Oxford Centre for Maritime Archaeology Monographs

Alexandria and the North-Western Delta

Joint Conference Proceedings of *Alexandria: City and Harbour* (Oxford 2004) and *The Trade and Topography of Egypt's North-West Delta* (Berlin 2006)

Edited by Damian Robinson and Andrew Wilson

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5: The Development and Operation of the Portus Magnus in Alexandria – An Overview

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1. The Bay of Alexandria and the IEASM Project

Fieldwork and research perspectives

Founded by Alexander the Great in the western Nile Delta in 331 BC, Alexandria developed over several centuries as a result of specific geomorphological features and the systematic artificial development of its coastline. The Pleistocene sandstone bedrock provided a stable foundation for the construction of buildings, while also serving as a quarry. An inland lake was located behind the city, while across from it was an island. This island, named *Pharos* by the Greeks, was connected to Alexandria early on by means of a 1,200 m long causeway or *Heptastadium* that created a dual harbour complex, with the port of *Eunostos* to the west and the *Portus Magnus* (or *Magnus Portus*) to the east. The objective of the research project launched in 1992 by the *Institut Européen d'Archéologie Sous-marine* (IEASM) in cooperation with the Supreme Council for Antiquities of Egypt (SCA) was to determine the precise ancient topography of the Eastern Port of Alexandria now under water (Figure 5.1).[1] This study has included both the geodynamic research of natural and anthropic features and the analysis of the co-evolution of ancient

