Alkiviadis Ginalis · Ayşe Ercan Kydonakis

Some Reflections on the Archaeology of the Late Antique and Byzantine Harbours of Constantinople

This chapter aims to complement the other contributions of this volume[1] with particular remarks on the physical remains of the harbours of Constantinople. Due to the impossibility of covering the entire spectrum of archaeology within a chapter, the following archaeological commentary will focus primarily on the architecture of harbour facilities *per se*, which consist of features such as quay structures, breakwaters with mole or wall superstructures, as well as jetties and pier remains. In striking contrast to the relative abundance of historical accounts, the visual and archaeological knowledge of harbour structures along the coasts of the Golden Horn and the Sea of Marmara was for a long time limited to sparse visual evidence, such as photographic illustrations, maps, plans and historical depictions, together with short references and rather vague field notes[2]. In fact, it was not until 2004 that a comprehensive insight into the harbours of Byzantine Constantinople, notably the harbour of Theodosius at Yenikapı, Chrysopolis at Üsküdar and Neorion/Prosphorion at Sirkeci was possible for the very first time due to the large-scale rescue excavations conducted prior to the so-called Marmaray-Metro Construction Project[3]. Following the geographical order of the Volume, the paper is structured on the basis of the archaeological data. Hence, starting with the site of Yenikapı.

The Theodosian Harbour at Yenikapı

With an exceptionally large excavation area of 58 000 m² (**fig. 1**), the archaeological site at Yenikapı revealed, not only a total number of 37 shipwrecks of the Early to Late Byzantine periods[4], but also a multitude of architectural remains. The latter are situated both at the eastern and the very western end of the harbour excavation area. Amongst the various harbour structures brought to light, the most striking features form two massive jetties located in the eastern harbour basin (**fig. 2**)[5]. Both jetties are oriented in a north-south direction corresponding to a perpendicular position to the northern shoreline of the late antique harbour basin (**fig. 3**). In contrast to the very poor state of preservation of the western jetty, the eastern one is in surprisingly good condition and completely preserved over a length of 35 m and a total width of 4 m (**fig. 4**)[6].

The structure consists of two different parts: a solid and homogeneous foundation, which has a uniform and linear shape; and a superstructure of large ashlar blocks (**fig. 5**). The foundation is characterised by a compact composition of mortar mixed with rubble stones and ceramics (**figs 6-7**)[7], resembling the construction method of *opus caementicium*. Considering the unique conditions in the marine environment, it can be assumed that the construction of the foundation required a certain type of hydraulic concrete, mixing quicklime, seawater and an aggregate as a mortar-binding material[8]. Whether the aggregate used for the concrete composition consists of pozzolanic mortar, the so-called *puteolanus pulvis* (a volcanic sand from the Gulf of Naples near Puteoli)[9], or any other volcanic ash or aggregate, still needs to be investigated through archaeometric analysis. Although Brandon aptly suggests that the concrete foundation of the eastern jetty represents a structure that can no longer be defined as »Roman marine concrete«[10], it nevertheless follows Roman harbour construction techniques. As described by the Roman architect and engineer Vitruvius Pollio, as well as later by the Byzantine scholar and historian Procopius of Caesarea, hydraulic concrete installations protruding into the

1 A first German version without the present article was published in 2016: Daim, Häfen.
2 Dark, Harbours 152-154; Demangel, Contribution 42. 46-47; Krischen, Landmauer tab. 18; Schneider/Meyer-Plath, Landmauer tab. 25a-b; Mamboury/Wiegand, Kaiserpaläste, tab. XXVIII-XXX, XXXV-XXXVI; Mango, Spolia figs 1-3; Müller-Wiener, Häfen, tab. 48,2; Simeonov, Brachialion, in this volume, figs 3-4. 12; G. Simeonov, Hebdomon figs 1. 14, in this volume.
3 Kızıltan, Yenikapı, Sirkeci and Üsküdar.
4 For a detailed study of the shipwrecks see Kocabaş, Yenikapı Shipwrecks; Kocabaş et al., Collection; Pulak/Ingram/Jones, Byzantine Shipwrecks; Pulak et al., Shipwrecks of Yenikapı. A short but excellent overview with an historical analysis is provided by Külzer, Harbour of Theodosius esp. 84-89, in this volume.
5 A jetty forms a permanent solid structure built out into the sea or harbour basin as part of a harbour or dockyard alongside which ships could berth for loading and unloading activities: Ginalis, Byzantine Ports 35; Dear/Kemp, Ships and the Sea 290-291.
6 Ercan, Yenikapı 121.
7 Gökçay, Architectural Finds 177.
8 For the technology and character of Roman marine and hydraulic concrete see Blezard, Cements; Brandon et al., Building for Eternity 1-4. 141-187.
9 As has been used for example at Roman Imperial harbours such as Caesarea Maritima, Pompeiopolis, Cosa, etc.: Brandon et al., Building for Eternity 73-81. 94-101; McCann, Cosa; Oleson, Technology; Raban, Caesarea Maritima 64 ff.
10 Brandon et al., Building for Eternity 136.

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water, such as jetties or moles, were constructed by using rectangular wooden formworks or chests (as Procopius refers to them)[11]. Such wooden formworks or caissons were prepared on land and subsequently sunk into the water in order to be placed on the seabed for the filling of the hydraulic concrete mixture[12].

Remains of such wooden caissons have actually been preserved at the eastern jetty at Yenikapı, indicating that the feature is composed of a series of individual concrete masses (**figs 4. 6**)[13]. Four samples from parallel vertical boards of the wooden formwork had been dated through dendrochronological analysis to the period between AD 657 and 786[14]. Hence, the construction of the jetty may well be allocated to further historically documented harbour works such as the construction or repair of the harbour fortification surrounding the harbour basin at the turn of the seventh to the eighth century or further restoration measures in the first half of the ninth century[15].

A dating to the Middle Byzantine period is further supported by the upper construction part, which sits on the homogeneous concrete foundation. This superstructure consists of large ashlar blocks (**fig. 8**). These, however, do not represent only uniform building materials, but also a mixture of various re-used blocks fitted in for the construction of the walking level. Accordingly, apart from mostly limestone blocks of different shapes, marble blocks and even three *spolia* blocks are used. The latter pertains to the fragments of a frieze block decorated with a band of acanthus leaves confined by strips of egg-and-dart and Lesbian *cymatium* (**fig. 9**)[16]. Based on the decorative style, a *terminus post quem* of the mid-fifth to the mid-sixth century may be considered for the three decoration fragments[17]. As such, the superstructure again indicates that the construction of the eastern jetty may not be dated earlier than the beginning of the seventh century. Additionally, the superstructure does not form a continuous level of ashlar blocks. Instead, the blocks were merely placed at the edges of each concrete unit, thus forming chambers. The chambers were subsequently filled again with a rough conglomerate of quarry stones and mortar, most likely another hydraulic concrete composition (**figs 10-11**).

It is very likely that the chamber system technique was intentionally chosen for achieving a robust construction, but pertaining an inexpensive technique with available construction materials and labour means[18]. Accordingly, this may well correspond to a time when the Byzantine Empire was in need of swift action, as it was facing serious economic difficulties[19]. Yet, when did this occur?

The technique used in Yenikapı has counterparts in a number of harbour sites primarily along the central Greek coasts, such as the harbours of Anthedon, Larymna, Theologos or Aegina and the outer harbours of Thessalian Thebes, but also at the Corinthian harbour of Lechaion[20]. The marked proliferation of these harbours seems to be directly linked to the growing importance of Boeotia and Thessaly as major producers and suppliers of grain and likewise other agricultural products, particularly from the seventh century onwards, in relation to the well-known consequences of the Arab conquests[21]. The increasing role of this new maritime network has clear reflections in Constantinople, and particularly in its largest harbour located in Yenikapı.

A reference to a warehouse/granary called *Horrea* or *Horion Lamias* situated on the eastern side of the Theodosian harbour from the seventh century onwards is particularly noteworthy within the historical context[22]. This granary[23], identified with the so-called *Horrea Alexandrina* listed in the *Notitia urbis Constantinopolitanae* from the fifth century AD[24], not only indicates continuous trade and shipping activities in the Theodosian harbour up to the late Middle Byzantine period, but also its possible close relationship to the harbour network of Central Greece[25]. This phenomenon possibly evinced by the etymology of granary's name, Lamia, which has been previously explained by a female monster[26]. Nevertheless, as the *Horrea Alexandrina* signified the shipment of grain from Alexandria in Egypt, it is very likely that the *Horion Lamias* is associated with the city of Lamia[27] – thus indicating the shipment of grain from central Greece, as a substitute of

11 Vitruvius, De Architectura V. 12. 3 (129 Rose/Müller-Strübing); Prokopios, De Aedificiis I 11, 18-20 (IV 44 Haury/Wirth).
12 Brandon et al., Building for Eternity 189-222.
13 Ercan, Yenikapı 122-123; Gökçay, Architectural finds 177; the up-to-five preserved units show an inclination towards the harbour basin of +1.15 m, +1.21 m, +1.15 m, +1.42 m and +1.57 m: Ercan, Yenikapı 123.
14 Kuniholm et al., Of Harbors and Trees 63.
15 Külzer, Harbour of Theodosius 40, in this volume; Müller-Wiener, Häfen 9.
16 Ercan, Yenikapı 121.
17 Comparative examples from the sea walls, as well as the sea gate at the Boukoleon Palace, suggest a date during the reign of Emperor Justinian I (6th c.): Mamboury/Wiegand, Kaiserpaläste tab. XVII-XVIII; Mango, Spolia 648 fig. 7.
18 Ginalis, Anthedon.
19 Ibid.
20 Ginalis, Anthedon; Ginalis, Byzantine Ports 190; Knoblauch, Ägina 73; Paris, Lechaion 10-11; Rothaus, Lechaion 295-296; Schäfer, Larymna 533-537; Schläger/Blackman/Schäfer, Anthedon 36, Abb. 14; Triantafillidis/Koutsoumba, Aegina 169.
21 Ginalis, Anthedon; Ginalis, Byzantine Ports 176-177. 193. 238-239. 244-245; Karagiorgou, Urbanism 31. 168 ff.; Trombley, Boeotia 991-992.
22 Miracula Artemii (Crisafulli/Nesbitt) 107 (16); Patria Konstantinoupoleos 51. 85 (II 179, 246 Preger).
23 For warehouses, granaries and other commercial facilities see Ginalis, Byzantine Ports 48-54.
24 Notitia urbis Constantinopolitane X 6. 9 (237 Seeck); Magdalino, Constantinople 23; Mundell Mango, Commercial Map 200-201 fig. 4; Kislinger, Better and Worse Sites 9-10, in this volume.
25 Magdalino, Grain Supply 37.
26 Ercan, Yenikapı 78; Janin, Constantinople 351-352.
27 Until the middle of the 6th c. the important Phthiotian city, which during the Byzantine era belonged to the province of Thessaly, was known with its ancient toponym »Lamia«; the bishopric was refounded in the 8th-9th c.: Koder/Hild, Hellas und Thessalia 53-54. 81. 283-284. Written accounts adopted the Slavic origin toponym »Zetounion« (from the Palæoslavic word »zito«, meaning »grain« or »cereal crop«) only after the 9th c. However, its wider surrounding agriculturally fertile area remained known and associated with the toponym »Lamia«: Avramea, Thessalia 199; de Rosen, Rhomanian Boeotia 138-139; Karagiorgou, Urbanism 94-95. 107-110. 113; Pallis, Lamia 59.

Egypt. In this respect, the creation of the theme of Hellas in AD 695[28] could again serve as an historical reference point for the construction of the eastern jetty at the turn of the seventh century to the eighth century[29].

Some of the ashlar blocks feature small notches of either rectangular or trapezoidal shape, also known as dovetail grooves (**fig. 12**). Metal clamps, which were formed by pouring liquid lead into these grooves, provided a strong bonding between the individual blocks in order to achieve a high stability and long-lasting resistance[30]. However, the isolated appearance of grooved ashlar blocks indicates that the use of metal clamps was not an essential measure for the stability of the jetty's upper part. Consequently, certain blocks seem to have been removed from their original place in the structure, rendering the notches more or less unnecessary. In fact, the use of dovetailed lead fixings seems to be a characteristic of ancient harbour architecture, for instance known from Caesarea Maritima[31]. Possibly taken from an earlier harbour facility, it presumably originated either from another jetty or an older quay installation along the eastern end of the harbour (see below).

Grooved stone blocks in a similarly re-used context can also be found at other Byzantine harbour sites, such as at Thessalian Thebes, Lechaion or along the Küçükçekmece Lake[32]. Similar to Anthedon, the chambers of rubble stones and mortar were finally covered with a last layer of limestone ashlar blocks and stone slabs, respectively (**fig. 13**)[33]. Whether the jetty bore a further superstructure of brickwork remains unknown. During the Byzantine era, the Roman tradition of combining concrete with brick for the construction of arched harbour structures most likely continued (as shown for example by Cristoforo Buondelmonti's depiction of Constantinople in his *Liber insularum archipelagi*)[34]. Since the brickwork usually rests directly on the concrete foundation, in this case, such a structure on top of the ashlar block chambers should not be excluded.

Finally, in contrast to the usually rectangular-shaped wooden chests, a pentagonal shape was chosen for the southernmost caisson. Visually, this results in giving the jetty a pointed end (**fig. 4**). Due to this singular ground plan, it has been suggested that the last part of the jetty may be associated with the previous existence of a lighthouse[35]. However, beyond the fact that no evidence of such a structure could be determined whatsoever[36], a lighthouse or lid beacon within the interior harbour zone is not plausible considering its location within the harbour basin. As such, it can be suggested that the pentagonal shape, together with the incorporated ornamental *spolia*, rather served purely visual aesthetics[37].

A further wall joins the eastern jetty at its southern end, which extends the structure approximately 20 to 25 m towards the south (**fig. 14**). The wall consists of one row with two preserved layers of large, re-used ashlar blocks and rubble that are set in a system of headers (**fig. 15**). A second row most probably existed. This implies a maximum total width of around 2 m (half the size of the above-described Middle Byzantine jetty). Without any use of mortar binding, the blocks seem to have been placed loosely on the ground, providing the impression of a rather provisional construction. On top of the well-worked ashlar blocks, undressed stones are placed up to the height of the walking level of the adjacent eastern jetty. Despite the big difference in size to the latter, the structure should also be identified as a jetty.

However, based on the rough construction technique, as well as the fact that it forms an annexe to the Middle Byzantine equivalent, a much later date has to be assumed. This is supported by the processing of re-used ashlar blocks, which were most likely dismantled from the eastern jetty to its north. The extension of the eastern jetty towards south is due to the constant siltation process of the harbour basin by the Lycus river (Bayrampaşa Deresi today), which emptied into the bay of the Theodosian harbour (**fig. 3**)[38]. The loose arrangement of ashlar blocks, without any mortar binding, indeed indicates that they must have been placed either on dry ground or in relatively shallow water. As such, the water depth in the harbour basin must have dropped by a large extent and the navigable sea level must have retreated farther south at some point after the ninth century. This obviously required building measures to reach the necessary draught for the docking of the vessels. Based on the wreck finds in that area, the eastern part of the eastern harbour basin remained in use for harbour activities at least until the eleventh century[39].

