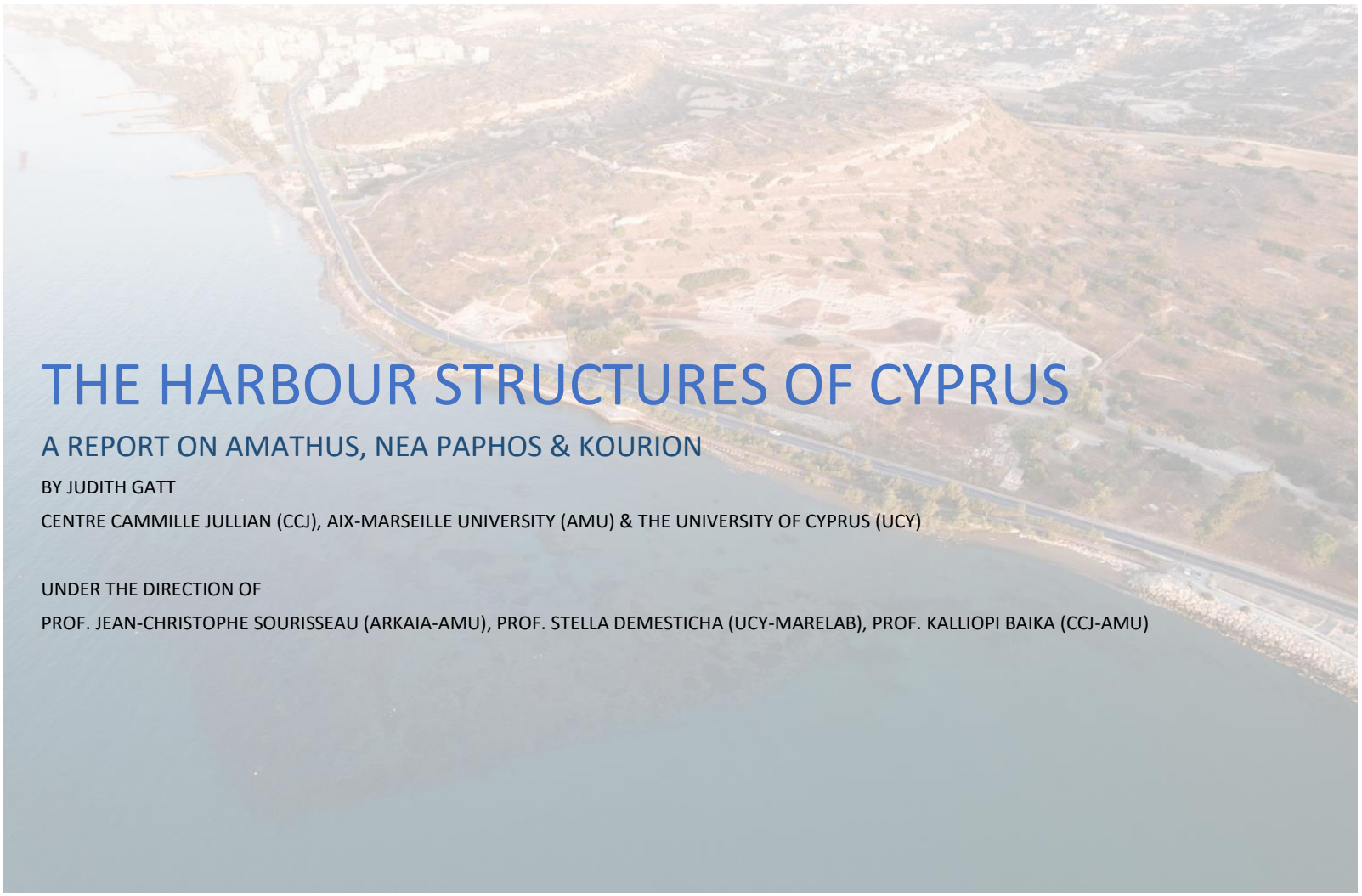

THE HARBOUR STRUCTURES OF CYPRUS

A REPORT ON AMATHUS, NEA PAPHOS & KOURION

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HONOR FROST FOUNDATION

NEANIAS

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INTRODUCTION

With the permission of the Department of Antiquity of Cyprus (Αρ. Φακ. 14.01.01.23/17), a survey was conducted for four weeks in the period between August and September 2022 on three harbour sites of the south coast of the island, in the framework of the Ph.D. thesis of the author. The PhD thesis aims in continuing the documentation and study of Classical-Hellenistic harbour construction techniques identified in the best-preserved harbour sites of Cyprus and conducting a comparative study of these techniques with those of the Eastern Mediterranean and the Aegean. This study contributes primarily to our knowledge on Classical and Hellenistic harbour engineering, and to a further extent it will provide answers on the dating and function of the harbour basins and the location of the paleoshorline for the harbour sites under study.

The survey was conducted at the ancient harbours of Amathus, Nea Paphos and Kourion (**Fig.1**). The objectives were to collect photographic material on the preserved harbour structures and record observations on their construction technique. More specifically, for Amathus harbour structures architectural, photographic, and topographic data was collected. At Nea Paphos harbour photos were taken, and preliminary observations were recorded, in collaboration with the Ports Authorities of Cyprus. Finally, Kourion's harbour site was visited three times, but due to the bad weather conditions, the survey was not successful, and thus no data was collected.

Fig. 1: Harbour sites visited in the framework of the survey (Gatt 2021, after www.bing.maps.com).

Members from both universities (Aix-Marseille University & University of Cyprus) participated as volunteers in the survey which was supported by the NEANIAS project. Data collected during the survey will be tested on the NEANIAS Underwater Services, especially service UW-MOS: *Seafloor Mosaicing from Optical Data service.* Aerial photos of Amathus were kindly provided by the photographer Constantinos Christou.

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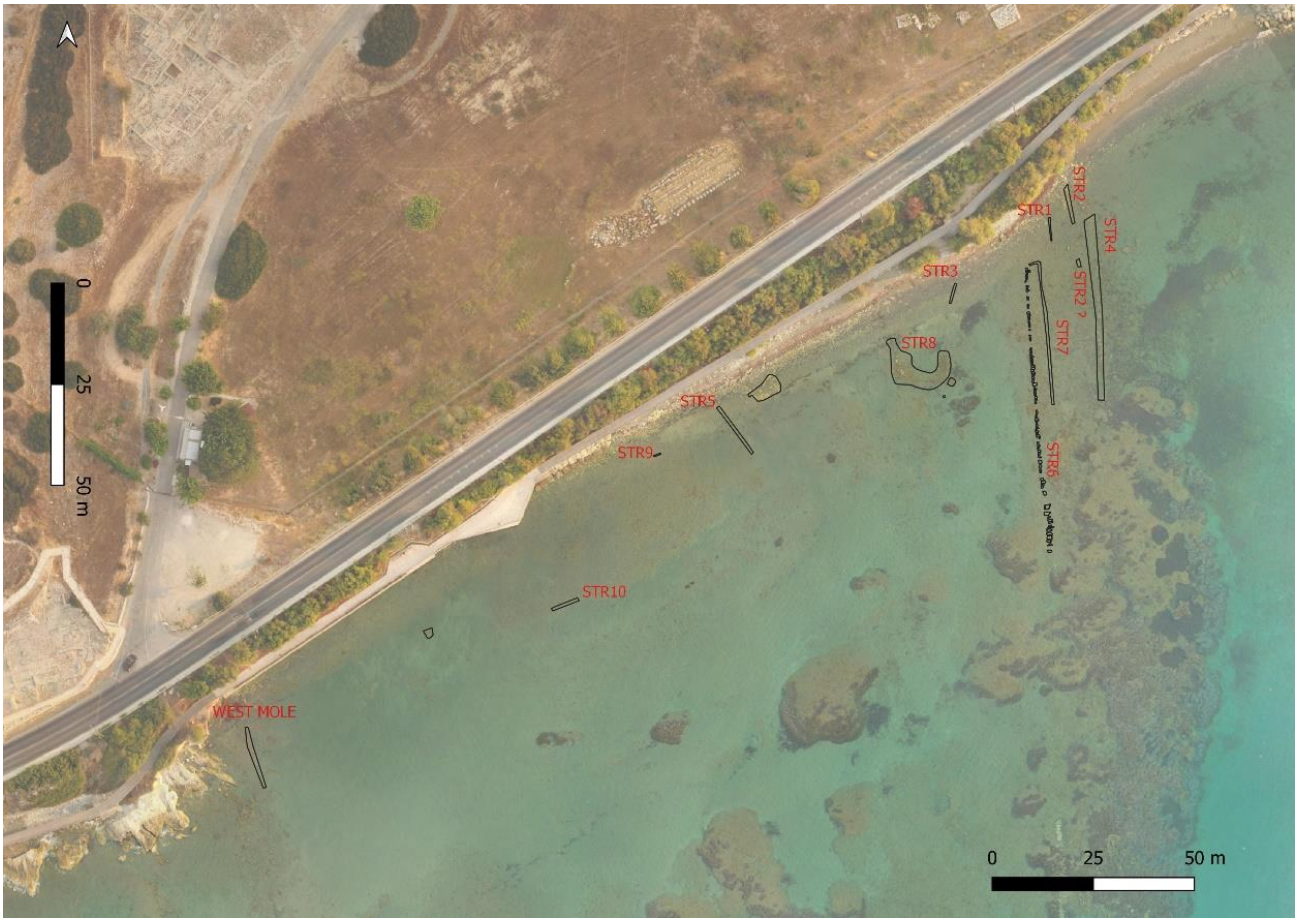
1. AMATHUS HARBOUR SURVEY