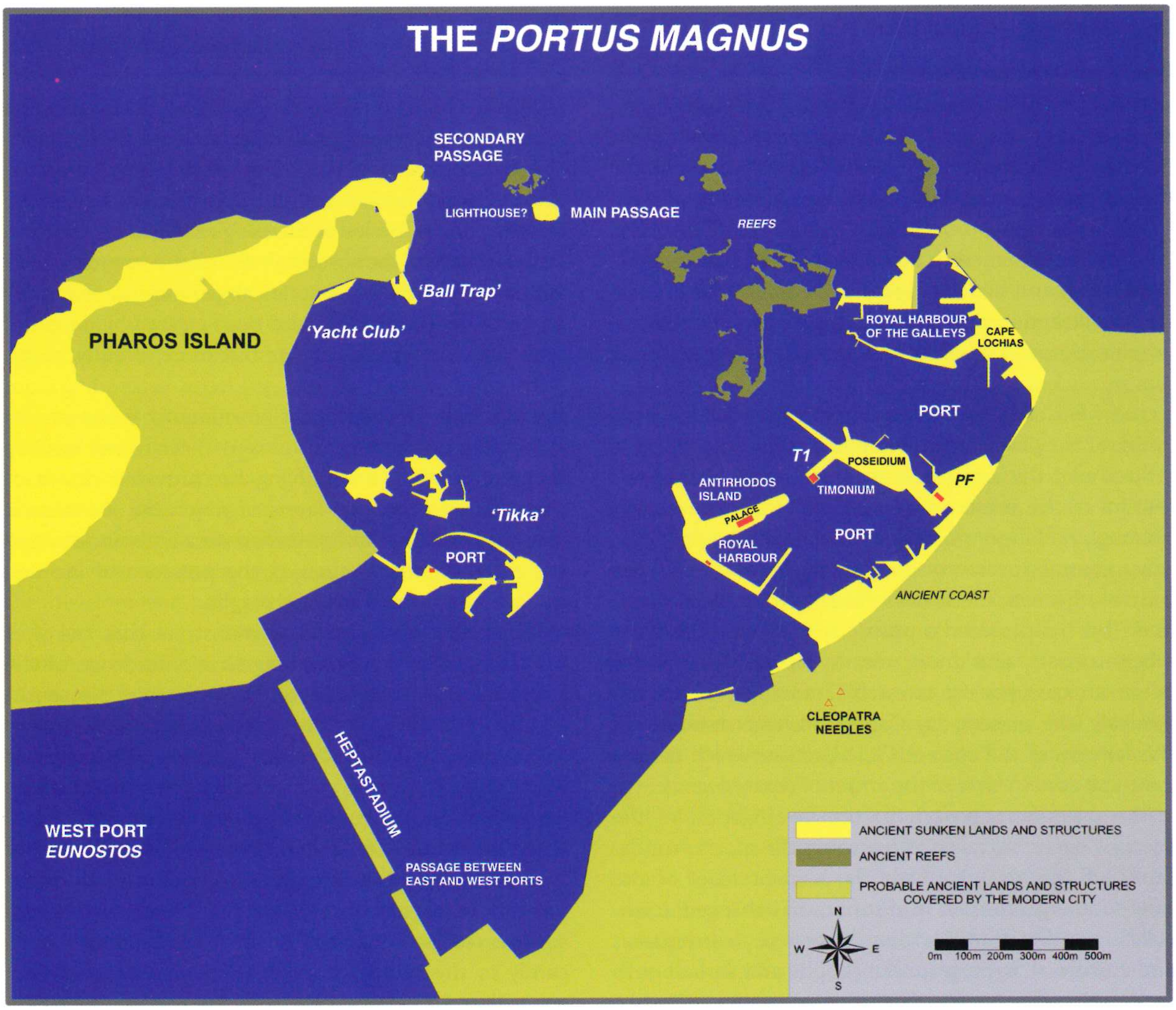

Figure 5.1 The ancient topography of the *Portus Magnus*. (© Franck Goddio/Hilti Foundation.)

society and the coastal area of the western Nile Delta. The comprehensive cartographic work carried out on the land and port infrastructure of the Bay of Alexandria has been complemented by the work completed in the Bay of Aboukir, approximately 30 km to the north-east.[2] Together the work of IEASM off the coast of Egypt in conjunction with the rediscovery and investigation of other archaeological sites in the coastal regions of the south-eastern Mediterranean[3] is offering new research perspectives. Such work includes physical geography, geomorphological prospecting, palaeobotany and marine biology and integrates these with the study of the circumstances and chronology of the phenomena which led to the submersion of the shores. Overall these new studies highlight the need to take into account the individual nature of each site, due to the variable influence of sedimentary dynamics, fluctuations in local sea-level and the importance of the physical surroundings in relation to the economic and political organisation of the area.[4]

The general objectives of the research project and its scientific approach

Taking into account the archaeological results of the last decade or so, the research objectives of this project were to understand how the *Portus Magnus* of Alexandria was organised. A broader goal was to define the overall role the site played for local coastal communities.

The scientific approach to the study of the *Portus Magnus* was designed to utilise the full range of geomorphological[5] and archaeological data, as well as literary, epigraphic and iconographic sources. Extensive historiographical knowledge of the accounts of the first explorers was also essential to the study.[6] These data have provided a crucial link between the monuments from antiquity still visible at the time when the early travellers' reports were written and the area under examination, which covers 400 ha of the present day Eastern Port. For example, although no longer visible beneath the modern city, the exact coastal position of the *Caesareum*, marked in the past by the two 'Cleopatra's Needles', has been identified. This has provided a precise spatial reference point where ancient and more recent textual descriptions of an archaeologically attestable monument coalesce. Similarly, the present-day Cape Silsileh corresponds to the remains of the ancient Cape Lochias, which demarcates the eastern limit of the ancient *Portus Magnus*.

The scientific approach to the investigation of the *Portus Magnus* has taken into account the specific topography of the areas studied. The ancient relief of the now-submerged former land surface has changed drastically over the centuries due to seismic (earthquakes and tsunamis), hydrographical (floods and variations in sea-level) and geological (subsidence) events. However, the properties of the land by no means stopped changing once submerged; in fact the opposite has been the case. Once under water, the land was no less subject to seismic change and sediment, current, swell and wave activity. Furthermore, the top layer of the seafloor mainly consists of sand and alluvia from the Nile, carried by currents from the east. In Alexandria large amounts of this sediment have accumulated over the centuries in the west of the port. The deposition of sediment has resulted in the infilling of the area around the ancient *Heptastadium* causeway, upon which an entire city neighbourhood has now been built.[7] It is likely that numerous areas of the ancient port and city have been covered with sediment. While it is certainly possible to locate artefacts and structures by means of isolated excavations, such an approach was simply not appropriate for the study of the entire *Portus Magnus*. However, the simple observation of the current state of the seafloor using geophysical and geological prospecting instruments (bathymetric sounders, lateral scanning sonar, sediment sonar, magnetometer and geological core drilling) also failed to provide full insight into the ancient topography. Instead an understanding of this would only prove possible by prospecting with state-of-the-art electronic detection instruments, such as magnetometers utilising nuclear magnetic resonance (NMR) technology. One effective method of locating underwater archaeological ruins covered in sediment was to use sensitive NMR magnetometers to create a very high definition magnetic map. This indicates the location of the buried archaeological ruins by continuously measuring the absolute value of the magnetic field, with a sensitivity of about 1/100 gamma. An electronic image of the seafloor has also been created by means of scanning with side-scan sonar and, more recently, multibeam sonar, which has revealed items protruding from the sediment. This additional information has been useful in locating archaeological remains that are not entirely covered. Sub-bottom profiling has provided details of the different geological layers of which the sediment is composed and has also provided details about localised seismic phenomena, such as the presence of inclined sedimentary layers, horst and diapirs.