In contrast to the general assumption that the Theodosian harbour must have been entirely silted up by the end of the twelfth century at the latest, Külzer rightly suggests a limited

28 Koder/Hild, Hellas und Thessalia 57; Živcović, Date of the Creation 142-143. About the considerable extension of the Slavic controlled territories in central and southern Greece from the late sixth to the early 9th c., see Koder, Siedlungsgebiete; Kislinger, Regionalgeschichte als Quellenproblem and Kislinger, Dyrrhachion.

29 Ginalis, Anthedon.

30 Ercan, Yenikapı 121; Ginalis, Byzantine Ports 184. 242.

31 Kingsley, Barbarian Seas 136; Raban, Sebastos, Royal Harbour 115. A connection between the lead clamps and the so-called ἄργυρος χυτός (»liquid silver« or rather quicksilver), referred by the Late Byzantine historian Pachymeres is highly questionable and has been rightly doubted by Heher, Harbour of Julian 60, in this volume.

32 Aydıngün, Excavation Site 17 figs 49-50; Aydıngün/Aydıngün/Öniz, Küçükçekmece 440-441; Ginalis, Byzantine Ports 184, Ill. II.II.48b.

33 Ginalis, Anthedon; Schläger/Blackman/Schäfer, Anthedon 47.

34 Aidoni et al., Journeys 22; Effenberger, Pictorial Sources fig. 1, in this volume. For arched harbour structures in Roman times see Blackman, Ancient harbours II 197. 202 ff; Blackman, Sea Transport 648-649.

35 Kocabaş, Theodosian Harbour 25.

36 Ercan, Yenikapı 134-135.

37 Ibid. 121.

38 Ercan, Yenikapı 86 fig. III. 13; Külzer, Harbour of Theodosius 41, in this volume; Pulak/Ingram/Jones, Byzantine Shipwrecks 39. The existence and strong impact of the Lycus River on the development of the Theodosian Harbour is also reflected in medieval drawings of Constantinople, such as in the *Liber insularum archipelagi* by Cristoforo Buondelmonti: Effenberger, Pictorial Sources figs 1-2, in this volume.

39 Kocabaş, Yenikapı Shipwrecks 31 fig. 5; Külzer, Harbour of Theodosius 47-48; Pulak/Ingram/Jones, Byzantine Shipwrecks fig. 3.

but continuous use far into the Late Byzantine period[40]. This may be supported, not only by written accounts, but also by the existence of Late Byzantine kilns, supposedly unearthed in close vicinity to the eastern jetty. Located just northeast of the jetty, the kilns may be related to this very last phase of at least minor harbour activities up to the fifteenth century. A further indication for a continuous use even far beyond that is given by the latest archaeological activities of the Istanbul Archaeological Museum in the eastern part of the Yalı Mahallesi area (at the south-eastern end of the Theodosian harbour area)[41]. During the archaeological excavations, an approximately 40 m long and 4-5 m wide jetty was uncovered, belonging to the very last construction phase at the Theodosian harbour during the Ottoman period[42]. Interestingly enough, the jetty again features a construction system using wooden chests filled with a conglomerate of mortar mixed with rubble stones, which resembles a certain hydraulic concrete mixture.

Finally, despite its at least partial rededication around the twelfth century, similar to the site of Chrysopolis, the continuous use of the harbour area far into the Late Byzantine period and even beyond can be seen here as well (see further down). This is verified by harbour construction works dating as late as the Ottoman period. A 1.95 m wide jetty (Kibotos Iskele) inclining towards the sea can be allocated to these late harbour works (**fig. 16**).

The second prominent jetty is located in the western part of the eastern harbour basin (**fig. 2**). The roughly 20 m long structure is in very poor condition compared to its eastern counterpart despite its massive appearance. Nevertheless, the archaeological remains allow us to reach to firm conclusions regarding its architecture, its structural composition and thus its chronology. The jetty consists of three preserved solid and homogeneous masses (**fig. 17**). These show a compact conglomerate of mortar, mixed with rubble stones and ceramics, which again resembles a hydraulic concrete mixture. Whether that comprises Roman pozzolanic mortar or any other volcanic ash or other aggregate, has yet to be examined here, too. Despite the apparent visual resemblance to the eastern jetty, the structural composition of the concrete bears some differences. While the concrete mixture of the eastern jetty shows a high percentage of small to middle-sized rubble stones and a comparatively low percentage of mortar (**fig. 7**), the composition of the western jetty reveals a much higher percentage of mortar into which middle-sized to large boulders were embedded (**fig. 18**). On a closer examination, one can observe that the embedded stones are not waste quarry stones but whole river stones. These most probably derive from the nearby Lycus River, which emptied into the eastern harbour basin[43].

The use of construction material from the immediate vicinity may point to the earliest construction phase and the foundation of the harbour in the Early Byzantine period. This is supported, not only by the shipwreck YK 37 (dated to the fifth century) in its immediate vicinity (**figs 19-20**)[44], but also by the implementation of Roman engineering and construction techniques using rectangular wooden formworks. Although no physical remains of caissons were discovered at the western jetty, the gaps between the individual masses again clearly indicate the utilisation of such chests. In addition, the colossal dimensions and compactness of the hydraulic concrete masses (compared to the eastern jetty) imply a much earlier construction date on their own.

Unfortunately, apart from large stone blocks scattered around the concrete masses, as well as layers of massive ashlar blocks at the southern front of the jetty, no further construction components have been preserved that could provide any additional indications (**fig. 21**). As for the southern end of the jetty, it should be noted that the ashlar blocks do not rest continuously on the hydraulic concrete mass (as is the case at the eastern jetty). Instead, they give the impression that they are fitted into the washed-out and eroded concrete. This building measure could have aimed for two possible purposes: either to stabilize the jetty against the risk of collapsing; or, more likely, to extend the structure further south. As such, the massive ashlar blocks may be considered as later additions. A step-like arrangement of the ashlar blocks towards a wooden pier (see below) supports this interpretation. Marble column pieces and a marble impost block with the monogram of Emperor Justinian I have been unearthed immediately in front of the jetty (**fig. 22**), providing a *terminus ante quem* of the mid-sixth century for its erection. Consequently, it may be assumed that the western jetty was erected as early as the end of the fourth century or the beginning of the fifth century and underwent repair or extension during the sixth century. This is further supported by another type of harbour infrastructure: wooden piers[45].

Throughout the harbour basin, a large number of wooden piles belonging to piers have been brought to light, ranging from the fifth to the fifteenth centuries based on dendrochronological analysis[46]. A great majority of them is oriented

40 See Külzer, Harbour of Theodosius, in this volume; Ercan, Yenikapı 62. 92. 96. 118; Kocabaş, Theodosian Harbour 32; Magdalino, Maritime Neighbourhoods 215.

41 For further information on the archaeological fieldwork conducted in this area, see Öncü/Çölmekçi, Istanbul Boğazı; Öncü/Çölmekçi, Istanbul Boğazı 2016.

42 Akkemik et al., Dendroprovenancing.

43 Ercan, Yenikapı 59 fig. III.2; Külzer, Harbour of Theodosius fig. 4.

44 YK 37 forms the northernmost wreck find and belongs to the earliest group of vessels retrieved from the Theodosian Harbour: Kocabaş, Yenikapı Shipwrecks 34 fig. 5.

45 Different to permanent solid jetties, the pier forms a structure of timber supported on wooden piles. Piers were constructed in addition to jetties in order to provide additional mooring space for ships within the harbour basin. As shown for example by the late antique to medieval harbour of Olbia, piers were used equally to jetties within harbour areas, leading into the basin at a right angle to the shoreline: Dear/Kemp, Ships and the Sea 427; Ginalis, Byzantine Ports 35-37; Kingsley, Barbarian Seas 89-90.

46 Kuniholm et al., Of Harbors and Trees 47; it has to be mentioned that the dating of the wooden remains always refer to the time of their cutting and not necessarily to their immediate use for construction. A certain time period has obviously to be calculated from the time of cutting the woods, the transport and processing of the material to their use for building activities.

in a north-south direction (**fig. 23**). In line with the distribution of shipwrecks[47], the earliest pier constructions have been discovered at the northern end of the harbour basin, pointing to their connection to the harbour's quay area. According to the analysis of a series of posts, almost all wooden piers show multiple phases, which correlate with numerous repairs as well as enlargements (thus reaching total lengths of up to over 40 m) going along with the siltation process towards south and southeast[48]. The longest-lasting pier with a usage of over 80 years and three phases of repair/extension (four phases in total) constitutes the so-called »Marmaray İskele 1« at the western end of the harbour[49]. While the earliest phase dates to around the year AD 527, its latest posts are from around the year AD 610. A date around AD 553 is also given for the wooden pier connected to the southern end of the western jetty (**fig. 24**)[50]. This again provides a *terminus ante quem* of the mid-sixth century for the erection of the western jetty. Simultaneously, dendrochronological analysis attests to its continuous use up to the ninth century, which is similarly confirmed by the nearby shipwrecks YK 27, YK 28 and YK 32, dated to the seventh to ninth centuries (**figs 19-20**)[51].

At the western end of the harbour basin a further series of harbour installations has been uncovered (**figs 3. 25**). The wealth of different overlapping facilities provides a very complex picture, leading scholars to different interpretations and still puzzling the excavators. Concerning harbour-related structures, the most striking feature forms a quayside[52]. Due to the limitation of the excavation area, only a total length of 25.50 m could be revealed (**fig. 26**). The 2.80 m wide quay shows a southwest-northeast orientation and consists mostly of a single row with 1-2 layers of ashlar blocks[53]. The latter, however, are not comprised of standardised or uniform construction material, but rather randomly arranged, 2.75 m × 1.35 m large stones. Interestingly enough, these stones represent almost exclusively re-used material of bossage and local dressed stone slabs (**fig. 27**). The compilation of re-used stone material is supported by the use of two inscribed *spolia* blocks (**figs 28-29a**)[54]. Similar to the extension of the eastern jetty (see above), again no mortar binding was used, and the blocks are only loosely placed on the ground and on top of each other[55].

One of the ashlar blocks features a 10 cm wide hole pierced horizontally through the stone, whereas one of the inscribed *spolia* blocks points to a second perforation (**fig. 29a-b**). Rather than interpreting them as being part of a lifting device[56], the holes were intended for the mooring of ships. Besides vertically projecting bollards, perforated stone blocks or so-called »mooring stones« formed the most commonly used device for berthing ships since classical antiquity[57]. By piercing the blocks of the quay's frontal façade, the mooring device was incorporated into the wall as a single architectural unit with the quay.

As for the dating of the quay line, it has been suggested that the harbour facilities at the western end belong to the earliest construction phase, possibly dating to the initial building project of the Theodosian harbour between AD 390 and 425[58]. However, one gets the impression that the rough and seemingly provisional construction does not reflect a representative installation for an imperial harbour of the fourth/fifth century – especially given the fact that comparably large harbour sites, such as Caesarea Maritima, Demetrias, Thessalian Thebes, Corinth's eastern harbour of Lechaion or Ephesus, show a far more elaborate architecture[59]. *Prima facie*, an earlier construction period significantly preceding the Byzantine era may at first be suggested by the building material and the inscribed *spolia* used[60]. On closer examination, however, the construction assembly is of clearly re-used context, which suggests a rather later date. This is in fact supported by further excavation works undertaken in the Light Rail System area north-west of the Yenikapı site.

Among a series of building remains, which are roughly dated between the sixth/seventh and the ninth century, a 13 m long and 3 m wide structure has been unearthed[61]. Running in an east-west direction parallel to the Theodosian harbour and extended by wooden piles suggests an identification as a jetty with a pier projection belonging to a further harbour infrastructure. Whether its preserved part is sitting on a hydraulic concrete foundation within wooden caissons is not known to the authors. The partly destroyed jetty shows a solid architecture consisting of ashlar blocks with mortar binding and a flat surface covered by a thick concrete layer (**fig. 29c**). Hence, it is more reminiscent of the elaborate and

47 Kocabaş, Yenikapı Shipwrecks fig. 5.
48 Gökçay, Architectural Finds 168. 176; Kuniholm et al., Of Harbors and Trees 58-63. 66-77; Pearson et al., Dendroarchaeology 3407 fig. 8.
49 Gökçay, Architectural Finds 168; Kuniholm et al., Of Harbors and Trees 67; Pearson et al., Dendroarchaeology 3408.
50 Pearson et al., Dendroarchaeology tab. 1.
51 Kocabaş, Yenikapı Shipwrecks 21. 23 fig. 5; Kuniholm et al., Of Harbors and Trees 61; Pearson et al., Dendroarchaeology; Külzer, Harbour of Theodosius 46, in this volume.
52 A quay forms a projection along the shoreline of the harbour, usually constructed of stone masonry. The solid structure constitutes the main facility for the accommodation of ships to load and unload cargo or embark and disembark passengers: Dear/Kemp, Ships and the Sea 450; Ginalis, Byzantine Ports 32-34.
53 Ercan, Yenikapı 120; Gökçay, Architectural Finds 170; Kocabaş, Theodosian Harbour 25.
54 Ercan, Yenikapı 120; Gökçay, Architectural Finds 170.
55 Ibid.; Kocabaş, Theodosian Harbour 25.
56 Kocabaş, Theodosian Harbour 25.
57 For mooring devices see Blackman, Bollards 115-122; Ginalis, Byzantine Ports 38-43.
58 Gökçay, Architectural Finds 170; Külzer, Harbour of Theodosius 39, in this volume.
59 Ginalis, Byzantine Ports 162-193; Kingsley, Barbarian Seas 132-138; Külzer, Ephesos 49-57; Paris, Lechaion; Rothaus, Lechaion; Steskal, Ephesos; https://www.theguardian.com/science/2017/dec/14/new-underwater-discoveries-in-greece-reveal-ancient-roman-engineering (accessed 8 July 2019).
60 The incorporated inscribed *spolia* blocks provide a *terminus post quem* of the Roman Republican period for the erection of the quayside. While Gökçay dates the incorporated inscribed *spolia* blocks to the 4th c. BC, Ercan suggests a date between the third and the second centuries BC: Ercan, Yenikapı 120; Gökçay, Architectural Finds 170.
61 Kızıltan, İstanbul Kazıları 362.

representative architecture of imperial harbour installations than the quay facility described above. Its location north of the maritime circuit wall enclosing the Theodosian harbour basin (see further down) implicates the existence of a harbour site prior to the foundation of the Theodosian harbour. As such, a date to the fourth century or even earlier may be suggested[62].