INTRODUCTION

Amathus is the best-preserved harbour site located on the south coast of the island. Its recent publication (Empereur et al. 2017) and documentation in the framework of the ANDIKAT project rendered this site the optimum case study for the research on the harbour construction techniques of Cyprus.

The survey, aiming to continue the systematic archaeological documentation of the harbour structure remains, lasted four weeks, from the 17th of August to the 15th of September, and mainly focused on the northern part of the harbour basin. The survey was conducted only via snorkeling. The first two weeks focused on the observation and architectural documentation of the submerged remains (**Fig.2**). The third week was dedicated to the photographic documentation and the fourth week on the mapping of the remains with total station.



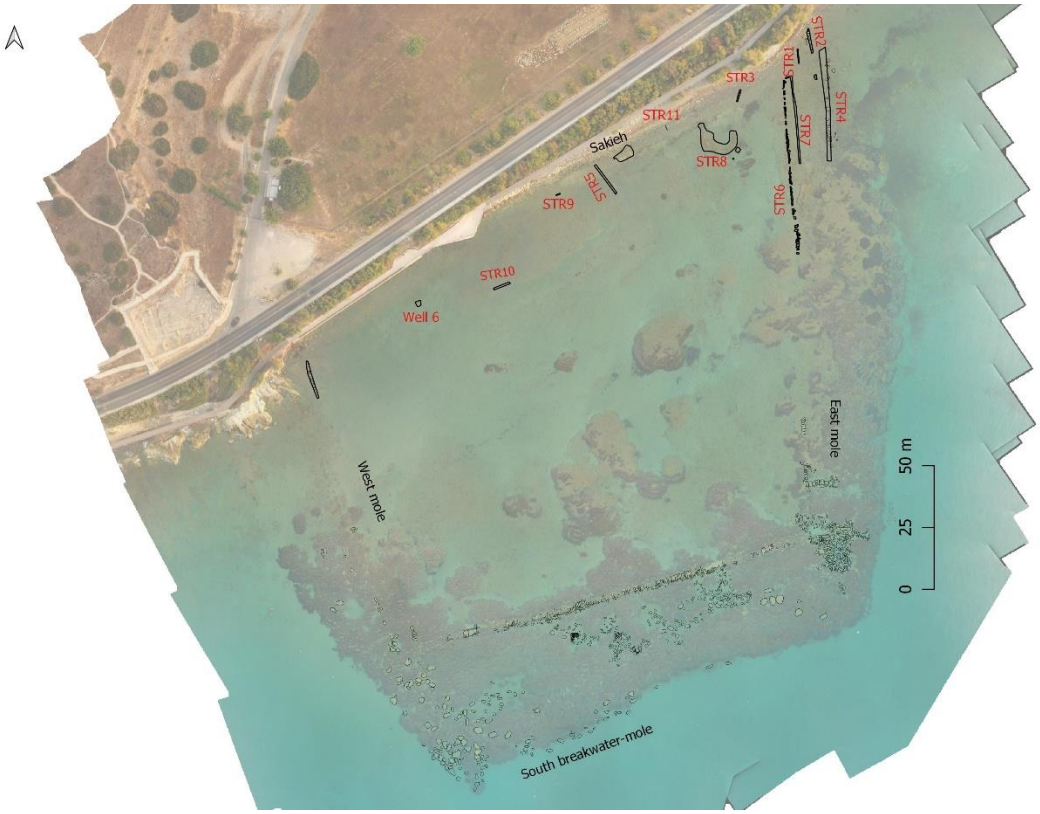


Fig.2: Location of the submerged remains (in red) documented at Amathus (J.Gatt 2022, *after* Orthophoto of Amathus generated after refraction correction using Agrafiotis et al., 2020 method. Image courtesy: 2019, Cyprus University of Technology, PVL; University of Cyprus, ARU © ANDIKAT project).

METHODOLOGY

As stated in the permit application, the **main objective of the research is the systematic documentation of the harbour infrastructure**. This documentation contributes to:

1) a precise mapping of the harbour site of Amathus

2) enhancing our understanding of the harbour construction techniques of Amathus harbour in its totality (north and south section), as the study conducted in the 80's mainly focused on the southern area of the harbour basin.

3) advance the research on the determination of the paleo-shoreline diachronically, based on geoarchaeological indicators. The location of the paleo-shoreline is a key element for the study of harbour structures as it indicates the limits of the harbour basin and the functionality of the harbour structures.

Therefore, the 2022 survey focused mainly on the **documention of the northern extremities of the East and West moles to define their limits.** Several archaeological structures remain undocumented in the northern area of the harbour basin (today visible on the aerial orthophoto of Amathus). In the survey of the 1980's, only three submerged wells were documented in the

northern part of the harbour basin (Empereur et al. 2017 133-149). Moreover, several interpretations on the northern extremities of the east and west mole have been presented (**Fig.3-4**) with no sufficient documentation. Therefore, documenting all submerged remains located in the northern area of the harbour basin on a preliminary level, was the priority of this survey. This was achieved by documenting the structures/features/natural formations (quarries, wells, beach rock etc.) via architectural drawing and photography and mapping of the remains with total station.

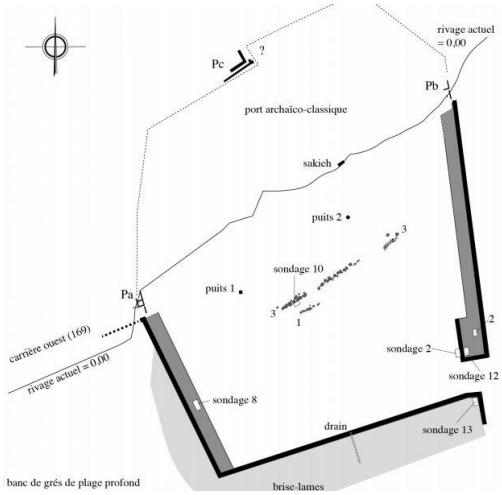


Fig. 3: Plan of Amathus's harbour (Aupert 2020: fig.3).

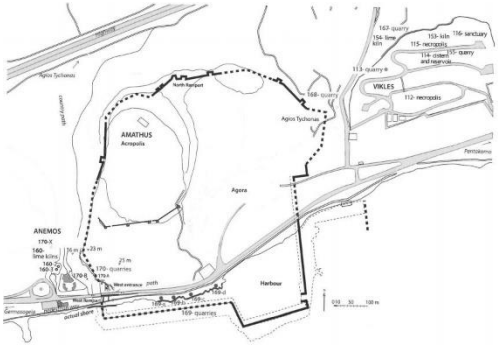


Fig. 4: General plan of Amathus (Empereur et al. 2017: 96, Fig. 1).