The results of this work demonstrate that the sites were subject to both the long-term subsidence of the land that commonly affects this section of the south-eastern basin of the Mediterranean as well as short-term cataclysmic sediment failure. Together these factors, which may have operated independently or together, would have caused considerable destruction and explain the submergence of the *Portus Magnus* as well as other large parts of the Canopic region.[8] All of the evidence has shown that regular subsidence and the rising sea-level – observed since ancient times – contributed significantly to the submergence of the *Portus Magnus*. It is generally acknowledged that the sea-level in Alexandria has risen by 1 to 1.5 m and the land level dropped by

5 to 6 m over the last 2,000 years producing a relative sea-level change of 6–7.5 m.[9] The southern coast of the eastern Mediterranean has also been subject to various forms of tectonic movement due to subduction of the African plate under the Anatolian plate.[10] Ancient texts give accounts of earthquakes and tsunamis affecting the region,[11] especially the tsunami of 21st July 365, which affected the south-eastern Mediterranean coastline,[12] as well as the earthquake in the mid-eighth century.[13]

2. An overview of the topography of Alexandria's *Portus Magnus* and issues to be considered

Texts versus archaeology

While geophysical prospection in the Port of Alexandria and subsequent underwater excavations have failed to reveal the splendour of the palaces of Alexandria, they have generated excellent cartographic details of the Eastern Port and its surroundings. This new view of Alexandria can be compared to views of the port offered in ancient literature in order to facilitate its interpretation. The available sources, however, must be treated with varying degrees of caution and a critical distinction must be made between the accounts of Classical, Greek, Latin and Arab authors whose reports vary in their accuracy from Strabo as an authentic eyewitness, through Pliny's over-succinct textual information, to the (second or third century AD) *Alexander Romance* which contains descriptions of Alexandria during Alexander's reign embellished with legends from various periods.[14] While the new topographical map of the *Portus Magnus* is informed by the descriptions provided by ancient authors, it is based soundly upon an accurate and detailed understanding of the actual situation in the field. The ruins of vast built-up areas have been found. These were preserved by their submersion from being dismantled and subsumed beneath the developing city, as happened to other areas of the ancient city from medieval times through to the present.[15] We are still a long way from being able to date the development and transformations of each sector, assign a function or name to many of the structures, or determine or date the circumstances that reduced the site to chaotic ruins (Figure 5.2). Nevertheless, by analysing the configuration and composition of the site and the anthropic and geological substrata of the areas still accessible to marine exploration, it is possible to determine step by step the extent to which buildings were levelled, the areas of subsidence, signs of reuse, sawing or technical reworking of masonry, intentional destruction following the desecration of pagan temples, attempts to protect the coast from potential tsunamis or to alleviate the results of subsidence, and so on.

The research has allowed the contours of the former land surface to be traced with a certain degree of accuracy (*cf.* Figure 5.1), and in some cases has provided information on the structures and buildings which once stood near the palaces, such as the royal ports, the *Timonium* and the island of *Antirhodos*, as well as the ancient sea walls. This research has revolutionised our topographical knowledge of the port infrastructure leading to the *Basileia*, a seafront palace complex containing a series of government buildings and cultural institutions. The results have also radically changed our topographical knowledge of the ports and palaces of Alexandria. The study of the harbours has focused on determining their depths and sedimentation type, identifying shipwrecks and tracing the plan of the docks. The numerous architectural elements covering the palace area were identified and studied and limited excavations carried out to determine the timeline of the development, abandonment and destruction of the sites. The layout of the ports turns out to be more technically coherent than previously believed.[16]

The results of the archaeological research in Alexandria's *Portus Magnus* will not be discussed in detail here. The forthcoming publication *Alexandria. The Topography of the Portus Magnus. Underwater Archaeology in the Eastern Port of Alexandria in Egypt*[17] will present a detailed analysis of the discoveries, prospecting areas, soundings, timelines, possible parallels with ancient texts and so on. Nonetheless, we shall discuss here a number of points concerning the infrastructure of the Eastern Port. The results provide a basis for a technical examination of the choice of the site and the architecture of the ancient port.