Accordingly, the shoreline along the Sea of Marmara must have possessed permanent harbour facilities as early as the Roman and possibly the Hellenistic period as shown by the inscribed *spolia* from the quay line. Harbour activities prior to the Byzantine era are indeed attested by a large number of trading goods and other archaeological objects found throughout the harbour basin[63]. If that should indeed be the case, contrary to the general perception, the shoreline must have been quite different as late as the fourth century. This goes along with Mango's suggestion of a much deeper bay, which had only gradually been filled in due to the siltation by the Lycus river, as well as the continuous land reclamation for the shaping of the new capital under the reign of emperor Constantine I and his successors[64].

The jetty and its associated pier construction as well as the gradual transformation of the coastline provide a rough *terminus post quem* for the construction of the quayside, but the question of its exact date remains. In this regard, the above-mentioned wooden pier »Marmaray İskele 1« may shed further light on its historical placement. Running from the quay in a bow towards the southeast, the 43.5 m long wooden pier is immediately associated with the coastal facility. With its four construction phases ranging roughly between the years shortly after AD 527 and 610[65], it provides a *terminus ante quem* of the first half of the sixth century for the construction of the quay.

As a matter of fact, despite the potentially large time frame between the Hellenistic, Roman and Early Byzantine periods, a sixth century date appears to be likely. Considering the extensive building activities under the reign of Emperor Justinian I, which included the construction of harbour sites according to Procopius[66], it is conceivable that the Theodosian harbour underwent some repair or perhaps extension as well. Although no literary sources refer to any public work of such scale and significance, the construction of the granaries on the island of Tenedos under the reign of Emperor Justinian I must have had quite an impact on the harbour activities and hence the required infrastructures and harbour installations[67]. Thus, although a late fifth century date or the reigns of Justinian's immediate predecessors, Emperor Anastasius I (491-518) and Justin I (518-527) are equally conceivable for its erection, the wooden remains of the pier show a perfect match with that of Justinianic sites such as Capidava[68]. As such, the construction of the quayside has most likely been implemented as part of the extensive building programme during the reign of Justinian himself.

The last phase of the wooden pier »Marmaray İskele 1« shows a continuous use of the western harbour basin at least up to the mid-seventh century. This is supported by the shipwreck YK 11, which was unearthed in close vicinity to the eastern end of the wooden pier (**fig. 19**)[69]. However, the condition of the ship's hull points to its abandonment in shallow water. As such, at the time of its dereliction at some point during the seventh century, the western harbour basin must have already suffered from heavy siltation by the Lycus River.

Additionally, due to different environmental effects such as earthquakes during the sixth century, a sudden alteration of the coastline, which, along with the siltation by the river Lycus, led the harbour basin to become shallower, may have required the shift of harbour infrastructures or even the construction of new facilities[70]. This correlates well with the building activities in the eastern harbour basin discussed above, as well as further historically documented harbour works such as the construction of the eastern jetty or the repair and extension of the sea walls around the harbour at the turn of the seventh to the eighth centuries.

To its west, the quayside is confined by a breakwater of 20 m length, aligning on a northwest-southeast direction (**fig. 30**)[71]. Similar to the quay line, unfortunately it could not be uncovered in its entirety. Thus, its structural and functional characteristics can no longer be reconstructed with certainty. However, some technical and architectural conclusions can still be drawn. Reaching up to the surface of the quay, the breakwater must have protruded from the surface of the sea (**fig. 31**)[72]. Consequently, it can be identified as of

62 The authors hope that more detailed information on the jetty and its pier projection will be disclosed and published in future by the Istanbul Archaeological Museum.

63 Asal, Yenikapı excavations 7; Ercan, Yenikapı 58; Külzer, Harbour of Theodosius 37, in this volume; Öncü, Greek-Roman period.

64 Mango, Shoreline 20-21 fig. 1.

65 Kuniholm et al., Of Harbors and Trees 67-68 fig. 6; it has again to be made aware that the dating of the wooden remains always refer to the time of their cutting and not necessarily to their immediate use.

66 Prokopios, De Aedificiis I 8. 1-9 and I 11. 16-20 (IV 33-34. 43-44 Haury/Wirth); Ercan, Yenikapı 48. 50. 125; Hohlfelder, Building Harbours 369.

67 Prokopios, De Aedificiis V 1. 7-16 (IV 150-152 Haury/Wirth); Koder, Aigaion Pelagos 287-291; Külzer, Harbour of Theodosius 39, in this volume; Müller, Getreide 5-11.

68 Kuniholm et al., Of Harbors and Trees 67-68 fig. 6.

69 Pulak/Ingram/Jones, Byzantine Shipwrecks 47-50. Due to its small dimension (with a documented length of 9 m and a width of 3 m), the likewise 7th-cent. YK 11 wreck has been identified as a local cargo vessel for coastal shipping. Hence, it might form the link between the quayside and the harbour activities at the western harbour basin of the Theodosian Harbour and the granaries on the island of Tenedos: Külzer, Harbour of Theodosius 39 n. 48, in this volume.

70 Ercan, Yenikapı 106; Guidoboni, Earthquakes 292-295; Külzer, Harbour of Theodosius 39, in this volume.

71 Ercan, Yenikapı 86. 135; Gökçay, Architectural Finds 170-171. A breakwater forms an artificially placed construction, which provides protection to unsheltered harbour sites against the prevailing strong sea waves, currents and tides. By breaking the force of the sea, it assured a safe anchorage for ships: Dear/Kemp, Ships and the Sea 65; Ginalis, Byzantine Ports 26; Feuser, Hafenstädte 229-230.

72 Whether the height of its projection from the water allowed waves to break over it in order to prevent siltation by creating controlled currents within the harbour basin, remains unanswered. The erection of sea walls points to the absence of an effective de-silting measure, which resulted in an even faster siltation of the harbour basin (see below).

type »Mound Breakwater«[73]. Typically for a mound-formed type, the breakwater consists of two different construction parts: one internal and one external. Built in cross-sections, it started from the core to the outer protective covering. The core comprises a mixture of debris or soil with small stones in order to gain maximum compactness, whereas the external part consists mainly of larger quarry stones.

The purpose of the external part was mainly to prevent the movement and washing out of the internal rubble material. According to the stone size used for the core part as well as the thickness of the outer covering, sometimes a second layer of stones was required to cover the whole mound[74]. This, however, cannot be verified here. Its efficiency and stability depended, not only on the size of the feature, the thickness of the stones and the weight of the composition, but also on the gradient of the slope. The slope provided stability for the construction material by preventing possible undermining by the sea. The gradient of the slope differs between the inner and the outer part of the breakwater. While the inner part (the side towards the harbour basin) drops quite abruptly with a steep vertical angle, similar to the breakwater at the harbour of Chrysopolis at Üsküdar (see below), the outer part (the side towards the open sea) probably possessed a gentle inclination, which must have started nearly from the middle of the structure. This provided the construction with the necessary stability against the strong winds and absorbed the force of the waves from the open sea. Beyond its structural composition, the breakwater shows residues of mortar (most probably again a certain type of hydraulic concrete) encrusted with the rubble filling of the breakwater's external section. This forms a compact mass, which probably acted as reinforcing binding material for the weight of any superstructure[75]. Indeed, a wide flat surface follows the steep-angled inner edge, which supports a wall 2.3 m high and 1.35 m wide (**figs 26. 30. 32**)[76].

Concerning the construction date of the breakwater, it has to be noted that the chronological determination of breakwaters turns out to be difficult, since they pertain to a type of construction that has remained architecturally unchanged for millennia. As such, a relatively accurate dating often relies on constructional details, as well as on associated buildings and archaeological finds, respectively. While its structural characteristics and the use of mortar (hydraulic concrete) allow a time frame between the Roman Imperial and the Middle Byzantine periods, the fact that the breakwater is stratigraphically overlapping the quay is certainly decisive for its dating (**fig. 31**). Consequently, contrary to the interpretation of the excavators, the quay provides a *terminus post quem* of the late fifth to early sixth century for the construction of the breakwater and thus also for its wall superstructure. A sixth century date is also supported by its neighbouring Harbour of Julian/Sophia (later the Kontoskalion Harbour), for which the construction of a breakwater under the reign of Emperor Anastasius I (491-518) is attested[77] (**fig. 33**).

As for the wall superstructure, according to the excavators it is supposed to belong to the Theodosian sea wall, forming its extension along the breakwater[78]. However, taking into account the proposed dating limit by its breakwater foundation, together with further construction measures to the north and west of the harbour facilities[79], a date after the mid-sixth century should be considered. On closer examination, this wall seems indeed to be architecturally slightly different to the Theodosian walls surrounding the city. The Theodosian walls are constructed with a core of mortar faced with carefully cut limestone blocks and regular bands of brick[80]. Although the wall on the breakwater consists of successive courses of ashlar blocks with traces of brick bands that recall the Theodosian walls, it shows a much simpler and irregular construction with building material comprising small to medium-sized stone blocks and *spolia* (**fig. 30**).

Whether the erection of the breakwater and that of its wall superstructure are to be dated to the same period remains speculative. This question is closely related to the yet unexplained function of a series of holes drilled below the wall in an east-west direction. This continuous row of holes would appear to indicate that wooden beams connected the breakwater conglomerate to the superstructure (**figs 30. 32**)[81]. Traces of mortar coating suggest that at least the lower part of the wall and the holes were plastered. This would have protected the wooden features, which easily deform, swell or decompose when in contact with water. Unfortunately, it is still unknown whether the drilled wooden beams were only intended to provide greater stability for the wall or whether they functioned as connecting elements for the mortar binding. From an engineering perspective, however, this building measure is probably best explained as a binding element for a later, additional construction.

Consequently, it can be suggested that the two features most likely belong to different construction phases. This argument is supported by a short stretch of further wall just west of the sea wall (**figs 25-26**). Despite a slightly different orientation, these wall remnants may represent a potential sea wall

73 For the construction and typology of breakwaters, see Cornick, Engineering 116. 118 ff; Ginalis, Byzantine Ports 26-31.
74 Ginalis, Byzantine Ports 28, Ill I.7a, vol. II.
75 Gökçay, Architectural Finds 170.
76 Gökçay, Architectural Finds 172.
77 Heher, Harbour of Julian 52, in this volume. It should be mentioned that Heher wrongly agrees with van Millingen, Walls 291. 294 in the interpretation of the construction works as a mole. The term προβόλους should rather be interpreted as breakwater (see also προβόλιον and προβάλλω in LSJ 1470. 1472). This is verified by Cristoforo Buondelmonti's depiction of the harbour and later by the harbour reconstruction of Müller-Wiener: Effenberger, Pictorial Sources **figs 2. 4**, in this volume; Heher, Harbour of Julian fig. 7; Müller-Wiener, Häfen 37.
78 Gökçay, Architectural Finds 170; Kocabaş, Theodosian Harbour 25.
79 Some wall remains of the building complex associated with the harbour installation revealed stamped bricks dated to the 6th c. *in situ*: Ercan, Yenikapı 114.
80 For the Theodosian walls of Constantinople, see Asutay-Effenberger, Landmauer 13-71; Mango/Kiefer/Loerke, Monuments 519-520; Turnbell, Walls; van Millingen, Walls.
81 Gökçay, Architectural Finds 171.

as well, belonging to the initial phase of the breakwater and thus predating the sea wall discussed above. These eventually served as a supporting structure for the later sea wall with its buttresses that is visible today (**fig. 26**). Consequently, it can be proposed that the breakwater initially carried a different sea wall, which was erected, together with its substructure, probably around the sixth century (either together with the quay or slightly later). Subsequently, it must have been replaced by the above-discussed sea wall at some later point, postdating the entire building complex. According to written accounts, the sea walls supposedly underwent repairs either during the reign of Tiberius II (698-705) or Anastasius II (713-715)[82].

In fact, an identical building activity with identical construction phases can be observed at the Byzantine harbour of Thessaloniki, where rescue excavations unearthed a section of the sea wall with successive courses of ashlar blocks having traces of brick bands and buttresses[83]. Similar to its equivalent at the Theodosian harbour, based on the archaeological analysis and the written account of Caminiates, at least two major construction phases have been determined for the Byzantine era[84]. While it is suggested that the earlier one is dated to the Early Byzantine period, the following construction phase has to be placed at some point between the mid-seventh and the second half of the ninth centuries. Hence, similar to the inner circuit walls enclosing the harbour basin of the Theodosian harbour (**fig. 34**), a construction date at the turn of the seventh to the eighth centuries, may also be considered for the later sea wall[85]. However, only a closer investigation of the building material at both harbour sites, such as the mortar filling or the incorporated bricks, will provide accurate dating information.

In conclusion, the archaeological excavations at Yenikapı revealed a nearly complete historical sequence of human activities in the Theodosian harbour, ranging from its foundation in the late fourth or early fifth centuries (if not already from the pre-Byzantine era) up to its final rededication in the fifteenth century. This provides not only information on traded goods and artefacts in daily life, but also much sought-after information on shipbuilding traditions, as well as on harbour installations and their architecture from Late Antiquity to the Late Middle Ages. Interestingly, as far as the physical remains of coastal facilities are concerned, they nicely demonstrate the evolution of harbour activities. The earliest infrastructures, which belong to the first construction phase of the harbour around the end of the fourth or the beginning of the fifth centuries, were erected along the northern coast of the harbour basin just west of the outlet of the Lycus River (**fig. 3**). These include a jetty (the western jetty) and wooden piers. The wreck finds of YK 22, YK 26, YK 34, YK 35 and YK 37 (**figs 2. 19-20**), together with stamped bricks dumped next to the piers (**fig. 35**), attest to the loading and unloading of traded goods as early as the fifth century[86].

Based on the distribution of commercial installations listed in the fifth-century *Notitia urbis Constantinopolitanae*[87], it can be assumed that some harbour infrastructure may also have existed east of the river estuary (**fig. 36**). Accordingly, granaries (so-called *Horrea*) and marketplaces (so-called *Fora*) in its northern and eastern periphery, such as the *Horrea Alexandrina*, the *Horrea Theodosiana*, the Forum of Theodosius or the Forum of Amastrianus, show a close connection to the Harbour of Theodosius[88]. Although the grooved ashlar blocks on the eastern jetty may have belonged to a potential quay structure along the eastern end of the harbour, further physical remains of harbour facilities have yet to be discovered. Concerning the western harbour basin, the current state of archaeological knowledge suggests that no harbour installation existed at that time.

However, the pre-Byzantine building material of the western quayside allows the assumption that an earlier harbour site, possibly from the Hellenistic or Roman periods, may have existed. If so, this must have been situated slightly farther north or north-west and was later dismantled for the construction of the new quayside in the Early Byzantine period. Whether its facilities had been in use until the reign of Emperor Constantine I (306-337) remains unknown for the time being.