PRELIMINARY RESULTS

The documentation of the submerged remains (West mole and Structures STR1 - STR10)[1]

[1] STR is abbreviation for structure.

Fig. 5: Mapping of the submerged remains during the survey 2022 (J.Gatt 2022, after Orthophoto of Amathus generated after refraction correction using Agrafiotis et al., 2020 method. Image courtesy:2019, Cyprus University of Technology, PVL; University of Cyprus, ARU © ANDIKAT project).

West mole

The structure has an N-SE orientation (Fig.2). The total visible and documented length is 15.6m (Fig. 6). It consists of a single row of headers (whose maximum width is 1.20m) and two courses are visible today. The foundation level is not visible, as the area is silted. Ashlar blocks with lifting bosses[2] are preserved. They have similar dimensions to those of the ashlar blocks located along the south breakwater-mole and the southern extremities of the east and west mole (Empereur et al. 2017: 67-78). No evidence of fastening or other type of joining material between the blocks has been observed so far. The single row of ashlar blocks continues further to the south towards the direction of Sondage 8 which confirms a construction with core and facings[3]. However, it remains unclear whether a breakwater was built on the west side of the west mole. The northern extremity of the west mole was given directly the name "west mole" because from an architectural and construction point of view it corresponds to the harbour structures located in the south area of the basin.

[2] Protrusions that are left on the sides of the blocks during the working of the stone and aid in the transportation of large-scale blocks. Although usually they are removed after the block is placed in its final position sometimes, they are not removed due to economy or even for decorative purposes (Φιλοκύπρου 1998: 93-95; Ορλάνδος 1958: 163-165).

[3] This term describes a construction built of two parallel walls which in between are filled with a filling (Ginouvès 1992: 31).

Fig. 6: (Right) Aerial view of the north extremity of the west mole documented in 2022 (@Christou 2022). (Left) View of the north extremity of the west mole from the north (@ J. Gatt 2022).

Structure 1

The structure has a N-SW orientation (**Fig.2**, **Fig.7**). The total visible length of the structure is 6.16m. One course is visible, and the structure seems to be composed of two rows of small-medium-sized ashlar blocks mainly worked on the visible west lateral side of the structure. The maximum width of the structure is 0.62m and its maximum visible height is 0.16m. No foundation level is visible. There is no evidence of fastenings.

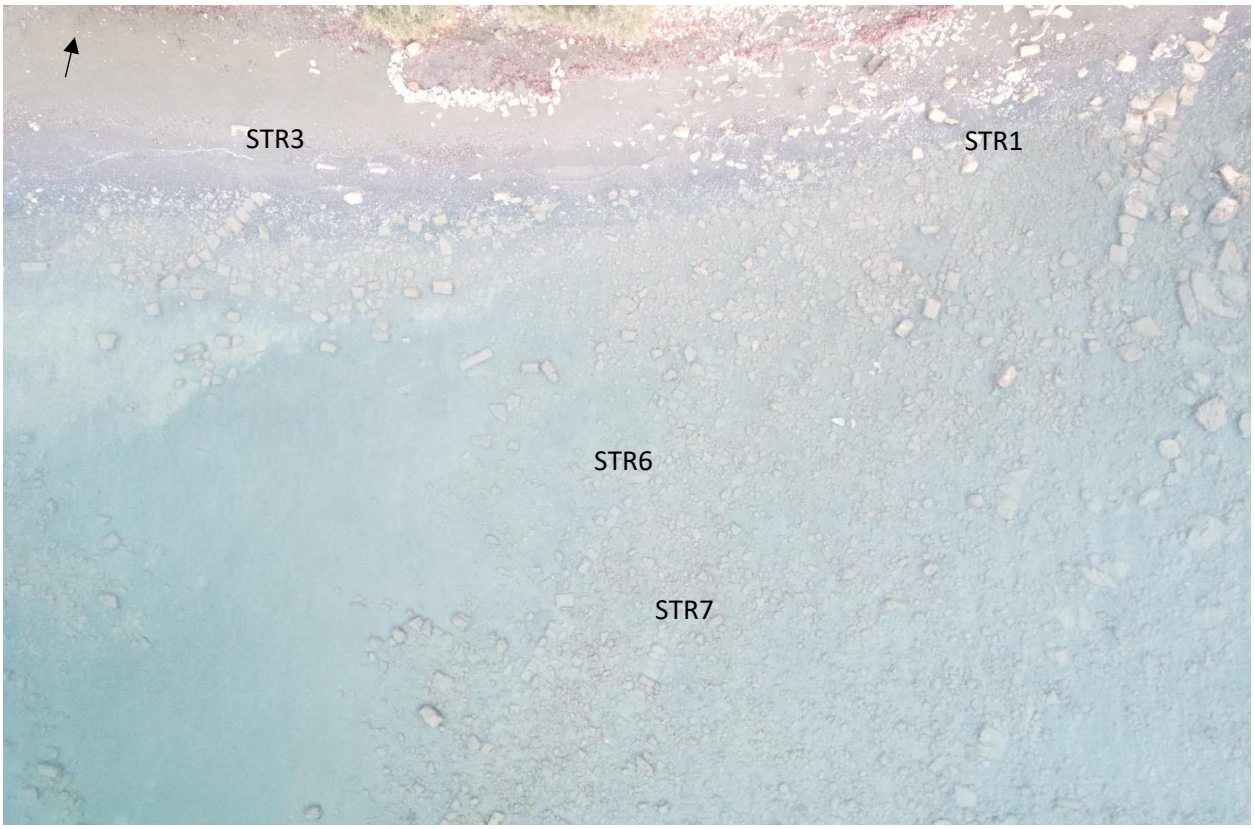


Fig. 7: Aerial view of STR1 in relation to other structures (@Christou 2022).

Structure 2

The structure has an N-SW direction (**Fig.2**). It is parallel to STR1 (to the west) and STR4 (to the east). The total visible length is 10.44m long (based on the architectural drawings) (**Fig.8**). Due to the frequent movement of sediment, its visible length can interchange between 10-12.5m. One course is visible with a maximum height of 26cm and the maximum width of the single row of blocks (mainly headers and some stretchers) is 1.10 m. Some blocks are concreted together while others are highly eroded. There are no traces of fastenings. No foundation is visible. To the west side of the structure, there is a concentration of blocks of similar size which however do not seem to be *in situ*. Also, approximately 9m south of the structure, there are three ashlar blocks of similar dimensions and with the same orientation and alignment of STR2. These blocks seem to be a continuation of STR2 although no aligned blocks are visible *in situ* along these 9m . Due to the limited time, these blocks were not documented.