Recent archaeological work has identified built-up areas to the west of the 'Royal Port' (in the central area of the Bay of Alexandria), highlighting the complexity of the *Portus Magnus*' infrastructure. While it remains unclear as to exactly how such structures were organised, the results shed new light on the navigable routes inside the *Portus Magnus*, confirming that it was 'wonderfully concealed'.[18] The eastern part of the great port is, in fact, delimited by a large stretch of land, now under water, which formed part of the ancient Cape Lochias. Appreciably wider and extending over 450 m west-north-west of present-day Cape Silsileh, it provided considerable natural protection for the *Portus Magnus*. Evidence shows that the small modern dyke made of concrete blocks protecting the western face of Cape Silsileh was constructed on ancient foundations. Similarly, the large modern 800 m long dyke at the western end of the cape has definitely been constructed partly on an ancient dyke. Since this part of the Port of Alexandria was exposed to north-westerly offshore swells, the construction of a dyke was necessary to add to the natural protection provided by the reefs, which protruded from the sea at that time.

A very sheltered port was established in Cape Lochias, with two docks and a surface area of approximately 7 ha. This port was closed to the south-west by a large 250 m long jetty extending from a rocky headland that

Figure 5.2 Red granite columns, on the 'ancient coast' in the south-east of the *Poseidium* peninsula. (Photo: Christoph Gerigk © Franck Goddio/Hilti Foundation.)

jutted out 180 m. The jetty, approximately 10 m wide, was made of limestone and mortar. The north-western third of the jetty is extremely well preserved and rises more than 3 m from the floor of the port. The excavation uncovered a counter-dyke made of limestone gravel in the southern dyke section of the shipyard port. The entrance to the port is located to the north-west, defined by a small sea wall also made of limestone and mortar. The inside of the port is divided into two docks by a sea wall parallel to the main jetty, 110 m long by 20 m wide and constructed from limestone blocks of various sizes. These elements combine to form a well-concealed port almost inserted into Cape Lochias. The narrow entrance is fully protected from swells by the northern reefs and by the refraction of the large jetty and small sea wall. Since the large central reef had to be navigated to enter the port, only oared vessels like galleys would have been able to enter easily.

The discoveries here correspond to ancient texts. According to Strabo: 'Above these buildings (in Cape Lochias) lies a concealed man-made port, private property of the kings'.[19] Julius Caesar writes: 'This area of the city (where Caesar was entrenched) contained a small part of the royal palace where he himself had been brought to lodge on arrival, and the theatre, adjacent to the palace, which served as a citadel and provided access to the port and the royal shipyards'.[20] It is also likely that the port, in view of its small size, would have been associated with another military port. Caesar, in fact, reports that he was able to set fire to 72 ships from where he was stationed. It is rather difficult to imagine how the inside of the port could have accommodated such a fleet.[21]

A large port was established between the south-western jetty of the inner port and the *Poseidium* peninsula, measuring 500 m long by almost 300 m wide, or approximately 15 ha. The port entrance, facing north-west, was protected from waves and swells by the reefs. The purpose of the large breakwater at the end of the peninsula was to offset the swells coming via the main channel of the *Portus Magnus* and refracted by the island of *Antirhodos*. The breakwater most probably had an additional port control function, reducing the space between the peninsula and the large central reef. The port structures included three jetties, two of which protruded from the peninsula. The third jetty, located to the north-west and approximately 80 m long, was positioned perpendicular to the large jetty in the inner port. This jetty, built from limestone blocks of various sizes, prevented residual swells from penetrating the port. Extensive port infrastructure was developed across the *Poseidon* peninsula (Figures 5.3–6), including a large breakwater protruding from the north-western end of the peninsula.