A wall, approximately 54 m long and 4.40 m wide, was unearthed just north-west of the quay and breakwater (**figs 26. 37**). Running beneath the sea wall discussed above, the excavators speculated that this 1.9 m high wall fragment formed the southern limit of the so-called »Constantinian« wall[89]. The latter reached the shoreline of the Sea of Marmara further west, implying that a certain section of the wall ran along the coast. According to Mango, however, the sea walls could hardly have existed under the reign of Constantine I due to the steady change of the coastline, as well as the continuous land reclamation of the deep bay (which later became the Harbour of Theodosius) up until the very end of the fourth century[90]. Only by AD 439, at the earliest, the construction of maritime circuit walls was finally ordered. At any rate, it seems that new harbour construction works on this shore

82 Külzer, Harbour of Theodosius 40; Müller-Wiener, Bildlexikon 313.
83 Leivadioti, Thessaloniki 87, Εικ. 49α-β.
84 Kameniates, De expugnatione VIII 3 (9 Böhlig); ibid. 22-25. It should further be noted that pre-Byzantine building remains have been discovered as well, indicating an earlier construction phase dating to the Roman period: Leivadioti, Thessaloniki 20-21.
85 Dark, Post Office Site 318; Külzer, Harbour of Theodosius 40; Mango, Shoreline 24-25; Müller-Wiener, Häfen 9.
86 Ercan, Yenikapı 115-116; Külzer, Harbour of Theodosius 45-46.
87 Notitia Urbis Constantinopolitanae 237. 239 (Seeck); Mundell Mango, Commercial Map.
88 Ercan, Yenikapı 21. 59. 65. 78; Heher, Harbour of Julian 52, in this volume; Külzer, Harbour of Theodosius 39, in this volume; Mundell Mango, Commercial Map 192-193 fig. 4.
89 Ercan, Yenikapı 110-111; Gökçay, Architectural Finds 172.
90 Mango, Shoreline 18-24; Many scholars accept the fact that the majority of the buildings attributed to Constantine I could not have been completed under his reign, but during the reign of his son Constantius II. The wall discussion basically relates to this debate: Magdalino, Maritime Neighbourhoods.

were not undertaken at least before the end of the fifth century.

Consequently, the Harbour of Theodosius was probably extended towards the west at the time of the »reconquest« and annexation of North Africa under the reign of Emperor Justinian I, which opened new markets and trading connections for Constantinople. It must have been that time when the previous harbour installation was abandoned and eventually partly removed to be used for the construction of the new quayside[91]. Therefore, it is in the sixth century that the Harbour of Theodosius, not only experienced its most prosperous time, but also seems to have reached its largest extent and final face.

The use of the entire harbour area did not last for long. The last phase of the wooden pier »Marmaray Iskele 1«, together with the shipwreck YK 11, demonstrate that the western harbour basin remained in use only until the end of the seventh century or beginning of the eighth century. This was caused by the Lycus River and a series of other environmental effects, which led to a slow but constant siltation of the harbour basin. The archaeological data obtained from the harbour installations, as well as the distribution and dating of the wreck finds, show that the siltation process took place from west to east[92].

Due to the loss of Egypt, Palestine and Syria to the Arabs in the seventh century, it was obviously no longer necessary to use the harbour at full capacity[93]. Therefore, in contrast to the neighbouring Harbour of Julian/Sophia[94], costly dredging works were not undertaken. Despite the reduction in the size of the harbour area and thus also the restriction of harbour activities, the Harbour of Theodosius continued to be a major hub for maritime trade throughout the Middle Byzantine period. The consequences of the Arab conquest of Egypt, which was the breadbasket of Constantinople, eventually entailed the reconfirmation of Byzantine authority over the Greek peninsula in the second half of the seventh century[95]. Thus, while the facilities at the western end of the harbour were abandoned after all, new infrastructure was constructed in the eastern harbour basin. Accordingly, in order to meet the new requirements, a massive eastern jetty was constructed in close vicinity to the newly renamed granary of Lamia at the turn of the seventh to the eighth centuries.

At some point after the ninth century, the siltation process reached the eastern harbour basin with the water depth constantly dropping. The retreat of the navigable sea level towards the south by the end of the twelfth century, at the latest, eventually required further building measures at the eastern end of the eastern harbour basin in order to reach the necessary draught for docking vessels. However, the extension of the eastern jetty towards the south shows that these may no longer have comprised major and elaborate harbour constructions. While the wreck sites attest to the use of the Harbour of Theodosius only up until the end of the Middle Byzantine period, some Late Byzantine kilns, together with written sources and depictions, point to minor harbour activities up to the fifteenth century[96].

Finally, based on the archaeological study of the Harbour of Theodosius, a very last observation is worth mentioning. The above-discussed constant siltation process of the harbour basin is not just associated with the Lycus River and a series of other environmental effects, as well as human impact (e. g., by dumping waste material into the harbour). Additionally, sea currents passing through the harbour mouth had a considerable effect. Consequently, the unequivocal west-east shift of the siltation process is closely related to the angle of the confluence between the incoming currents and the river outflow (**fig. 38**). Thus, the position and direction of the harbour mouth must have played a decisive role.

Accordingly, this may provide an indication for a potential reconstruction of the orientation of the breakwaters and its sea wall superstructures. Most recent harbour reconstructions suggest two equal breakwaters with a centrally located harbour entrance in an eastern orientated direction (**fig. 39**)[97]. In order to perform the west-east effect on the siltation process, the harbour entrance must have been located on the eastern side (**fig. 40**). This is also indicated by the different courses of the two breakwaters. Based on the aforementioned reconstruction models, the western breakwater ran in a more or less straight east-west direction, whereas the eastern one showed first a clearly north-south orientation before turning west where it continued to the centre of the harbour basin.

In line with Mango's and Janin's suggestions[98], it should rather be assumed that only one long western breakwater existed, which formed a large eastern harbour entrance. The use of a single breakwater is supported by historical depictions, such as Buondelmonti's drawing of Constantinople in his *Liber insularum archipelagi*, and also by the Byzantine harbour of Thessaloniki[99]. In fact, the same building technique can also be seen in photographs of the other harbour sites along the coast of the Sea of Marmara, the Harbour

91 The re-use of construction material from preceeding harbour installations is also suggested for the harbour of Thessaloniki: Leivadioti, Thessaloniki 21.

92 Ercan, Yenikapı 135; Külzer, Harbour of Theodosius 41, in this volume.

93 Of course, one should not ignore the impact of the decline in population due to famine and pestilence: Stathakopoulos, Famine and Pestilence.

94 Heher, Harbour of Julian 52-53, in this volume.

95 Ginalis, Byzantine Ports 238-239; Trombley, Boeotia 991-992. Contrary: Koder/Hild, Hellas und Thessalia; Lilie, »Thrakien« und »Thrakesion« 35-41; Haldon, Palgrave Atlas. – For the Arab conquests see: Kaegi, Early Islamic Conquests.

96 Effenberger, Pictorial Sources 20 fig. 1, in this volume; Ercan, Yenikapı 62. 92. 96. 118; Kocabaş, Theodosian Harbour 32; Külzer, Theodosius-Hafen 41-42; Magdalino, Maritime Neighbourhoods 215. Although it is beyond the scope of this article, it is important to note that at an elevation nearly equal to the later kilns, a small church was constructed to the southeast of the jetty possibly after the 10th or 11th c. For the archaeological analysis of the church and the theory about its abandonment in the 13th c., see Gökçay, Architectural Finds 166-180; Ercan, Yenikapı 80-82; Marinis, Architecture 208.

97 Berger, Langa Bostanı figs 1-4; http://www.byzantium1200.com/port_t.html (5 February 2020).

98 Janin, Constantinople Map 1; Mango, Shoreline fig. 1.

99 Effenberger, Pictorial Sources figs 1-2, in this volume; Leivadioti, Thessaloniki Σχεδ. 2.

of Julian/Sophia, the Boukoleon harbour and the mooring areas at Hebdomon (modern Bakırköy) and Brachialion (see below)[100].

Interestingly, all the harbours along the Sea of Marmara coast obviously possessed one single breakwater coming from the west. Exactly the same orientation of entrances is also shown by the siting of the modern harbours. All the harbour sites facing the Sea of Marmara possess just one single breakwater coming from the west, thus forming an eastern harbour entrance. With a southeast to east direction, they enclose and protect the harbour basins against the prevailing south-western and southern winds[101]. At the same time, the south-eastern to eastern currents must have made entrance into the harbour basins easier and also acted as a natural measure against their siltation during the Byzantine era.

Further Remarks on the Physical Remains of the Harbours of Constantinople and its Hinterland

Regarding the physical remains of harbour installations at other coastal sites in Constantinople, archaeological investigations were recently carried out at the harbours of Chalcedon at Kadıköy and that of Neorion/Prosphorion[102] at Sirkeci[103]. While the salvage excavation at Kadıköy supposedly revealed the remains of a jetty using a hydraulic concrete base similar to that found at the Harbour of Theodosius and Chrysopolis, a number of architectural elements and plenty of pottery finds belonging to the Early to Late Byzantine periods were brought to light at Sirkeci. These architectural elements comprise wooden structures, possibly connected with the harbour's surrounding warehouse facilities[104].

Within the archaeological context of the wider harbour bay, an eyewitness report by Charles Marling from 1906 provides vague but important information on further harbour features within the Neorion/Prosphorion Harbour[105]. According to his letter to Arthur B. Skinner, he observed a row of stone blocks of around 1 m in dimension during rescue excavations at the new post office south-east of the Ottoman Spice Bazaar, which he interpreted as a quay structure[106]. The method of construction, the use of building material and geological and ceramic evidence led Dark to support an Early Byzantine (fourth to seventh centuries) date[107]. In fact, considering the characteristics of quay structures at other harbour sites, an earlier date of the Roman, if not even Hellenistic, period may equally be suggested.

Similar data has been revealed by the Sirkeci Station Rescue Excavation between 2004 and 2012. Just as Dark suggested for the site at the new post office, a large building complex of the fifth to seventh centuries was documented at the eastern shaft of the Sirkeci Metro Station (north of the train station)[108]. After removing the Early Byzantine strata, however, wooden structures and so-called »waterfront stones« were revealed[109]. Together with wooden ships remains, these seem to belong to the harbour facility of the Prosphorion harbour itself. Unfortunately, no further data has yet been published, which could provide more detailed information. Only a single photograph offers a first glimpse of the so-called »waterfront stones« after all.

It shows a semi-circular three-levelled row of stones, which can be identified as a quayside (**fig. 41**). Each row is offset by around 20 cm and consist of roughly 1.20 m × 0.90 m large ashlar blocks. Among the almost uniform rectangular ashlar, at least two stone blocks possess lifting bosses for their placement on site. Such construction measures are mostly known from harbour sites of the Hellenistic period like the harbour of Amathus on Cyprus[110]. Archaeological finds dating as early as the seventh century BC have indeed been documented during the rescue excavation. However, since the quay line only includes a very small number of stone blocks with lifting bosses, which also seem to have been placed randomly, it can be assumed that these form reused material from a possible earlier harbour installation. The fact that metal clamps characteristic for classical antiquity are missing as well further supports a post-Hellenistic date. On the other hand, no mortar binding material seems to have been used either, which gives the quay construction an isodomic character. As such, given the use of hydraulic concrete for the Early Byzantine harbour facilities at Yenikapı, a date to the Roman period may rather be suggested. This is also indicated by its architectural characteristics, with the three-stepped construction method finding parallels both in Hellenistic and Roman harbours such as Mytilene, Leptis Magna or the river quay of the Tiber in Rome[111]. Finally, remains of two marble columns can be observed just next to the quayside. Although they seem to be of later, possibly even Early Byzantine date, they appear to be aligned with the quay. As such, the columns either belonged to an associated building, or formed mooring facilities for berthing ships.

100 Heher, Harbour of Julian 54. 63-64, in this volume; Heher, Bukoleon 67 fig. 5, in this volume; Simeonov, Hebdomon 127, in this volume; Simeonov, Brachialion 139, in this volume.
101 Heher, Boukoleonhafen 133.
102 The division of the wider bay along the northern coast of the peninsula and hence the exact location and separation of the two harbours is still uncertain: Kislinger, Neorion, in this volume; Dark, Harbours 153-154; Dark, Post Office Site 317.
103 Kızıltan, Yenikapı, Sirkeci and Üsküdar 15-16. The archaeological works at Kadıköy have not yet been published.
104 See Mundell Mango, Commercial Map 200-201 fig. 4; Kislinger, Neorion 94 n. 42, in this volume.
105 Kislinger, Neorion 93. 95 fig. 2; Dark, Post Office Site 315.
106 Unfortunately, the archaeological structure has never been published.
107 Dark, Post Office Site 317-318.
108 Gür, Rescue Excavations 17; Gür/Emre, Sirkeci 32-33.
109 The architectural interpretation of the remains will be subject of examination by K. Gür within the scope of an ongoing doctoral dissertation at Istanbul Technical University. For preliminary results, see Gür, Rescue Excavations 16-17; Gür/Emre, Sirkeci 32-33; Kızıltan, İstanbul Kazıları 364.
110 Empereur et al., Amathus 62-65.
111 Blackman, Ancient Harbours II 203 fig. 11; Ginalis, Byzantine Ports 34. 40; Theodoulou/Kourtzellis, Lesbos Underwater 97. 99.

Whether the harbour structures unearthed at the Sirkeci Station and those observed by Charles Marling during the rescue excavations at the new post office belong to the same harbour installation remains unclear. Considering the almost identical dimensions given for the stone blocks, it is quite feasible to assume it though. Far more convincing that the two sites may actually reflect parts of the eastern and western areas of one and the same infrastructure is their distance of only 300 m as well as their identical height in relation to the shoreline[112].

However, it is entirely possible that one belongs to the Neorion and the other to the Prosphorion harbour as well. Whatsoever, permanent harbour infrastructures at the Neorion/Prosphorion Harbour can be traced back at least to Hellenistic times with the current facility most likely representing the Roman phase by reusing material from the earlier harbour installation. A continuous use of both quay lines up to the Byzantine era has yet to be ascertained but seems likely. In any event, as one of the most important and most frequented harbours of Constantinople, the detailed analysis of the harbour remains of Neorion/Prosphorion as well as that of Chalcedon will provide new ground-breaking information for harbour studies of the pre-Byzantine, Early Byzantine and Late Byzantine periods.

For the rest of the Constantinopolitan harbours, information is even more limited. In the case of the Harbour of Julian/Sophia, the sources of information comprise only sporadic and rough drawings[113]. For the Harbour of Julian/Sophia (**fig. 33**), as well as for the mooring areas at Hebdomon at Bakırköy (**fig. 42**) and Brachialion at Mermer Kule (**fig. 43**), one can rely at least on a few photographs. Nevertheless, the drawings and photographs generally provide only rough impressions of the various harbour infrastructures. The only exceptions are the harbours of the Boukoleon Palace and Chrysopolis at Üsküdar.