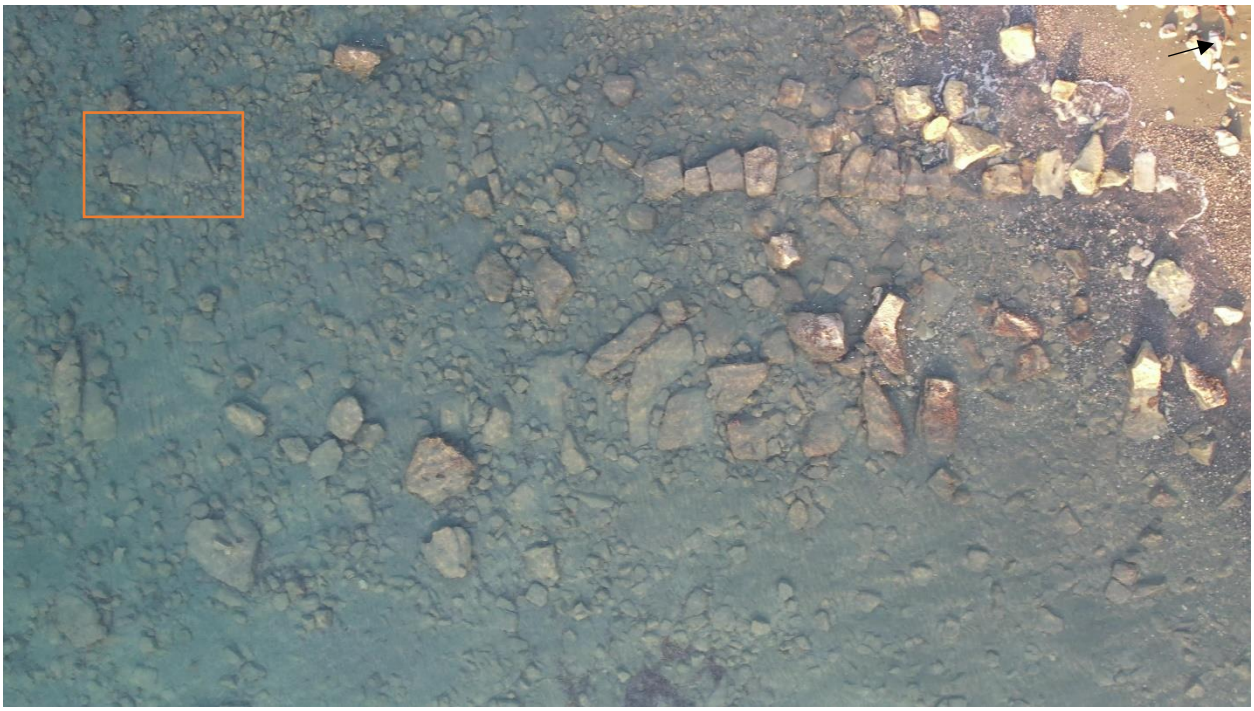


Fig.8: Aerial view of STR2. In orange the probable continuation of STR2 to the south (@ Christou 2022).

Structure 3

The structure has a NE-SW direction (**Fig.2**). Its orientation does not seem to be aligned with any of the other documented remains for the time being. Its total visible length is 5.24m long (**Fig.9**). It consists of one row of medium-sized blocks which are mainly worked on their western lateral side. Only one course is visible. The maximum visible height is 0.36m and the maximum width of the row of blocks is 0.62m. No foundation level is visible. There are no traces of fastenings.

Fig. 9: Left: Aerial view of STR3 (@Christou 2022). Right: View of STR3 from the south (@ Voutyrea 2022)

Structure 4

The structure has an N-SW direction (**Fig.2**). It is parallel to STR2. In total this structure is 42.50m long. Its maximum width is 2m and its maximum visible height is 39cm. One row of blocks with only one visible course is preserved. The northern extremity of this structure is not clear, because of a concentration of blocks and boulders[4]. The structure consists of a series of large blocks which vary in shape and size (**Fig.10**). Several ashlar blocks preserve lifting bosses, and others seem to preserve traces of lifting thongs (although for this to be confirmed the blocks must be cleaned). No foundation level is visible. There are no traces of fastenings. Most of the blocks are placed as headers while some are placed as stretchers and present a W-E inclination. Although this structure is visible in the plan published in 2017 (Empereur et al 2017: 16-Fig. 1), its function and role remain to be determined as well as its connection with the rest of the documented remains.

Fig.10: Blocks from STR4 (Gatt 2022).

Structure 5

It has a NW-SE orientation, and it is 14.45 m long but only 3.62m were documented with architectural drawing (**Fig.2**). The structure consists of a double row of medium sized blocks and one visible course with a filling in between (construction with core and facings) (**Fig. 11**). Its width is approximately 1.10m. The blocks are mainly worked on the western lateral face, and several seem to be dislocated. The two rows are not preserved in continuity. No foundation level is visible.

[4] An unworked stone of large size whose dimension of the largest surface is over 25cm (Ginouvès & Martin 1985: 47).

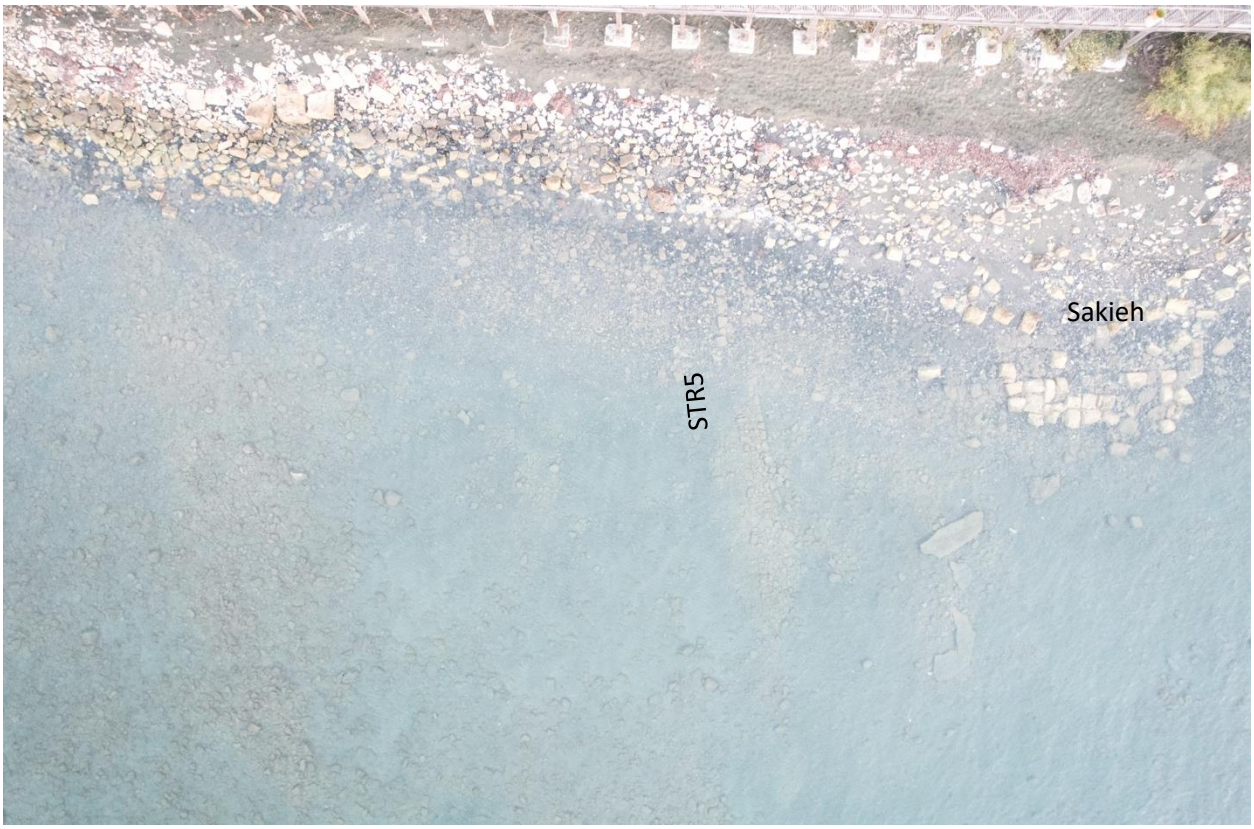


Fig. 11: Location of STR5 near the sakieh (@Christou 2022).

Structure 6

This structure has mainly an N-S direction, although along its extension there are very slight changes in the orientation (**Fig.2**). Its total visible length is 70.75m. This structure is parallel to STR7 (**Fig.12**) and connected to it on its northern extremity. It consists of a single row of blocks and has up to three visible courses of maximum height 0.30m (**Fig.14**). Stretchers and headers are visible along the structure with no visible pattern. The foundation is not visible. No traces of fastenings were observed.

The extremities of STR6 seem different:

a) the first 11m from the north extremity consist of small to medium-sized ashlar blocks (maximum width 0.50-0.80m), mainly worked on the western lateral face.
b) the first 56m from the south extremity consists of ashlar blocks with lifting bosses and are of larger dimensions, like those identified in the known harbour structures of the south area of the harbour basin. In this area, the maximum width of this single row of blocks is 1.50m.