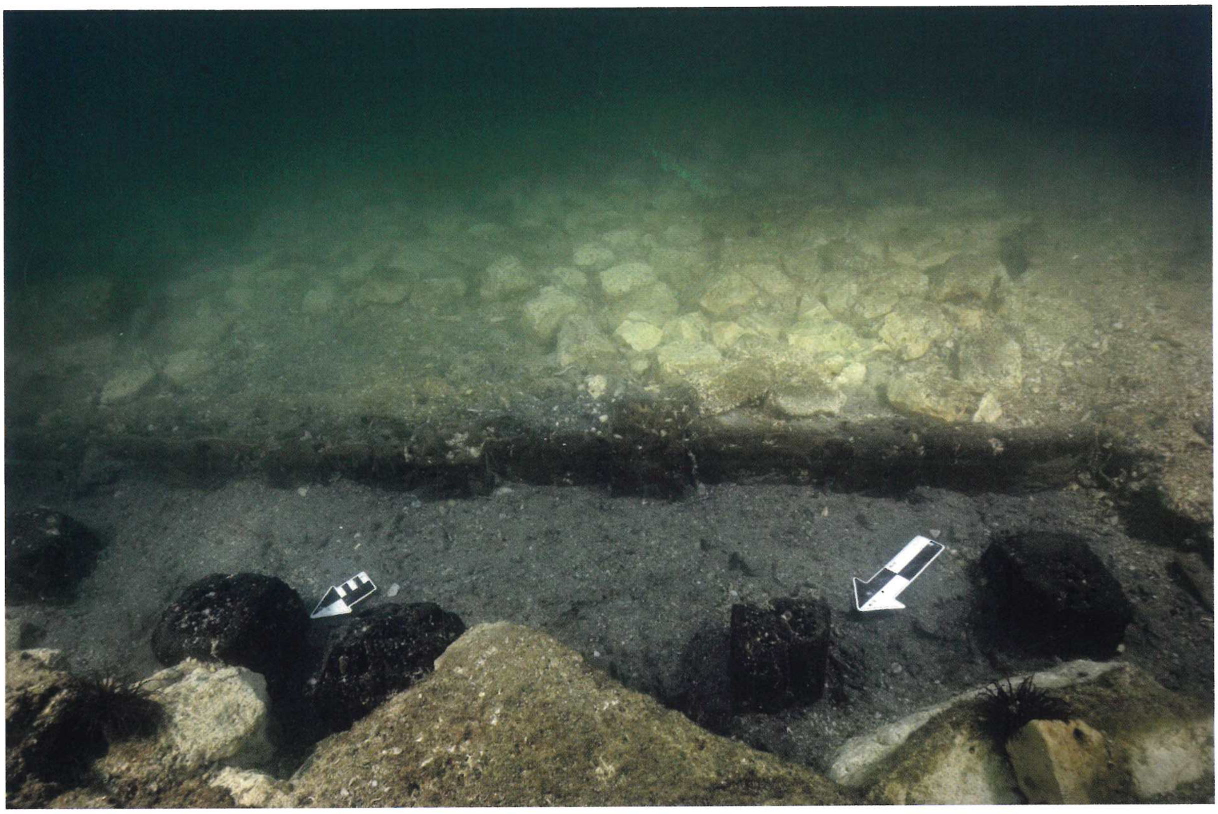

Figure 5.3 Port structures assembled from piles and wood planks that support a structure made of limestone blocks, PF sector, north-eastern part of the *Poseidium* peninsula. (Photo: Christoph Gerigk © Franck Goddio/Hilti Foundation.)