The Boukoleon Harbour

The intensive studies of the Boukoleon Palace and its surrounding sea walls entailed a more detailed photographic documentation of at least part of its harbour facilities (**fig. 44**). As for the latter, Heher rightly assumes that, with the extension of the Great Palace towards the south, the first mooring facilities must have existed as early as the time of Emperor Justinian I[114]. This is supported by Procopius' reference to the anchoring of Belisarius in front of the palace, as well as by ceramic finds and the sea walls in this section, which show a construction phase of the sixth century[115]. The photographic documentation of the harbour mainly includes a quayside at the eastern end of the harbour (**fig. 45**) that runs in front of Justinian's house (leading from the grand staircase to the lighthouse tower) (**fig. 46**). Fortunately, the high quality of Mamboury and Wiegand's photographic record still allows a clear recognition of the quay structure. Accordingly, it is clearly visible that it consisted of massive limestone ashlar and large marble blocks (0.6 m × 0.7 m), according to Mamboury and Wiegand having a total width of at least 6 m and at the grand staircase even up to 12 m[116].

On closer examination, it can be observed that not all of the blocks show an identical orientation. While the quay is seemingly constructed of rows of east-west-running stone blocks, north-south-running rows of ashlar were inserted at regular intervals (**figs 47-48**). This gives the impression of a chamber system, among others strongly resembling the quaysides of the harbours of Anthedon and Larymna (see below)[117]. The chambers must have been filled with a type of hydraulic concrete, consisting of a conglomerate of rubble stones and mortar with inclusions of coarse ceramic. These were subsequently covered with the limestone ashlar blocks and with marble blocks around the grand staircase, as this has been nicely reconstructed by Helbert (**fig. 49**)[118]. Anna Komnene claimed that the harbour had been built using mortared fieldstones and marble blocks[119]. This is also indicated by Mamboury and Wiegand's report of large limestone blocks, quarry stones and brick mortar[120]. Recent core drillings in front of Justinian's house and the southeast corner of the grand staircase further attested this construction method[121]. At a depth of approximately 3.75-4.8 m, the latter revealed an artificial conglomerate of clayey sand with brick and stone, as well as marble fragments. This is followed by a stratum of mudstone, made of dark grey stones between 4.8 m and 6.9 m, and finally a layer of brown-grey gravel/rubble stones and clayey sand with brick inclusions down to a depth of 10 m. While the top layer (approximately 1 m thick) obviously represents the cover plates of ashlar and marble blocks with their mortar binding, the following layers most likely form the compact mortar filling of the quay chambers.

Similar structural remains have also been documented around 50 m east of the so-called Tower of Belisarius and 40 m south of the façade of the western palace section (**fig. 46**). Mamboury and Wiegand referred to an »isolated foundation of quarry stones with brick mortar, followed by

112 Kislinger, Neorion 93 fig. 2, in this volume.
113 See Heher, Harbour of Julian figs 2. 7. 9, in this volume.
114 See Heher, Harbour of the Bukoleon 70-71; Heher, Boukoleonhafen 123. 125.
115 Prokopios, Bella III 12. 2 (I 365 Haury/Wirth); Heher, Harbour of the Boukoleon 71, in this volume; Özgümüş, Bukoleon 66.
116 Mamboury/Wiegand, Kaiserpaläste 13.
117 Ginalis, Anthedon; Schäfer, Larymna 533-537 fig. 14; Schläger/Blackman/Schäfer, Anthedon 36 figs 9. 14.
118 The marble blocks have most likely been re-used, as this is the case also for the use of marble *spolia* for the construction of the sea wall's lower section: Mango, Boukoleon 47.
119 Heher, Boukoleonhafen 133; Heher, Harbour of the Bukoleon 80.
120 Mamboury/Wiegand, Kaiserpaläste 6. 13.
121 Bolognesi Recchi Franceschini, Monumental Itinerary 55-56.

four layers of bricks«, which they interpreted as the foundation of the eponymous animal statue »Boukoleon«[122]. Heher rightly doubts this interpretation and in turn proposes an identification as a quay line belonging to a large ceremonial square. Alternatively, he suggests that it may have been part of a breakwater or mole construction[123].

Given the description of the structural remains, the feature obviously constituted a hydraulic concrete foundation with a brick superstructure. As such, it can indeed be identified as the architectural element of some sort of harbour infrastructure. The proposed existence of a quay-like facility that featured a ceremonial area is therefore conceivable. However, given the location of the remains, it seems more likely to assume a mole construction on the inner side of a breakwater, which enclosed the harbour basin coming from the western sea wall or the Tower of Belisar[124]. This would not only explain Buondelmonti's drawing of an enclosed harbour basin[125], but also agree with Nicetas Choniates's statement »…περὶ τὰς ἀκτὰς σαλεῦον καὶ τοὺς προβλῆτας, οἳ τὸ πάραλον τεῖχος τῆς πόλεως διειλήφασι, τὰς τῶν κυμάτων ἀποθραύοντες ἐμβολάς«[126].

Concerning its superstructure, it seems that the brickwork rests directly on the concrete foundation. As such and in contrast to the eastern jetty at the Harbour of Theodosius, we might find here a continuation of the Roman tradition combining concrete with brick for the construction of an arched mole structure. Given the arches or blind arcades at the western sea wall, the existence of an arched mole seems not too far-fetched. Whether the latter formed just blind arcades as decorative elements or proper arches remains unknown. In fact, in order to find a way to act against the problem of siltation in a small harbour like the harbour of the Boukoleon Palace, such a building measure would have certainly made sense. While the breakwater substructure reduced the force of the waves and hence broke the strength of the sea, it allowed the waves to break over it. Passing through the arches of the mole, these subsequently created currents within the harbour basin[127].

As for the dating of the quay construction at the eastern end of the harbour, the chamber system of intersecting lateral and longitudinal walls finds comparison in the eastern jetty at the Harbour of Theodosius, as well as in quaysides and jetty or mole constructions of the seventh to eighth centuries at a series of harbour sites, such as Anthedon, Larymna, Theologos, Aegina, Thessalian Thebes and Lechaion[128]. Consequently, the quayside at the Boukoleon harbour seems to again represent Middle Byzantine harbour architecture.

A Middle Byzantine date for the harbour has also been suggested by Mango and Heher[129]. As opposed to Heher's assumption that the quayside could only have been constructed after the third and last construction phase of the sea wall during the ninth to tenth centuries, a date around the turn of the seventh to the eighth century should rather be accepted. This matches perfectly with the erection of the second construction phase of the sea wall and the Tower of Belisar, as well as that of the grand staircase as a monumental access to the palace during the reign of Justinian II (685-695 and 705-711) or Tiberius III (698-705)[130]. An additional 3.2 m was added to the 6 m wide sea wall during the third construction phase, meaning that it can be assumed that the quayside originally had a total width of 9.2 m. Unsurprisingly, this coincides exactly with the width of the seventh-to-eighth-century-dated southern quay at the harbour of Anthedon and the eastern quayside at Larymna (for which a width of 4.6 m is given for a single chamber)[131]. Accordingly, the quayside would originally have had a double-chamber construction.

As a result, Mango is right in assuming that an independent palace harbour approximately 1.45 ha in size, with a harbour basin of up to 250 m long and 40 m wide, intended for private imperial use, was constructed, or simply altered to its final shape, at some point after the sixth century and before the ninth century[132]. Based on the analysis of the architectural remains of the various harbour features, a slightly different picture than that presented by Helbert (**fig. 50**) can be suggested: a significant difference may be proposed for the western harbour basin. While the existence of a quayside along the entire façade of the Boukoleon Palace can indeed be assumed, the harbour cannot have reached as far south as the Tower of Belisar. The breakwater, with its mole superstructure, should rather be considered as an extension of the western sea wall. As such, it can be doubted whether the palace harbour ever featured a supposed ceremonial square.

Accordingly, it can be suggested that, with the new harbour situation in the Middle Byzantine period, the main embarkation and disembarkation area even shifted from the western to the eastern harbour basin. This is supported by the massive quayside in front of Justinian's house (**figs 47-48**) and by the change of the access point to the Boukoleon Palace. While the first mooring facilities were accessible through a 2.7 m wide gate at the western harbour basin during the

122 Heher, Boukoleonhafen 134; Mamboury/Wiegand, Kaiserpaläste 5, tab. VII, XXXV.
123 See Heher, Harbour of the Bukoleon 82, in this volume; Heher, Boukoleonhafen 135.
124 Even though the structural remains could have easily belonged to a jetty as well, such identification has to be ignored. Even with a calculated quayside of around 9 m along the eastern harbour side, the distance of at least 40 m to the Tower of Belisar is far too great for a jetty in this harbour.
125 Effenberger, Pictorial Sources fig. 1, in this volume.
126 Niketas Choniates, Historia 129 (van Dieten); Heher, Harbour of the Bukoleon 80.
127 Ginalis, Byzantine Ports 31.
128 Ginalis, Anthedon; Ginalis, Byzantine Ports 190; Knoblauch, Ägina 73; Paris, Lechaion 10-11; Rothaus, Lechaion 295-296; Schäfer, Larymna 533-537 fig. 14; Schläger/Blackman/Schäfer, Anthedon 36 figs 9. 14; Triantafillidis/Koutsoumba, Aegina 169.
129 See Heher, Harbour of the Bukoleon 79, in this volume; Mango, Boukoleon 47.
130 Bolognesi Recchi Franceschini, Seventh Survey 137-138; Heher, Boukoleonhafen 126. 129; Heher, Harbour of the Bukoleon 73; Mango, Boukoleon 47.
131 Ginalis, Anthedon; Schäfer, Larymna 533.
132 Heher, Boukoleonhafen 132-135; Mango, Boukoleon 47.

reign of Justinian I, in correspondence with the alteration of the harbour at the turn of the seventh century to the eighth century the construction of the second phase of the sea wall shifted the gate to the eastern harbour basin[133]. This seems also to have been taken into account in the later construction of the grand staircase, which shows a large eastern gate (**figs 44b-d. 51**)[134].

The Harbour of Chrysopolis at Üsküdar

Originally forming a deep sheltered bay, the harbour site of Chrysopolis at Üsküdar was used as a strategic interstation for the shipping lane through the Bosporus since classical antiquity[135]. Alongside the coastal sites of Chalcedon at Kadıköy, Hiereia (Hieron) and Eutropiu Limen at Kalamış bay, it additionally acted as an important ferry harbour linking Constantinople with its Asian coast opposite. Furthermore, it formed a so-called *Epineion*[136] for Bithynia from the Roman Imperial period onwards and especially during the Byzantine era[137]. Hence, it is not surprising that again plenty of archaeological evidence of harbour activities were brought to light during the Marmaray-Metro Construction Project between 2004 and 2008[138]. The salvage excavations revealed, not only a large number of ceramic artefacts, marble objects, stone anchors and a variety of architectural elements ranging from pre-Classical times to the Ottoman period, but also various building remains belonging to harbour infrastructures[139]. These include a breakwater with a possible mole construction[140], jetties, wooden pier remains and a potential quayside[141]. The harbour situation is again quite complex due to the strong alteration of the coastline. The harbour site of Chrysopolis must have shifted quite frequently through time as a result of the constant regression of the bay due to siltation from the estuaries of the rivers Bülbül and Çavuş[142]. Therefore, it must be assumed that the harbour sites of the Archaic, Classical, Roman and Byzantine periods are situated in different locations. Similar harbour situations are also documented at other coastal sites in Asia Minor such as Ephesus or Clazomenae[143].

As for the unearthed harbour structures, the most striking features again constitute wooden remains, which belong to various sections of pier constructions, as well as to jetty formworks or caissons. Although the wooden pier structures could not be entirely excavated, remains with a dimension of 8.4 x 4 m and even as large as 8.2 x 5.25 m have been uncovered[144]. Unlike the equivalent remains documented at the Harbour of Theodosius at Yenikapı, the piers do not consist of vertical piles only. For the first time, horizontal grid systems with a floor level have also been preserved, which provide an unique insight into the engineering details of pier constructions as shown for example by the depiction of Gregory of Nazianzus' departure from Constantinople dated to the eleventh century (**fig. 52**)[145]. The horizontal grid consists of 0.25 m wide and 5.2 m long carved wooden logs set in a grid on top of each other and pegged on the vertical piles driven into the ground (**fig. 53**). A mortise-and-tenon joinery system was applied for the fastening of the wooden elements[146]. One pier section indicates that the uppermost layer of logs corresponds to the orientation of the pier. This last layer of logs was subsequently covered with planks, thus set perpendicular to the orientation of the pier (**fig. 54**). As for the construction material itself, it seems that the timbers were fired and pitched in order to provide longer resistance to deterioration in the maritime environment[147].

The pier sections possess a roughly northwest-southeast orientation. Interestingly, its various parts show a different river sediment infill. While the north-western section is filled with pure sand, at the south-eastern end boulders can also be found. Whether the latter derive from the siltation process or whether they were set in order to reinforce the pier in connection to another harbour structure and support it against environmental impact, respectively, remains to be clarified. Corresponding to an alignment perpendicular to the north-west oriented shoreline, it points to the fact that at the time of the construction of the piers, the coastline must have considerably shifted (up to 1 km) towards the north-west opening of the deep bay[148].

This shift of the coastline also altered its physical condition[149]. Thus, the change from a deep sheltered bay to an exposed open shoreline eventually required building measures for the protection of the harbour site. Accordingly, a breakwater had been erected. Like the breakwater at the Harbour of Theodosius (see above), the composition consists of large

133 Heher, Boukoleonhafen 129; Heher, Harbour of the Bukoleon 75-77 fig. 21.
134 Mamboury/Wiegand, Kaiserpaläste tab. XXIII.
135 Karagöz, Khrysopolis Liman 401. 404. 414; Karagöz, Khrysopolis – Scutari 3 fig. 7; Karagöz, Excavations 86.
136 During classical antiquity, the epineion (ἐπίνειον) constituted a harbour area outside its associated city, but yet forming a part of it. During the Roman Imperial period, these so-called out-ports developed into independent coastal sites, often taking over the role and significance of their preceding ancient cities. The latest by the Early Byzantine period *epineia* formed crucial coastal centres, which acted as vital economic hubs and linking stations for the settlement network within a certain province: Ginalis, Byzantine Ports 15. 250-252.
137 Belke, Bithynien und Hellespont 296-298; Belke, Gates 166, in this volume; Karagöz, Khrysopolis Liman 406. 412.
138 Belke, Gates 165; Karagöz, Excavations 85; Kızıltan, Yenikapı, Sirkeci and Üsküdar 15.
139 Karagöz, Excavations 89-101.
140 A mole forms a masonry structure along the inner side of the breakwater. This increases the mooring space for the loading and unloading of ships within the harbour basin in order to extend the commercial and traffic-related functions of the quay: Ginalis, Byzantine Ports 26. 30; Feuser, Hafenstädte 229.
141 Karagöz, Khrysopolis Liman 402. 408-414; Karagöz, Chrysopolis 46-49. 52.
142 Belke, Gates 165-166; Karagöz, Khrysopolis – Scutari fig. 7; Karagöz, Excavations 101.
143 Ersoy, Clazomenae 2-6; Steskal, Ephesos 327.
144 Karagöz, Khrysopolis Liman 408-410; Karagöz, Yapı 422.
145 Cod. Taphou 14, f. 265r; Aidoni et al., Seaports 21 fig. 5.
146 Karagöz, Chrysopolis 49-50; Karagöz, Excavations 101.
147 Karagöz, Yapı 422.
148 Belke, Gates 165; Karagöz, Chrysopolis 46; Karagöz, Khrysopolis – Scutari 5.
149 Physical conditions indicate the consistence and configuration of a specific coastline, which is affected by the predominating waves, currents, tides and winds: Ginalis, Byzantine Ports 9; Karmon, Components 1.

quarry stones piled up on top of an internal core of rubble material[150]. In order to provide the construction with stability against strong winds and absorb the force of the waves to prevent a possible undermining, the structure shows an inclination towards the sea (**fig. 55**). In contrast to the sloping outer part of the breakwater, the inner part drops abruptly with a steep vertical angle. The upper part of the breakwater is flattened, consisting of cut stones.