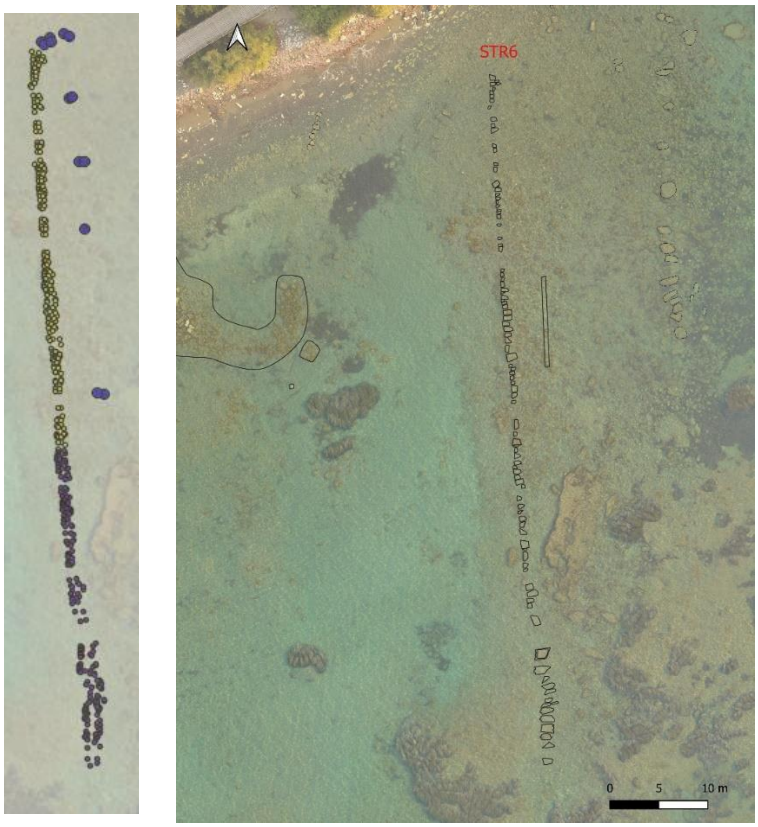


Fig.12: Total station points for the documentation of STR6-STR7 and plan of STR6 (@J. Gatt 2022).

It is probable that reused material was used in the construction of the northern extremity of STR6, as the presence of a block with a potential trace of a cramp indicates (Fig.13). The southern extremity of STR6 is not clear as Posidonia meadows and sand cover the possible continuation of this structure. Finally, to the east of STR6, a concentration of cobble[5] and gravel that seem to be the filling placed in between STR6 and STR7 was identified. Although this structure is visible in the plan published in 2017 (Empereur et al 2017: 16-Fig. 1), its function and role remain to be determined as well as its connection with the rest of the documented remains.

[5] An unworked stone whose largest surface size range from 8-25cm (Ginouvès & Martin 1985: 47)

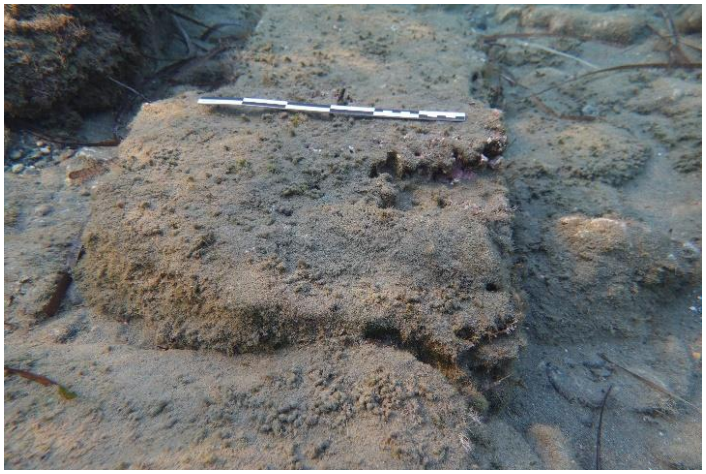


Fig.13: Traces of a cramp on the west side of a block of STR6P (© J.Gatt 2022).

Fig.14: Three visible courses of blocks at STR6 (©J.Gatt 2022).

Structure 7

This structure has an N-S direction and as mentioned above it is related to the north with STR6 and runs parallel to it (Fig.2). It is 26.50m long (visible length). It consists of one single row of medium-sized blocks (same as the northern extremity of STR6) and once more their west lateral face is worked. It preserves up to one visible course with a maximum visible height of 33cm and a maximum width of 60cm. There are no traces of fastenings nor any evidence of foundation. At the south extremity of STR7 a natural formation, called for the time being conventionally as beachrock[6], was found (Fig.15). This natural formation seems either to cover STR7 or may also correspond to its continuation. Although this structure is visible in the plan published in 2017 (Empereur et al 2017: 16-Fig. 1), its function and role remain to be determined as well as its connection with the rest of the documented remains.

[6] The survey in the 80's documented this natural formation as a beachrock (see Empereur et al. 2017: 125-131)

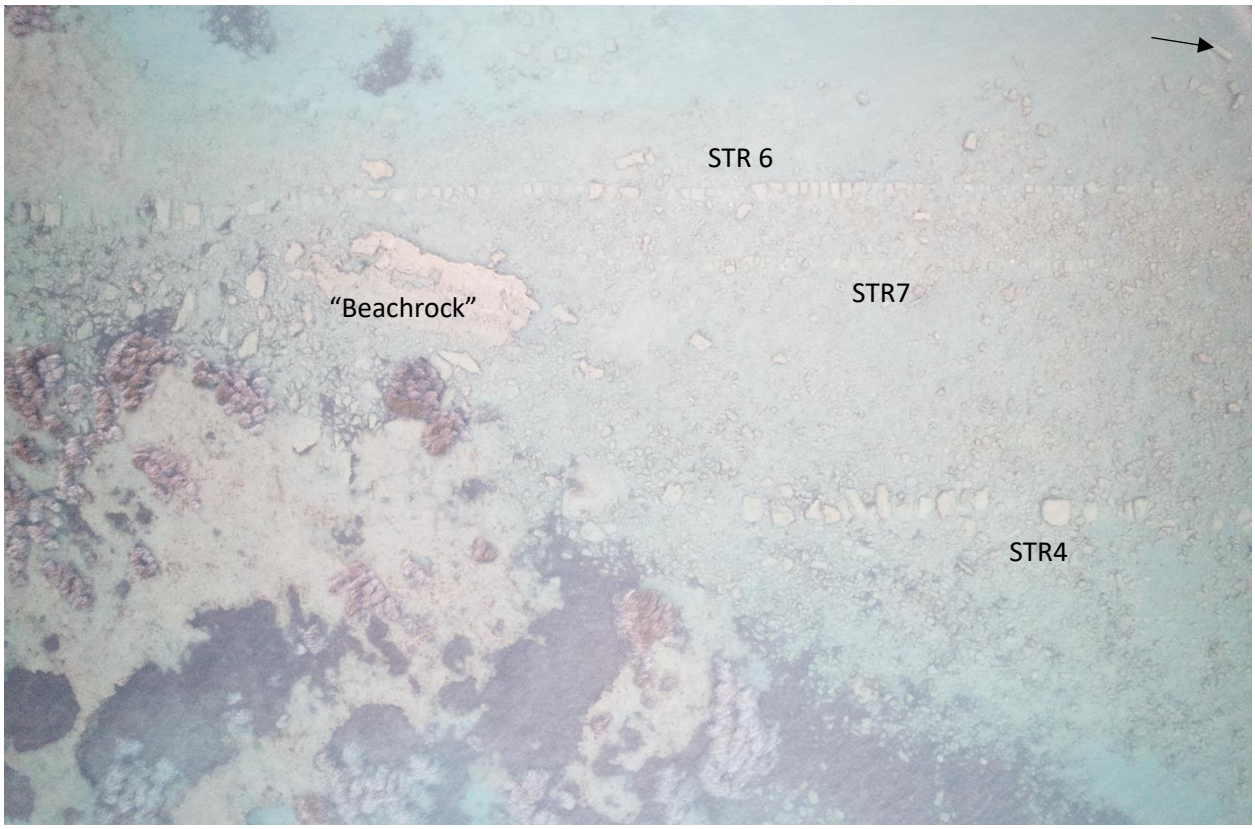


Fig.15: Location of 'beachrock' in relation to STR7 (@Christou 2022).

Structure 8

STR8 is a Π shaped structure with a NW orientation (**Fig.2** ; **Fig.16**). Worked and unworked blocks of stones form three "walls" connected in a trapezoidal shape. There are no traces of fastenings. Modern tyers and concrete blocks are found in the inner side of the structure.