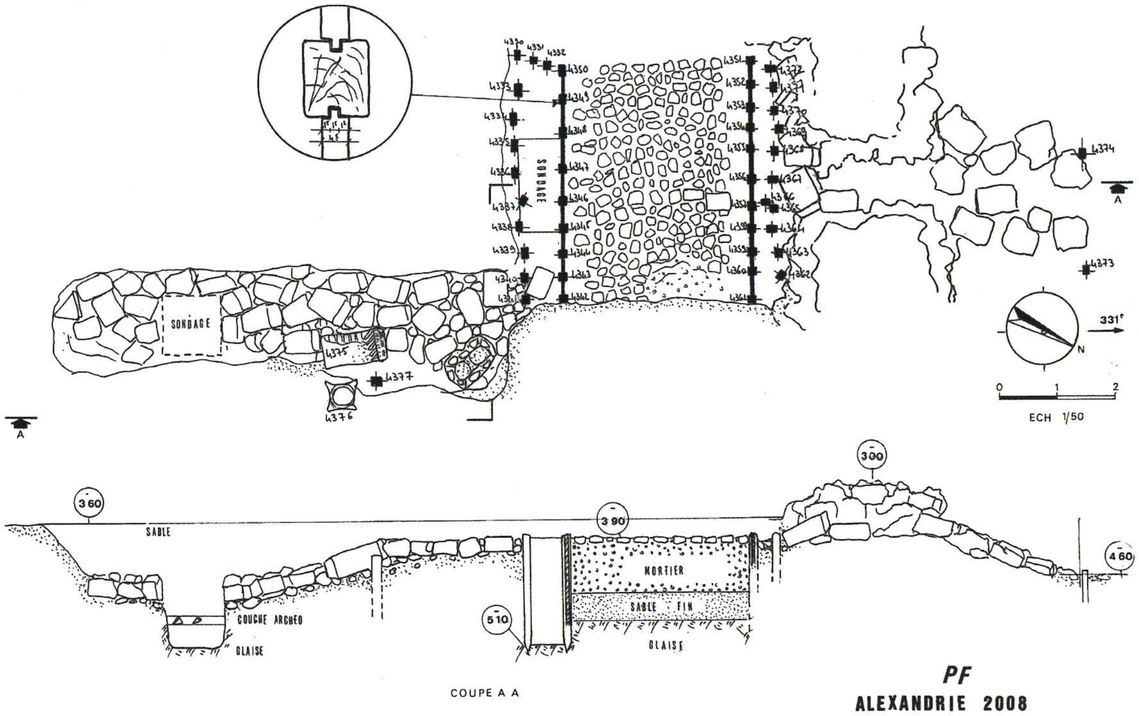

Figure 5.4 Plan and section of the port structures assembled from piles and wood planks that support a structure made of limestone blocks, PF sector, north-eastern part of the *Poseidium* peninsula. (Drawing: Patrice Sandrin © Franck Goddio/Hilti Foundation.)