A row of limestone blocks ranging in size from 0.5-2.9 m × 1-2 m × 0.25-0.9 m, with inserted *spolia* of marble column fragments from the fifth to sixth centuries, may also be allocated to a mole construction at the steep-angled inner edge of a breakwater (**fig. 56**). The existence of a mole is further supported by traces of intensive loading and unloading activities of traded goods attested to by numerous amphora fragments[151]. After removing the limestone ashlar blocks, almost completely preserved wooden formworks were revealed, forming the foundation of the mole construction (**fig. 16**). These caissons are 5.25 m long and 1.8 m wide and filled with a rough conglomerate of quarry stones and mortar, which most likely forms a certain type of hydraulic concrete composition[152]. According to the latest publications of the excavation results that refer to studies on the analysis of the mortar, its composition can allegedly be identified as the pozzolanic mortar described by Vitruvius and Procopius[153]. Based on Brandon's definition[154], it seems more likely that this material no longer represents »Roman marine concrete«, but rather follows Roman harbour construction techniques by using a similar reacting aggregate. Consequently, it has further to be examined whether the concrete mixture indeed comprises Roman pozzolanic mortar or any other volcanic ash or aggregate.

If the extent of 13 m in east-west direction and 7 m in north-south direction mentioned by Karagöz is to be attributed to the size of the mole construction and its breakwater substructure[155], then the dimension can be considered to be relatively small. However, it seems to have been sufficient for the demands of the harbour and to keep it operational for centuries. Concerning the functional efficiency, waves must have been able to break over the structure in order to counteract the constant siltation process from the rivers by creating controlled currents within the harbour basin. As such, the breakwater must have protruded from the surface of the sea. Level measures between +0.48 and +0.71 m indeed give that impression. Consequently, similar to the breakwater at the Theodosian harbour, it can again be identified as of type »Mound Breakwater«.

As for the dating of the harbour site, in contrast to the large time span of the archaeological finds, the earliest harbour facilities are not to be dated before the Roman Imperial period and most likely belong to Early Byzantine times, as attested by the wooden piers[156]. If any permanent harbour structures of the Classical to Hellenistic periods ever existed, then they must have been situated further inland. In contrast to the general understanding of the harbour situation[157], which is similar to the quayside in the western basin of the Harbour of Theodosius (see above), any Roman coastal facilities must also be located slightly further southeast. These may again have at least partly been re-used for any Early Byzantine harbour works. Unlike Procopius' detailed description of construction works at the harbour of Eutropiu Limen and possibly also at Hiereia during the sixth century[158], no such building activities at Chrysopolis are confirmed by any Early Byzantine sources.

The building material, the marble column *spolia* of the mole and the wooden piers located farther to the southeast indicate that additional harbour infrastructures must have existed in the Early Byzantine period. This is supported by a large number of ceramic artefacts such as oil lamps or *Unguentaria*, all dating to the fifth to sixth centuries. In fact, these may again belong to the extensive building activities under the reign of Emperor Justinian I or his immediate predecessors. Indeed, a considerable amount of African Red Slip Ware (ARS) shows trading connections to North African markets following its re-conquest and annexation in the 530s[159].

After the Early Byzantine period, the harbour obviously suffered increasingly from constant siltation by river alluvium and other environmental impacts, such as earthquakes, or geopolitical events[160]. This eventually led to the shift of the harbour area farther north-west, but when did the relocation of the harbour site and, accordingly, the erection of a new harbour installation take place? While the pottery (particularly the African Red Slip Ware) and the re-used *spolia* from the preceding Early Byzantine harbour site provide a *terminus post quem* of the sixth century, the construction of a large ecclesiastical complex on part of the supposed harbour basin in the twelfth to thirteenth centuries may be taken as a *terminus ante quem*[161]. On the one hand, it is not just to assume that it must have taken some time for the Early Byzantine harbour site to become unusable for ships, thus making relocation

150 Karagöz, Khrysopolis Liman 410; Karagöz, Chrysopolis 46.
151 Karagöz, Khrysopolis Liman 411; Karagöz, Chrysopolis 47; Karagöz, Khrysopolis – Scutari 3.
152 Karagöz, Khrysopolis Liman 413 fig. 13; Karagöz, Chrysopolis 47-48.
153 Vitruvius, De Architectura V 12. 3 (129 Rose/Müller-Strübing); Prokopios, De Aedificiis I 11. 18-20 (IV 44 Haury/Wirth); Karagöz, Khrysopolis Liman 413; Karagöz, Chrysopolis 47.
154 Brandon et al., Building for Eternity 136.
155 Karagöz, Khrysopolis Liman 412; Karagöz, Chrysopolis 47. The dimension of the breakwater must have been slightly larger (presumably at least 15-20 m for the east-west and 10 m for the north-south extent) though.
156 Karagöz, Khrysopolis Liman 408; Karagöz, Chrysopolis 49.
157 Belke, Gates 166, in this volume; Karagöz, Yapı 421-423.
158 Prokopios, De Aedificiis I 11. 16-23 (IV 43-45 Haury/Wirth); Belke, Gates 167. 170, in this volume; Hohlfelder, Building Harbours 368-370.
159 Karagöz, Khrysopolis Liman 414; Karagöz, Chrysopolis 44-45.
160 Belke, Gates 166; Karagöz, Khrysopolis Liman 412. 414; Karagöz, Khrysopolis – Scutari 3.
161 For the archaeology of the structure see Karagöz, Chrysopolis 42-46; Karagöz, Excavations 98-101; for the possible identification of the complex see Belke, Gates, in this volume; Hellenkemper, Politische Orte 251-252.

necessary. On the other hand, the erection of ecclesiastical facilities and possibly further urban infrastructure on the harbour area also implies a long-completed siltation process and the consolidation of the soil. Therefore, the specified time period must be narrowed down to possibly between the end of the seventh or the beginning of the eighth and the end of the tenth centuries.

The discovery of a single mooring stone also supports this argument (**fig. 57**). The nicely perforated berthing device, which probably belonged to the frontal façade of a quayside, bears an inscription reading ΝΗΚΗΦΟΡΟΣ (Nikephoros)[162]. Whether the name refers to one of the three Byzantine emperors (Nicephorus I, Nicephorus II Phocas or Nicephorus III Botaneiates), to the Patriarch Nicephorus I, or to any other associated person remains certainly speculative. As Belke correctly points out, different written sources from the eighth to ninth centuries mention harbour activities, indicating the existence of a functioning harbour at Chrysopolis as early as the beginning of the eighth century[163]. This allows a dating of the newly erected harbour to the early Middle Byzantine period, which, as already rightly suggested by Karagöz[164], makes an allocation to the reign of Emperor Nicephorus I (802-811) most likely.

Finally, despite its at least partial rededication around the twelfth century, like the Harbour of Theodosius, the continuous use of the harbour site of Chrysopolis far into the Late Byzantine period, and even beyond, can be seen here as well. This is verified by harbour construction works dating to as late as the Ottoman period. A 1.95 m wide jetty leading from the above-mentioned mole towards the sea can be counted among these late harbour works (see Kibotos Iskele **fig. 16**). Interestingly enough, the jetty again features a construction system using wooden chests filled with a conglomerate of mortar mixed with rubble stones, which resembles a certain hydraulic concrete mixture[165]. The individual caissons are subdivided so as to form a double-box construction. Stone slabs or finely cut stone blocks, which are inserted into the surface of the compact mortar, form the final walking level. Based on dendrochronological analyses of the wooden formworks, the jetty can be dated to the seventeenth to eighteenth centuries[166]. This reveals, not only the persistence of the harbour area, but also a continuation of ancient harbour construction techniques even up until early modern times.

The harbour area of Chrysopolis reveals intensive harbour activities with multiple construction phases. Although not as rich in material data as the Harbour of Theodosius (see above), archaeological investigation attests to an identical building history with harbour constructions dating to the end of the Roman Imperial (second to fourth centuries), the Early Byzantine (sixth century) and the Middle Byzantine periods (at the turn of the seventh century to the eighth century, or the ninth century at the latest). Although the harbour continued throughout the Late Byzantine period, the construction of new harbour facilities has archaeologically been documented only for the Ottoman period so far.

Conclusions

Until recently, the physical harbour remains of Constantinople have attracted only marginal attention and, therefore, in contrast to historiographical and literary-based studies, have rarely been the subject of systematic investigations by archaeologists. Only with the Marmaray-Metro Construction Project and the Sirkeci Station Rescue Excavation – particularly thanks to the meticulous work conducted by the Istanbul Archaeological Museum – a new impulse to the field of harbour archaeology was given. Although the archaeological studies of the harbour sites of Constantinople are still fragmentary, a large spectrum of infrastructures has already been revealed. These include facilities such as quay structures, breakwaters and their mole or wall superstructures, as well as jetties and wooden piers, which provide a further *tessera* in the puzzling mosaic of Byzantine harbour engineering and architecture.

Based on the observations discussed in this paper, the harbour architecture of Byzantine Constantinople shows clear chronological stages that conform to the general historical picture of Constantinople presented in other chapters of this volume.

Accordingly, during the first centuries of the Byzantine Empire, the harbour architecture seems to be still clearly marked by Roman traditions. This is especially reflected in the implementation of wooden formworks, so-called chests (kibotos), filled with Roman marine concrete (a specific type of hydraulic concrete mixture consisting of a compact, symmetrical uniform and linear shaped composition of pozzolanic mortar, mixed with rubble stones and ceramics). In all likelihood connected with the extensive building programme during the reign of Justinian I, harbour activities, and thus harbour works (including the foundation of new harbour sites), reached their peak. However, this does not always go along with the construction of elaborate facilities, but rather with the re-use of building material from preceding harbour installations.

Additionally, a transition of harbour architecture must have taken place in the sixth century, during which Roman traditions were adapted to new geopolitical and social circumstances. Although still based on the principles of Roman and Early Byzantine engineering, eventually a new highly sophisticated harbour architecture evolved during the Middle Byzantine period. Both quay structures and jetties now consisted of longitudinal and lateral walls that formed a chamber

162 Karagöz, Khrysopolis Liman 414 fig. 14.
163 See Belke, Gates 166, in this volume.
164 Karagöz, Khrysopolis Liman 414.
165 Karagöz, Chrysopolis 48; Karagöz, Khrysopolis Liman 412-413.
166 Karagöz, Khrysopolis Liman 412; Kuniholm et al., Of Harbors and Trees 53.

system. This offered an equally robust building technique, but avoided expensive and possibly unavailable construction material and skilled labour for complex stone masonry. The chambers were subsequently again filled with a rough conglomerate of quarry stones and mortar. However, it is most likely that the hydraulic concrete composition no longer represented »Roman marine concrete«, but a new hydraulic concrete mixture, using a similar reacting aggregate.

In contrast to permanent harbour structures, wooden piers remained architecturally unchanged throughout the Byzantine era. Finally, the archaeological remains also reflect harbour works for the Late Byzantine period, but only to a limited extent. Besides wooden piers, these comprise often rough and seemingly provisional constructions that no longer reflect any representative infrastructure. Interestingly, by the use of a double-box construction method, Roman harbour engineering seems to have continued even into early modern times.

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Summary / Zusammenfassung

Some Reflections on the Archaeology of the Late Antique and Byzantine Harbours of Constantinople

In 2004, one of the largest infrastructural projects ever conducted in Istanbul brought to light the first material evidence on the largest harbour of the Byzantine capital at Yenikapı district, notably the Theodosian harbour. Performed by the Istanbul Archaeological Museum, the archaeological excavations of a number of construction sites have among 37 shipwrecks of the Early to Late Byzantine periods also yielded evidence on Byzantine harbour architecture. Nevertheless, while the shipwrecks and small finds have received tremendous scholarly attention, the architecture and engineering techniques of the Byzantine harbour infrastructures have been largely omitted, despite their evident significance.

With these premises, this chapter presents the first comprehensive analysis of the archaeological evidence related to the harbours of Byzantine Constantinople with a particular focus on the study of their architectural characteristics. On the basis of the available material remains from the Theodosian harbour at Yenikapı, the harbour of Chrysopolis at Üsküdar and Neorion/Prosphorion at Sirkeci, the chapter aims to interpret various architectural features in the light of dendrochronological and archaeological evidence. In doing so, the authors try to contextualize the physical remains of these harbour sites and put them into a wider historical frame. This suggests a slightly alternative chronology, which shall initiate a scholarly debate on the development of harbour architecture and underwater construction techniques in Byzantium.

Überlegungen zur Archäologie der spätantiken und byzantinischen Häfen von Konstantinopel

Im Jahr 2004 brachte eines der größten jemals in Istanbul durchgeführten Bauprojekte erstmals materielle Hinterlassenschaften verschiedener Hafengebiete zum Vorschein, so auch des Theodosioshafens im Bezirk Yenikapı. Die vom Archäologischen Museum Istanbul an einer Reihe von Baustellen durchgeführten Ausgrabungen haben neben 37 Schiffswracks der früh- bis spätbyzantinischen Epochen auch zahlreiche Bauelemente der Hafeneinrichtungen freigelegt, welche bedeutende Einblicke in die byzantinische Hafenarchitektur liefern. Dennoch wurden, anders als bei den Wrackfunden und ihren Schiffsladungen, der Architektur und dem Ingenieurwesen der byzantinischen Hafeninfrastruktur bislang kaum wissenschaftliche Aufmerksamkeit geschenkt, trotz ihrer offensichtlichen Bedeutung.

Unter dieser Prämisse, versucht dieses Kapitel eine erste umfassende Analyse der archäologischen und architektonischen Befunde zu geben, wobei ein besonderer Schwerpunkt auf die historische Bauforschung der Häfen Konstantinopels gelegt wird. Auf der Grundlage der verfügbaren materiellen Hinterlassenschaft aus dem theodosianischen Hafen in Yenikapı, dem Hafen von Chrysopolis in Üsküdar und Neorion/Prosphorion in Sirkeci, werden verschiedene architektonische Merkmale im Lichte dendrochronologischer und archäologischer Untersuchungen interpretiert und in einen gesamthistorischen Kontext gestellt. Dabei ergeben sich neue Überlegungen und Datierungsvorschläge zu den besagten Hafenstandorten, welche eine wissenschaftliche Debatte über die Entwicklung byzantinischer Hafenarchitektur in Zusammenhang mit historischen Bautechniken im maritimen Bereich einleiten mögen.