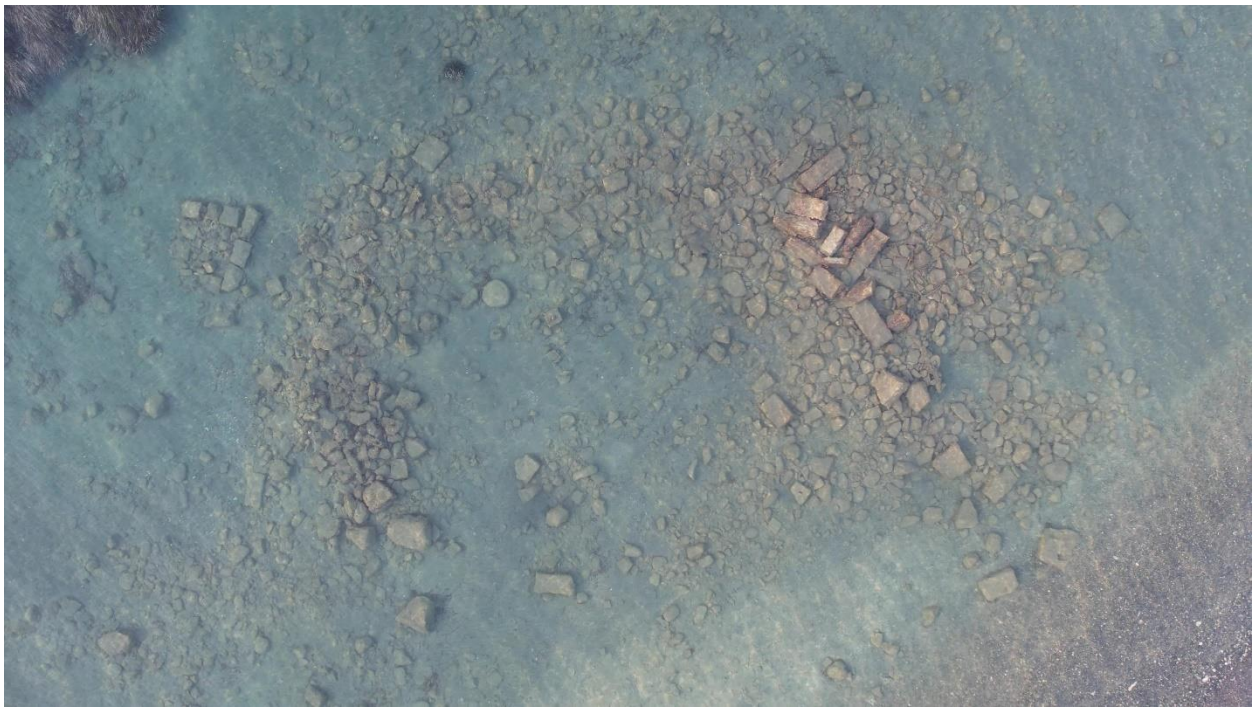


Fig.16: Plan and aerial view of STR8 from the north (@ Christou 2022).

Structure 9

This structure has a W-E direction, and its visible length is 2.28m (**Fig.2** ; **Fig.17**). It consists of a single row of medium sized blocks (mainly headers) with a maximum width of 0.52m; most of them are not entirely worked stones, while others are eroded. There are no traces of fastenings nor any evidence of a foundation.

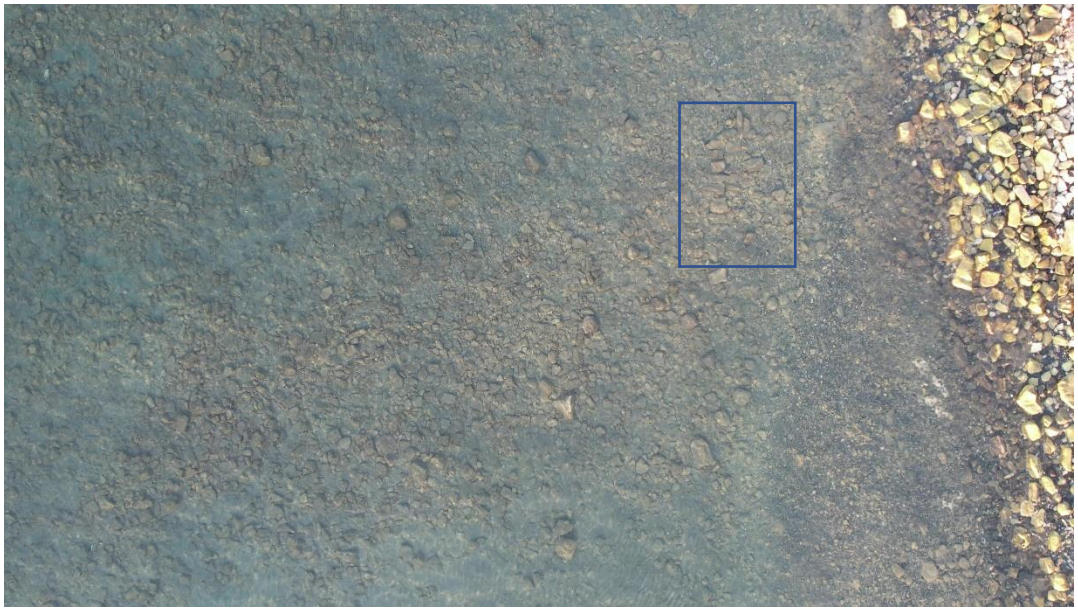


Fig. 17: Aerial view of STR9 (@Christou 2022)

Structure 10

This structure has a W-E direction, and its documented length is 6.85m (**Fig.2**). The structure extends further to the east and west but due to the limited survey time, only the best-preserved area was documented. It is around 22m from today's coastline. It consists of a double row of small sized blocks. The second row is not preserved in all areas. Only one course is visible. Its maximum width is 0.40m and its maximum visible height is 0.19m. There are no traces of fastenings nor any evidence of foundation. A column seems to be laying on the seabed with a N-S direction, vertically to the structure. Its dimensions are 0.85x0.26m.

Wells

Three new wells were located during the 2022 survey (Well 4-6). The numbering was given based on the three previously documented wells (Well 1-3) found in the harbour basin of Amathus in the 80's. Two are located to the east of STR8 and one to the east of the north extremity of West mole (**Fig.18**). The smallest one named conventionally Well 4 is 1m x0.77cm, Well 5 is 1.60mx1.69m, and Well 6 is 1.12m x 1.22m. They are all built with medium sized blocks worked on their exterior face. It is not clear if the preserved height is the actual height of these structures.