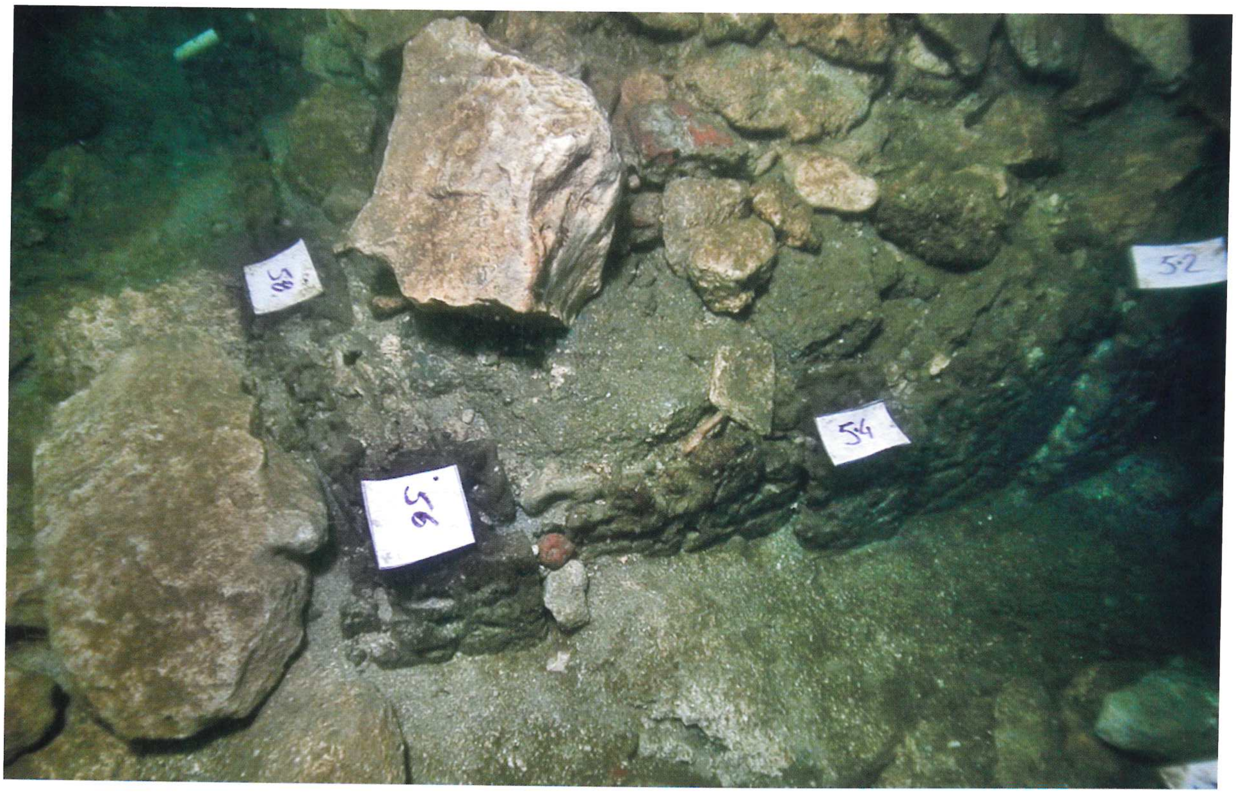

Figure 5.5 The remains of the wooden foundations (piles and planks) of the west corner of T1. (Photo: Fernando Pereira © Franck Goddio/Hilti Foundation.)

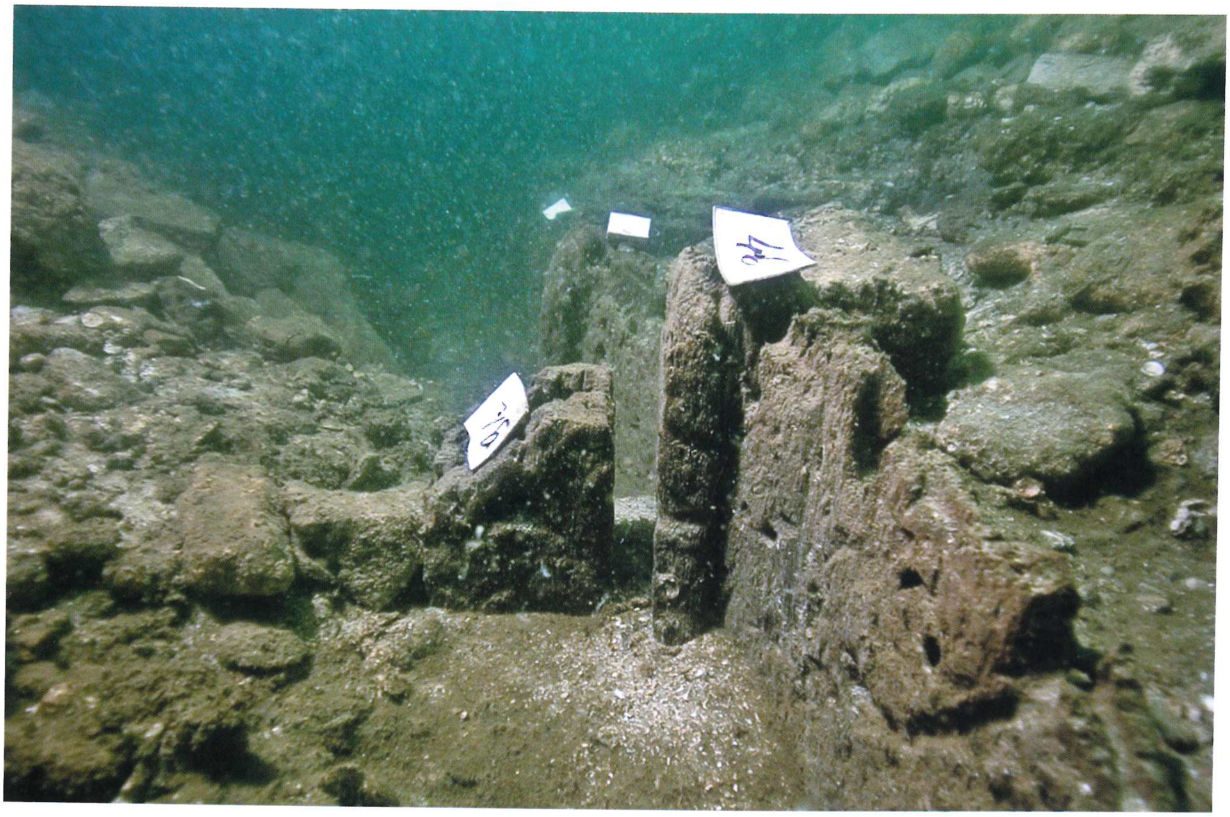

Figure 5.6 The remains of the wooden foundations (piles and planks) of T1. (Photo: Fernando Pereira © Franck Goddio/Hilti Foundation.)