Fig. 1 Aerial view of the archaeological excavations at Yenikapı. – (From Kızıltan et al., Istanbul Marmaray 26).

Fig. 2 Yenikapı excavation site plan. – (Drawing A. Ercan after Kızıltan et al., Istanbul Marmaray Site Plan).

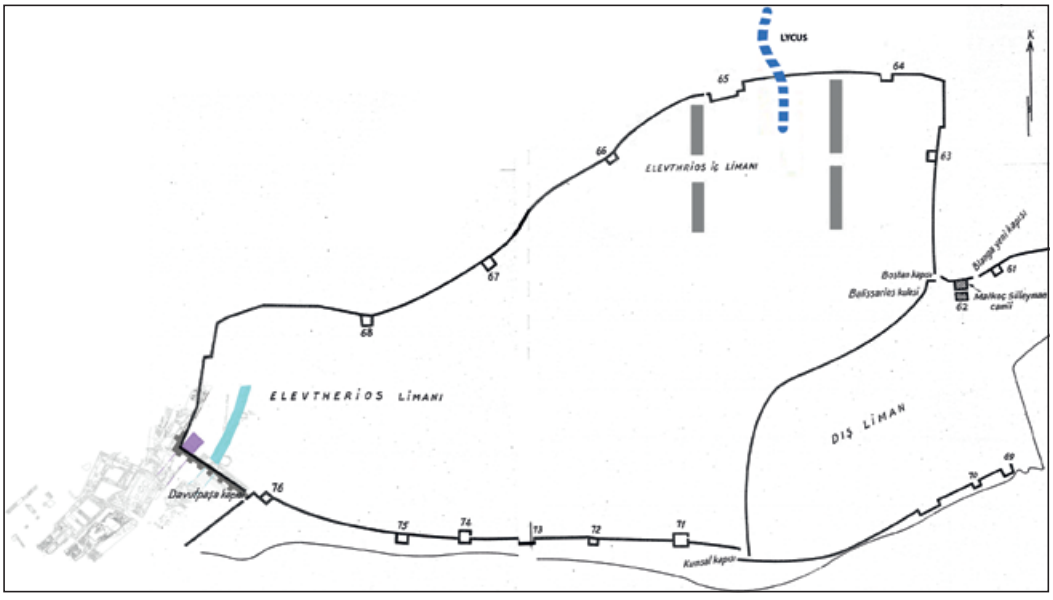

Fig. 3 Yenikapı harbour architectural plan. – (Drawing A. Ercan after Dirimtekin, Fetihten Plan 5-6, from Ercan, Yenikapı 104).

Fig. 4 Yenikapı, eastern jetty from the south. – (Photograph A. Ercan, from Ercan, Yenikapı 121).

Fig. 5 Northern facade of the eastern jetty, Yenikapı. – (Photograph A. Ercan, from Ercan, Yenikapı 163).

Fig. 6 Yenikapı, formwork of the eastern jetty, from the east. – (Photograph A. Ercan, from Ercan, Yenikapı 122).

Fig. 7 Yenikapı, concrete filling of the wooden formwork. – (Photograph A. Ercan, from Ercan, Yenikapı 122, detail).

Fig. 8 Yenikapı, *spolia* block from the southern facade. – (Photograph A. Ercan, IAM Archive).

Fig. 9 Yenikapı, *spolia* block from the eastern facade. – (Photograph A. Ercan, from Ercan, Yenikapı 164).

Fig. 10 Yenikapı, chamber filling of the eastern jetty. – (Photograph A. Ercan, from Ercan, Yenikapı 164).

Fig. 11 Yenikapı, eastern jetty looking south with remains of chamber filling. – (Photograph A. Ercan, from Ercan, Yenikapı 162).

Fig. 12 Yenikapı, grooves for metal clamps at eastern jetty. – (Photograph A. Ercan, from Ercan, Yenikapı 163).

Fig. 13 Yenikapı, stone slab covering of eastern jetty. – (Photograph A. Ercan, from Ercan, Yenikapı 162).

Fig. 14 Yenikapı, extension of the eastern jetty looking east. – (Photograph A. Ercan, IAM Archive).

Fig. 15 Yenikapı, wall extension of eastern jetty looking north. – (Photograph A. Ercan, from Ercan, Yenikapı 161).

Fig. 16 Harbour structures at Üsküdar. – (Photograph E. Engin, from Karagöz, Khrysopolis Liman 413).

Fig. 17 Yenikapı, western jetty. – (Photograph A. Ercan, IAM Archive).

Fig. 18 Yenikapı, western jetty. – (Photograph A. Ercan, from Ercan, Yenikapı 162).

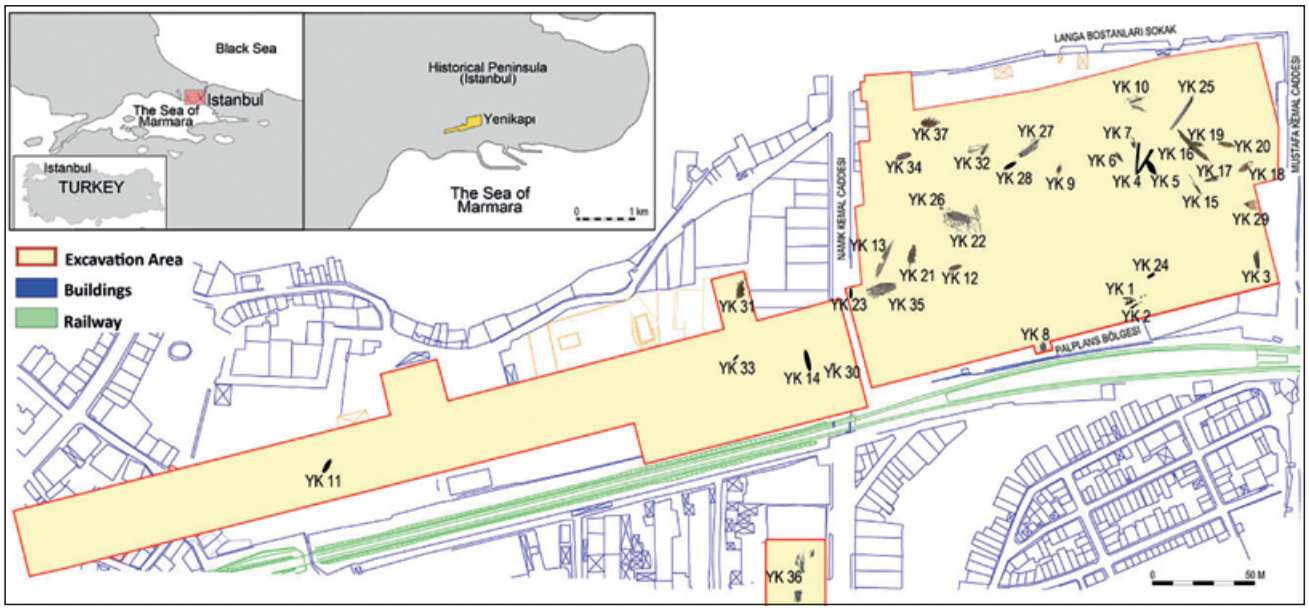

Fig. 19 Yenikapı, distribution of shipwrecks on site. – (Drawing IU Yenikapı Shipwrecks Project Archive, from Kocabaş, Byzantine–era Shipwrecks 10).

Fig. 20 Yenikapı, locations of shipwrecks in the eastern harbour basin. – (Drawing A. Ginalis after Kızıltan et al., Istanbul Marmaray Site Plan).

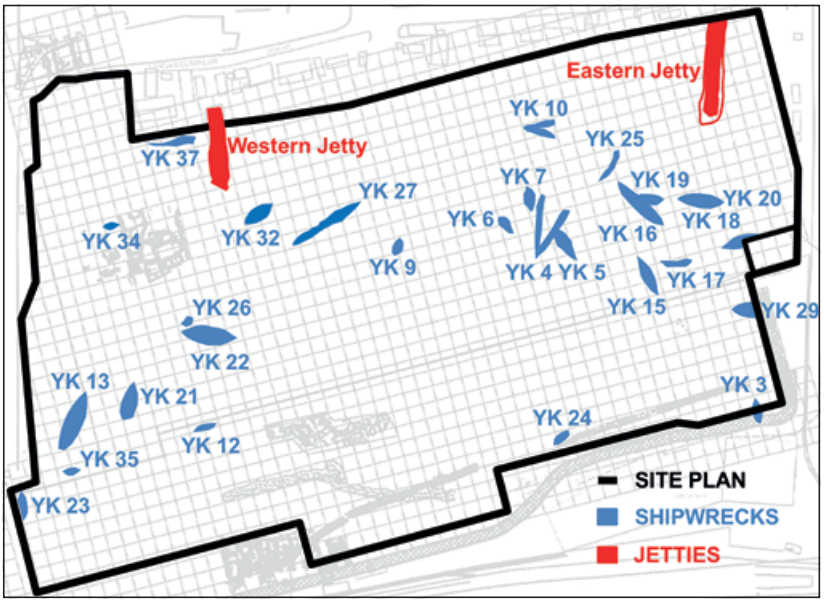

Fig. 21 Yenikapı, western jetty looking north-west. – (Photograph A. Ercan, from Ercan, Yenikapı 162).

Fig. 22 Yenikapı, architectural members found by the western jetty. – (From Kızıltan et al., Istanbul Marmaray 149).

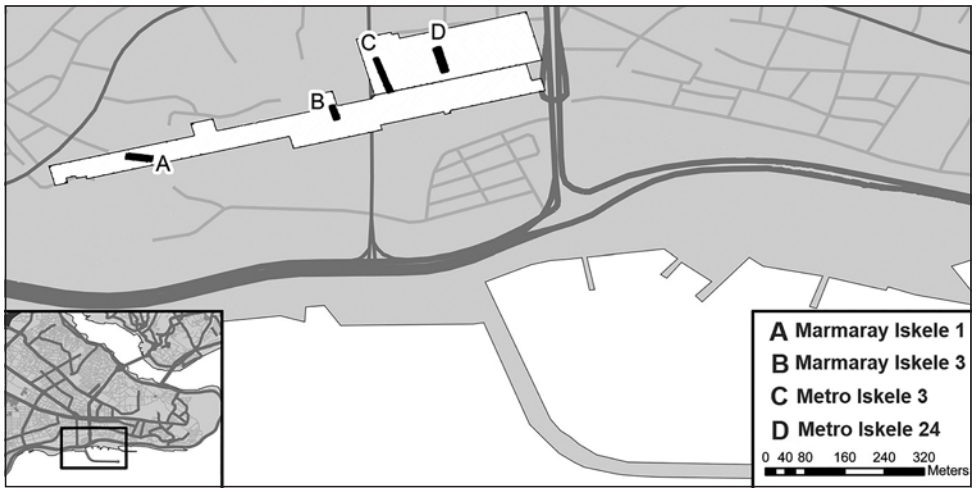

Fig. 23 Yenikapı, locations of wooden piers. – (Drawing A. Ginalis, after Pearson et al., Dendroarchaeology 3404).

Fig. 24 Yenikapı, wooden pier south of western jetty. – (Photograph A. Ercan, IAM Archive).

Fig. 25 Yenikapı, architectural remains on the western end of the harbour, looking south. – (Photograph B. Köşker, IAM Archive, from Gökçay, Architectural Finds 170).

Fig. 26 Yenikapı, quayside and sea wall on the western end of the harbour. – (Photograph B. Köşker, IAM Archive, from Ercan, Yenikapı 113).

Fig. 27 Yenikapı, quayside discovered at the western end. – (Photograph B. Köşker, IAM Archive, from Ercan, Yenikapı 120).

Fig. 28 Yenikapı, inscribed *spolia* block on the quayside. – (Photograph B. Köşker, IAM Archive).

Fig. 29 **a-b** Yenikapı, *spolia* block and pierced stone block on the quayside. – **c** Jetty with pier extension in the Light Rail System Area north-west of Yenikapı excavation site. – (a-b photographs B. Köşker, IAM Archive; c from Kızıltan, İstanbul Kazıları 360).

Fig. 30 Yenikapı, quayside, western end of the harbour looking west. – (Photograph B. Köşker, IAM Archive).

Fig. 31 Yenikapı, western end of the quayside. – (Photograph B. Köşker, IAM Archive).

Fig. 32 Yenikapı, row of holes for wooden beams. – (Photograph B. Köşker, IAM Archive, from Gökçay, Architectural Finds 171).

Fig. 33 The Harbour of Julian/Sophia. – (Photograph Sébah & Joaillier, http://www.eskiistanbul.net).

Fig. 34 Yenikapı, part of inner circuit wall enclosing the harbour basin. – (Photograph A. Ercan, from Ercan, Yenikapı 159).

Fig. 35 Yenikapı, group of stamped bricks scattered on the seabed. – (Photograph A. Ercan, from Ercan, Yenikapı 160).

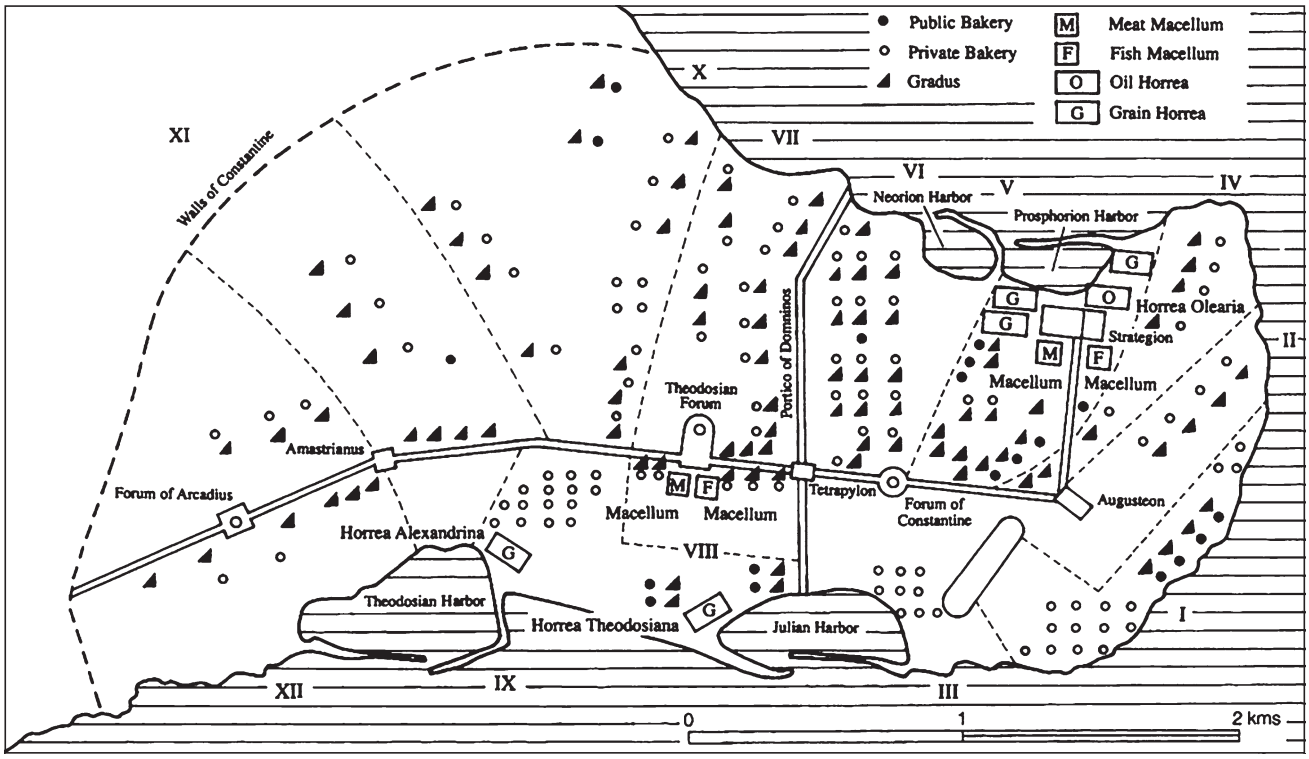

Fig. 36 Map of the distribution of commercial installations in the regions of Constantinople. – (Drawing A. Wilkins, from Mundell Mango, Commercial Map fig. 4).