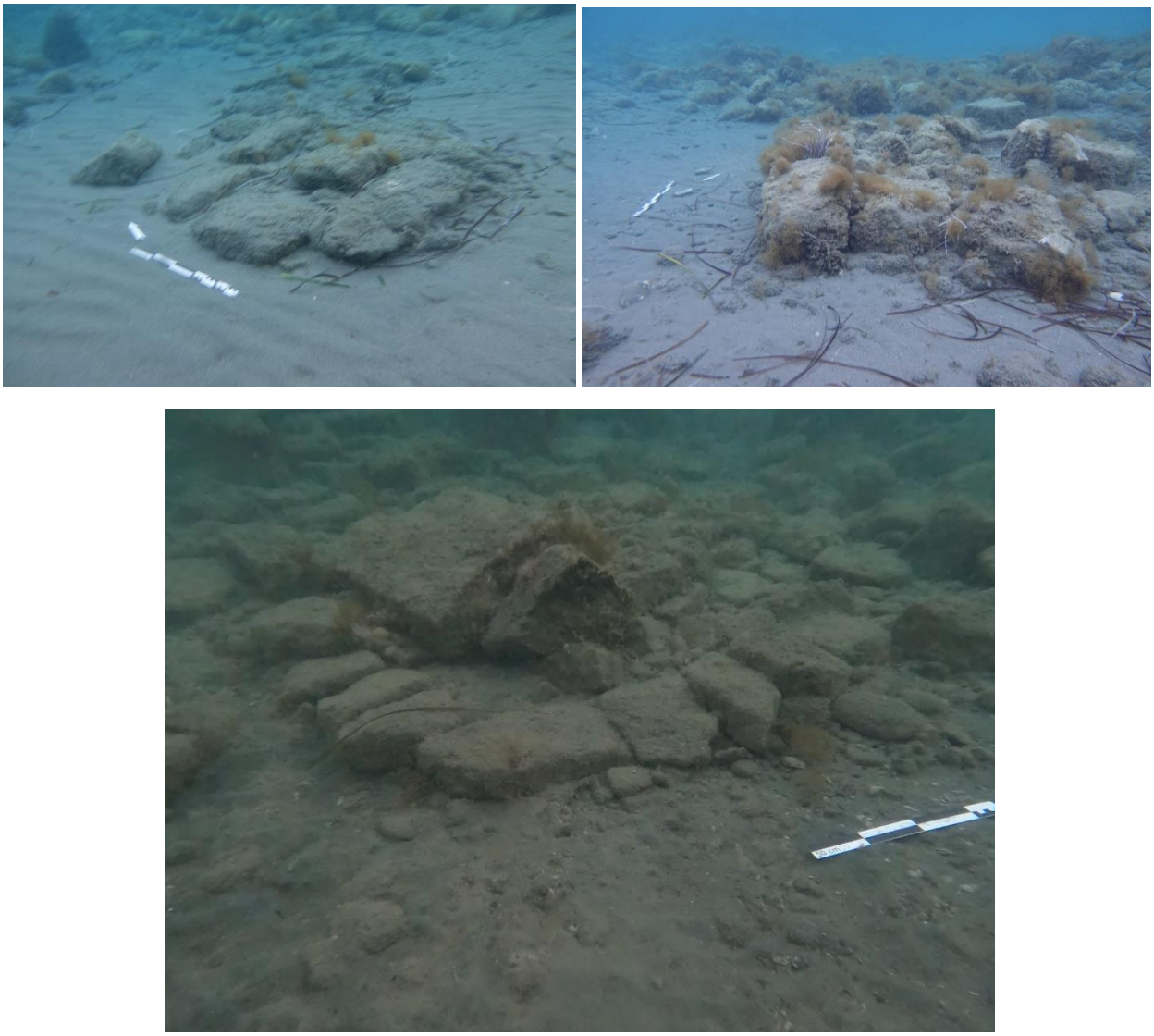


Fig.18: Up: Location of wells in relation to other documented structures (J.Gatt 2022, after Orthophoto of Amathus generated after refraction correction using Agrafiotis et al., 2020 method. Image courtesy:2019, Cyprus University of Technology, PVL; University of Cyprus, ARU © ANDIKAT project). Middle: Well 4 to the left and Well 5 to the right (@Gatt 2022) Down: Well 6 (@Papadakis 2022).

FUTURE PERSPECTIVES

During this short survey, the potential for future research on the site was highlighted and even more the need to continue the documentation for the purposes of the authors' Ph.D.'s research. More specifically, it is necessary to:

1. Continue the mapping of the submerged remains in the NE area, such as STR1-5,7-10 and along the south breakwater-mole.
2. Pursue a petrographic and geochemical analysis of the building material of the harbour structures of Amathus to identify its provenance. Although Empereur et al. (2017: 95-109)

had proposed as a source the quarries in the area, during the fieldwork it was possible to distinguish at least two types of stones based on the different erosion and vegetation attested. By conducting such a study, it would be possible to discuss the type and provenance of building material, as well as the logistics behind the construction of Amathus harbour.

2. NEA PAPHOS HARBOUR SURVEY

INTRODUCTION

Nea Paphos harbour dates to the early Hellenistic period. It has attracted the interest of many researchers (Dasweski 1981; Hohlfelder & Leonard 1994; Raban 1995; Hohlfelder 1996; Theodoulou 2006), however, due to the poor preservation of the harbour structures and the activity that is attested in the harbour basin till today, there is no clear understanding of the construction techniques of the harbour structures. Thanks to the collaboration with the local Port Authorities, it was possible to conduct a two-hour snorkeling expedition at the west area of the basin and photograph all visible remains, followed by a snorkeling along the remains located in the bathing area (**Fig.19**). The survey took place on the 30th of August.

Fig 19: Area in red is a non-bathing area. It was snorkeled with the permission of the Ports Authorities. In this area the spur, west breakwater and western extremity of east breakwater were surveyed. The green area, is the bathing area, were the east breakwater and parallel breakwater were surveyed (after Miszk & Wladyka 2016: 10, fig.3).

METHODOLOGY

As stated in the permit application, the **main objective of the research is the systematic documentation of the harbour infrastructure**.

This documentation would contribute to:

1) an assessment on the state of preservation of the harbour structures
2) reassess all previous documentation to provide a clearer description of the harbour construction techniques.

Due to the limited access on the site, as it is still a functioning harbour basin, the purposes of the survey had to be limited to one main objective: **Conduct preliminary observations of the harbour structures and their construction techniques**. It was considered essential to gain an opinion on the construction techniques and verify previous observations and interpretations. This was achieved by locating previously documented structures, photographing the structures, to make preliminary observations. No measurements and detailed plans of this area were conducted due to a lack of time.

PRELIMINARY RESULTS OF FIELDWORK

Spur

At the curve of the west breakwater, a concentration of blocks 70-50 meters long was identified. The spur consists of blocks of 1.80-2.70X1.60-2.70X0.85-1.15m and 0.32-0.45X0.20-0.22X0.16-0.21m. It is now 3m below current sea level (Daszewski 1981: 3-4; Leonard & Hohlfelder 1993: 376-378). During the survey, it was difficult to discern which were the blocks that belonged to the spur and which belonged to the recent reinforcement of the west mole, given the diversity of the seabed morphology (**Fig.20**). Starting from the corner of today's west mole large boulders are concentrated. Further to the east the seabed is covered by cobble and sand. Then a compact concentration of cobble is visible, followed by boulders that probably belong to the modern west mole.

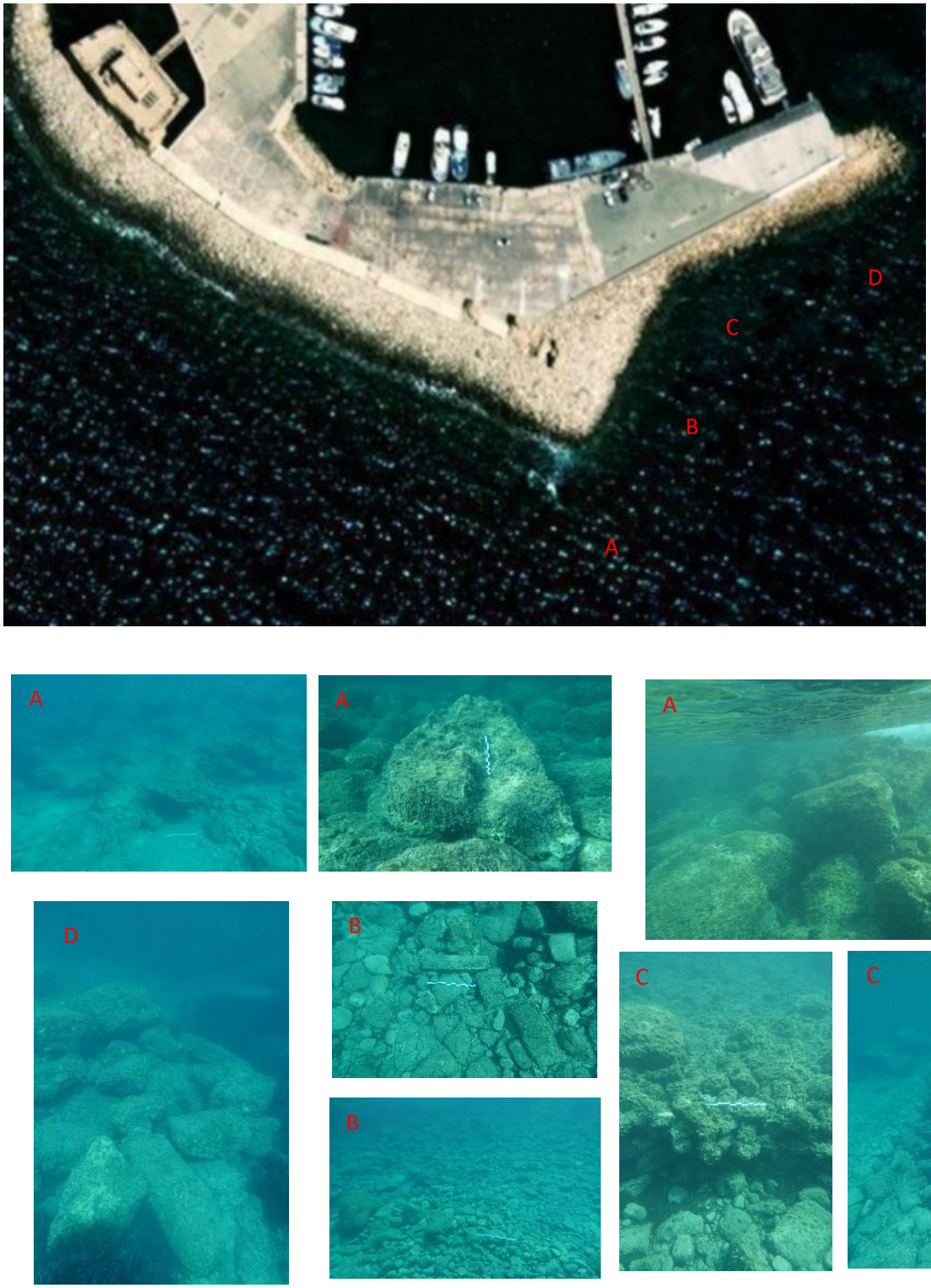


Fig.20: Location of different type of materials along the seaward side of the west mole (@J.Gatt 2022). You need to explain here what each letter/picture shows

East breakwater

The west extremity of the east breakwater, right on the entrance channel of the modern harbour, has been severely damaged by the dredging of the harbour basin. Although this area was documented by Hohlfelder (1995), surveying revealed interesting aspects regarding the construction of this structure. The structure's upper part has been destroyed, thus, what remains is the foundation of the breakwater almost to the level of the current seabed. Cobble is the main material found in this area with only some ashlar blocks and other architectural members (such as columns) located in the north and south extremities of the breakwater (**Fig.21;22**). Moving though further towards the east, the boulders reappear above the layer of cobble (**Fig. 23**). Some boulders have particular shapes (**Fig.25**) that differentiate from the rest, probably indicating material added in a later phase. Also, a rocky formation (**Fig.24**) located to the south of the east breakwater was identified. Its connection with the structure remains unclear.

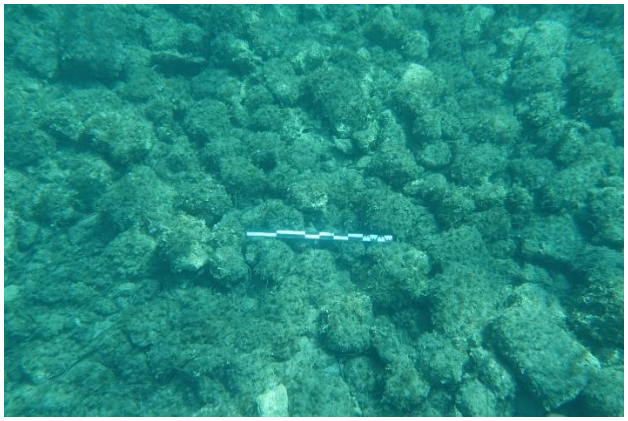


Fig.21: The cobble of the west extremity of the east breakwater (@J. Gatt 2022).

Fig.22: Architectural remains along the north and south extremity of the east breakwater (@J.Gatt 2022).

Fig.24: Rocky formation to the south of the east mole (@J.Gatt 2022).

Fig.23: Area of the East breakwater where the boulders appear above the layer of cobble (@J.Gatt 2022).

Fig.25: Blocks and boulders along the east breakwater (@J.Gatt 2022).

The eastern extremity of the east breakwater could be surveyed via snorkeling or walking above the remains. In this area four distinct parts of the structure can be seen. The cobble at the bottom of the structure as seen in the western extremity of the structure (**Fig.21**), the large boulders above the cobble (**Fig.23**) that surpass the current sea-level, ashlar blocks (**Fig. 27**) and remains of cemented rubble[7] (**Fig.26**). Upon what type of foundation, the cemented rubble is built on remains unknown. (**Fig.27**).

Fig.26: Traces of cemented rubble on the upper structure of the east breakwater (@J. Gatt).

[7] A term used by the ROMACONS project (Historical and Engineering Analysis of Hydraulic Concrete in Roman Maritime Structures) to describe hydraulic mortar mixed with debris.

Fig.27: The layer of cemented rubble upon which ashlar blocks are placed (@J. Gatt).

East parallel breakwater

To the south of the east breakwater there is the 'parallel' breakwater as described by Hohlfelder. It consists of boulders placed in a perfect line on top of a rocky sea bottom (Fig.28).

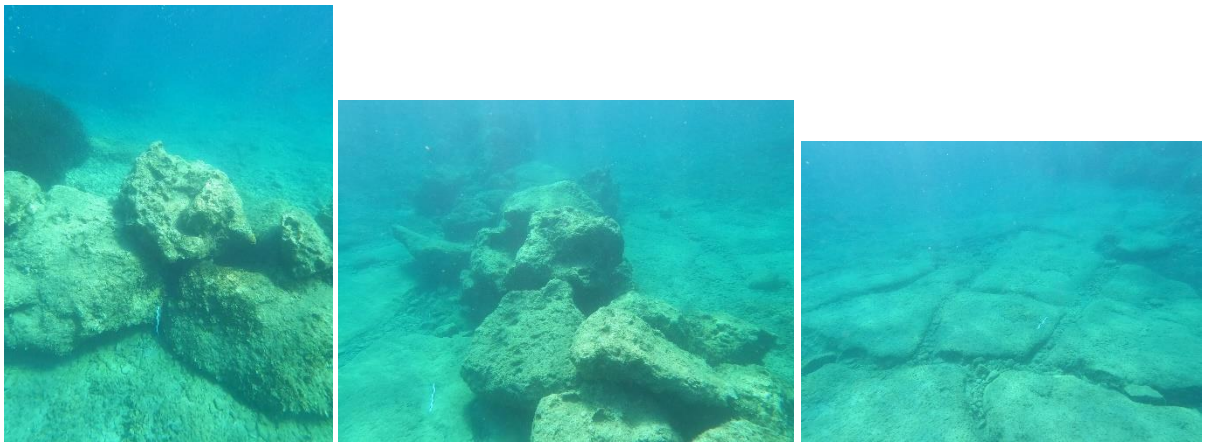


Fig.28: Photos of the parallel breakwater south of the east breakwater on the natural bedrock (?) (@J. Gatt) are you sure that the third photo is part of the parallel breakwater?

Terrestrial remains-West mole

To the north of the Castle there are remains of the possible west mole, built of ashlar blocks and mortar (Fig.29). It is preserved ca. 15 m in length and its height is approximately 2m. Its width is not clear as it is partially covered by cemented rubble and the boulders of the modern west breakwater. The cemented rubble was used to join the ashlar blocks and it seems also to have been used in the upper and lower part of the structure. Interestingly this mole seems to continue

towards the direction of the castle. At the lowest courses of the west façade of the castle there are remains of ashlar blocks as well as cemented rubble like that of the west mole (Fig.30).

Fig.29: View of the west mole from the east (above) and from the north (below) (@J.Gatt 2022).

Fig.30: Possible remains connected to the west mole at the lowest courses of the west façade of the castle (@J.Gatt 2022).

FUTURE PERSPECTIVES

Despite the poor preservation of the Nea Paphos harbour structures, it remains possible to extract information on their construction techniques.. The following work is required to complete the needs of the authors Ph.D. thesis:

1. Conduct a survey to map the east breakwater, the west mole as well as the potential remains of the spur, with total station to acquire a clear understanding of their preserved dimensions, depth and location.
2. Sampling of the cemented rubble from the west mole, east mole, and Venetian walls remains will propose a more accurate dating of the phases of construction of these structures.

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