Fig. 37 The so-called »Constantinian Wall«. – (From Kızıltan et al., Istanbul Marmaray 92).

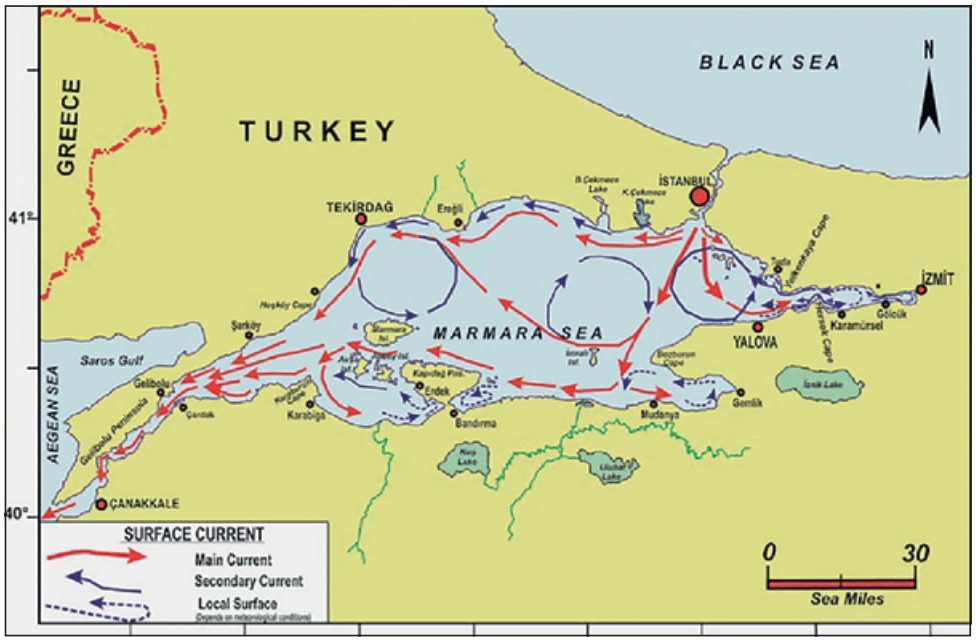

Fig. 38 Surface currents in the Sea of Marmara. – (Drawing M. Eryılmaz, from Meriç et al., Alien Benthic Foraminifers from Turkish Strait System. IJEGEO 5/1, 2018, 70).

Fig. 39 Reconstruction of the Harbour of Theodosius (at Yenikapı). – (From Byzantium1200.com, © Byzantium 1200).

Fig. 40 Map of Constantinople highlighting the Harbour of Theodosius. – (Drawing A. Ginalis after Constantinople during the Byzantine period by Cplakidas, licensed under CC BY 3.0).

Fig. 41 Quay section at Sirkeci (East Shaft). – (From Kızıltan, İstanbul Kazıları 365).

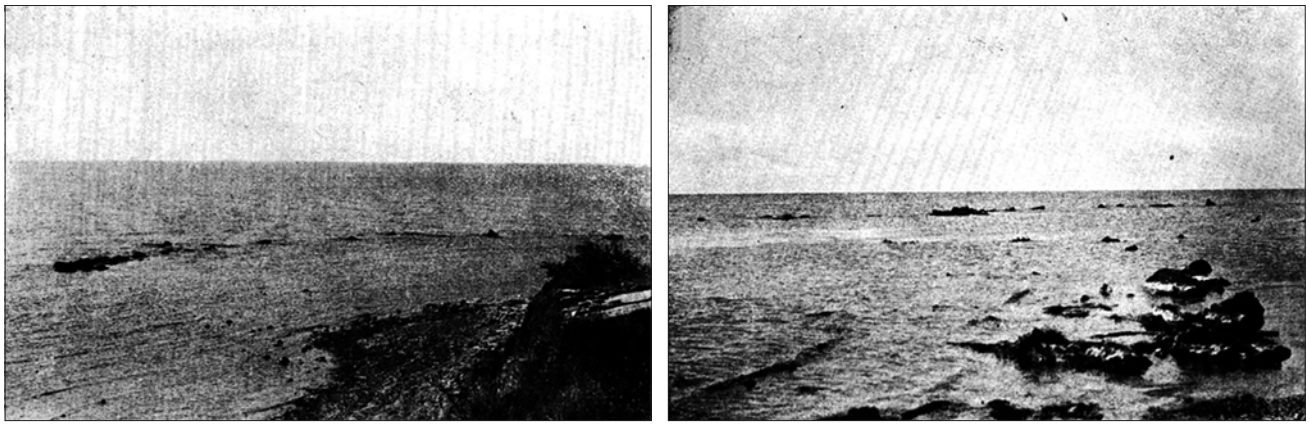

Fig. 42 Remains of the harbour at Hebdomon. – (From Demangel, Contribution 46-47).

Fig. 43 Remains of harbour structures at Brachialion. – (Photograph Sébah & Joaillier, from http://www.eskiistanbul.net).

Fig. 44 Eastern harbour basin of the Harbour of the Boukoleon Palace. – (Photograph E. Mamboury / Th. Wiegand, from DAI Istanbul (D–DAI–IST–1007, D–DAI–IST–1015, D–DAI–IST–2777).

Fig. 45 Façade of the Harbour of the Boukoleon Palace, facing the harbour. – (Photograph E. Mamboury / Th. Wiegand, from DAI Istanbul (D–DAI–IST–1020).

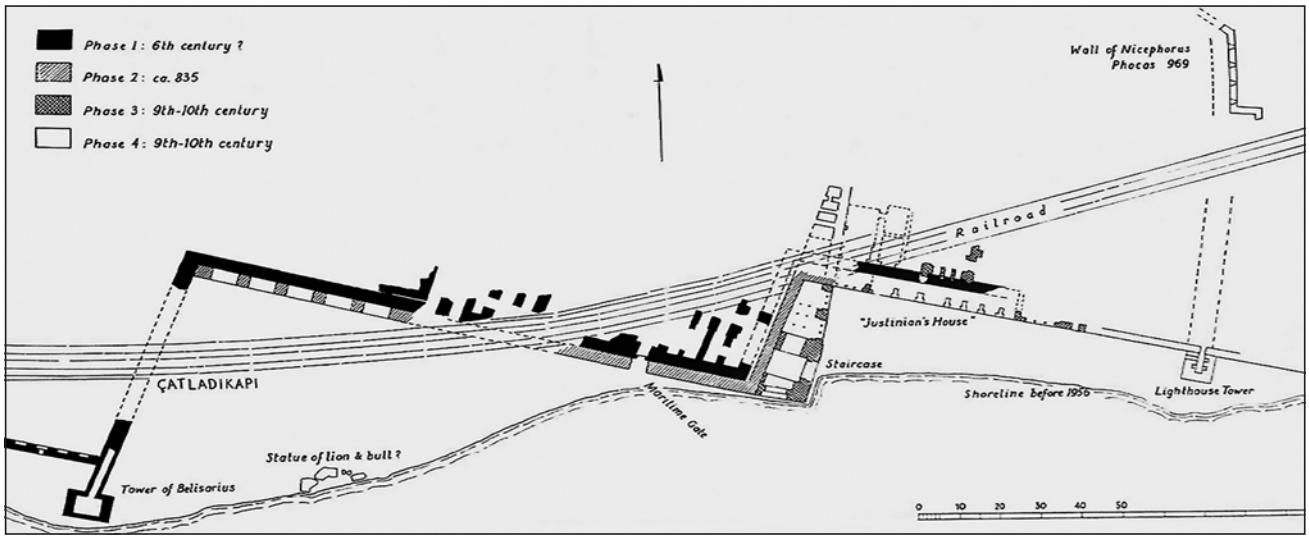

Fig. 46 Construction phases of the Harbour of the Boukoleon Palace. – (From Mango, Spolia 651).

Fig. 47 Quayside along the eastern harbour basin at Boukoleon. – (Photograph G. Berggren, from http://www.eskiistanbul.net).

Fig. 48 Chamber system applied at the quayside of the Harbour of the Boukoleon Palace. – (Photograph A. Ginalis after E. Mamboury / Th. Wiegand & G. Berggren, from DAI Istanbul (D–DAI–IST–1020) / http://www.eskiistanbul.net).

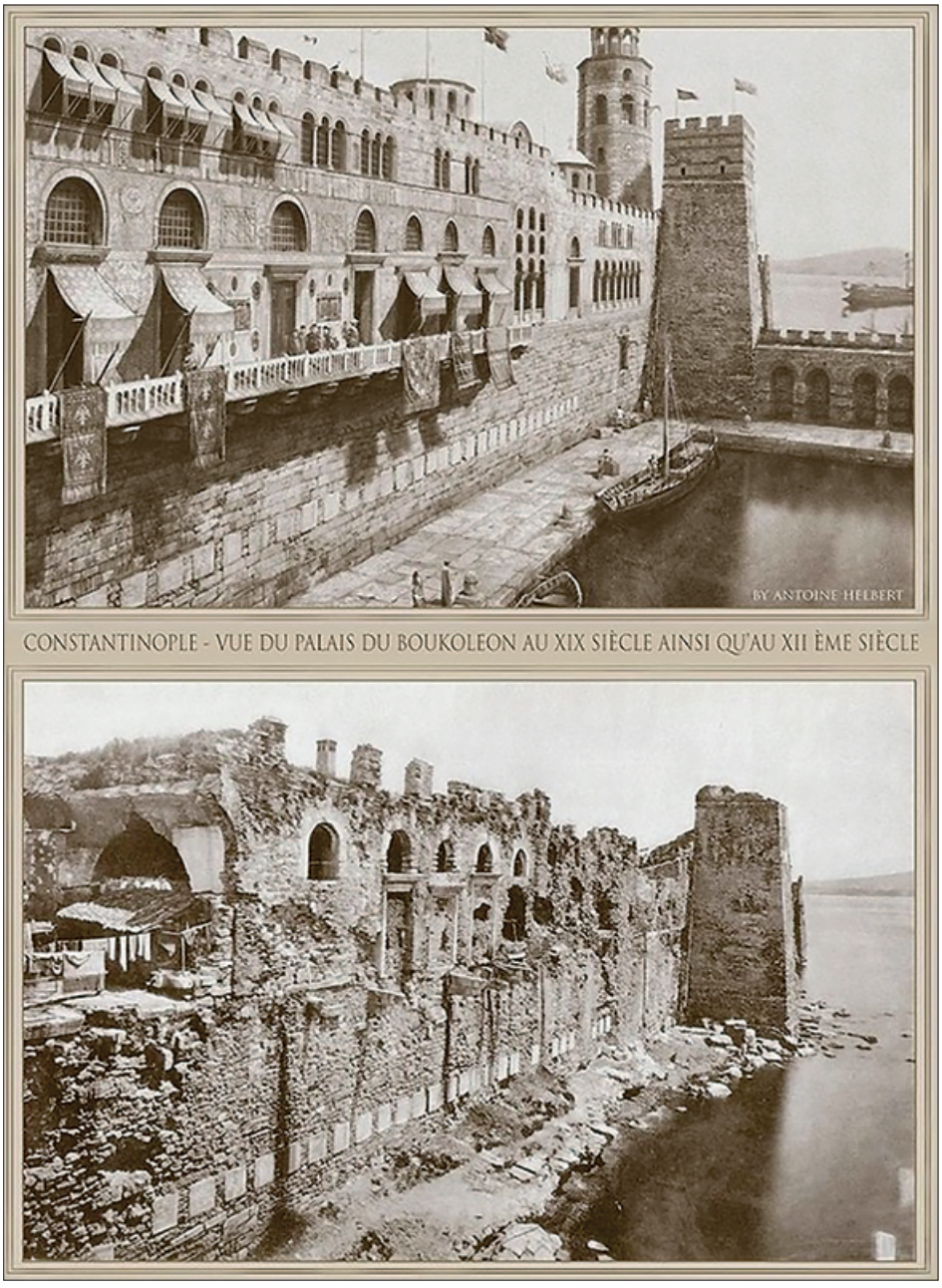

Fig. 49 Reconstruction of the quayside of the Harbour of the Boukoleon Palace. – (Drawing A. Helbert, from http://www.antoine–helbert.com/fr/portfolio/annexe–work/byzance–scenes.html, 16 September 2020).

Fig. 50 Reconstruction of the Harbour of the Boukoleon Palace. – (Drawing A. Helbert, from http://www.antoine–helbert.com/fr/portfolio/annexe–work/byzance–architecture.html, 16 September 2020).

Fig. 51 Eastern gate of the grand staircase at the Harbour of the Boukoleon Palace. – (Photograph E. Mamboury / Th. Wiegand, from DAI Istanbul (D–DAI–IST–1003).

Fig. 52 Departure of Gregory of Nazianzus from a wooden pier construction. Codex Taphou 14. F. 265r, Library of the Greek Orthodox Patriarchate Jerusalem. – (From Aidoni et al., Journeys 21).

Fig. 53 Remains of a wooden pier section at Üsküdar. – (Photograph Ş. Karagöz, from Karagöz, Chrysopolis 48).

Fig. 54 Wooden pier with cover planks at Üsküdar. – (Photograph Ş. Karagöz, from Karagöz, Marmaray–Üsküdar 104).

Fig. 55 Excavation site at Üsküdar. – (Photograph Ş. Karagöz, from Karagöz, Marmaray–Üsküdar 99).

Fig. 56 Mole construction at Üsküdar. – (Photograph E. Engin, from Karagöz, Khrysopolis Liman 403).

Fig. 57 Inscribed mooring stone at Üsküdar. – (Photograph D. Güner, from Karagöz, Khrysopolis Liman 414).