The island of Antirhodos, 350 m long by 70 m wide, is located off the south-western tip of the Poseidium peninsula and may be divided into three sections. The main section, with a south-east to north-east orientation, is aligned with the sea wall and the pier extending from the tip of the peninsula and lies parallel to the ancient coast (Figure 5.7). A large sea wall protrudes from the north-western end of the island, 340 m long by 30 m wide, forming a second section. At the end of the third section, oriented north-west to south-east, a jetty built from limestone blocks protrudes north-east, forming with the island a small haven fully sheltered from swells and waves, which may correspond to the 'small port' described by Strabo: '...private property of the kings, as is *Antirhodos*, the island located before the man-made port, containing a royal palace and a small port'.[22]

The ruins of quays and piers were identified during prospecting on the 'ancient coast' (Figure 5.8).[23] In particular a large sea wall covered with limestone slabs across from the southern section of the island of *Antirhodos* was noted. Parallel to the *Poseidon* peninsula, this 30 m wide sea wall protrudes 130 m out to sea. The end forms a right angle across from the jetty on the island of *Antirhodos*. This sea wall, together with the main section and southern section of the island of *Antirhodos*, the ancient coast and the Poseidon peninsula, characterises an extremely well sheltered and organised harbour. Navigation is facilitated by two channels, 80 m and 40 m wide, respectively. This parallelogram-shaped port is the largest in the *Portus Magnus*, measuring 500 m by 320 m with a surface area of 16 ha.

The western part of the *Portus Magnus* has been explored through geophysical and archaeological prospection, surface cleaning and in some cases limited excavations in order to determine how the port structures were organised. The research carried out in the sectors commonly known as 'Tikka', 'Yacht Club' and 'Ball Trap' (named after the adjacent buildings on the modern shore) reveals the complex organisation of the Port of Alexandria without indicating any exact correspondence with ancient texts. After describing the royal quarter and port and moving from east to west, Strabo continues: 'Next comes the *Caesareum*, then the *Emporium* and the warehouses followed by the arsenals, extending as far as the *Heptastadium*'.[24] These structures were mighty installations set up under the Ptolemies and maintained under the Caesars. The arsenals and warehouses were required to keep large-scale international traffic running smoothly. This section is directly connected to the *Heptastadium*. The *Letter of Aristeas*, probably written around the mid-second century BC and describing the translation into Greek of Hebrew scriptures (the Septuagint) during

Figure 5.7 The remains of structures (limestone blocks, wooden post and mortar), *Antirhodos* Island. (Photo: Christoph Gerigk © Franck Goddio/Hilti Foundation.)

Figure 5.8 The remains of quays or an esplanade identified during prospection on the 'ancient coast'. (Photo: Christoph Gerigk © Franck Goddio/Hilti Foundation.)

the reign of Ptolemy II Philadelphus, refers to the topography of this sector of Alexandria. The letter notes that, when Demetrius Phalereus was bringing the translators to the island of *Pharos*, he 'took the men with him and crossed the breakwater (*anachoma*), seven stadia long, to the island; then he crossed over the bridge and proceeded to the northerly parts'.[25] According to Strabo and Caesar,[26] there was a bridge at either end of the *Heptastadium* for boats to pass from one port to another and possibly to offset port sedimentation.[27] According to Xenocrates of Aphrodisias (mid first century AD), there were hauling channels for ships (*diolkos*) close to *Pharos*, probably in the northern section of the *Heptastadium*.[28] Certain texts, especially that of Caesar, suggest that the sector underwent modifications. Due to the drastic changes to the buildings, it is difficult to interpret the excavated ruins. The Alexandrian War in 48–47 BC led to demolitions (*ruinae*) and the reuse of ashler blocks (*quadrata extracto saxo*) to build improvised fortifications, barricade the streets and prevent access to hostile ships.[29]

In addition to these events, history brought about further transformations. Over time the gradual silting of the western section of the *Portus Magnus*, which began after the construction of the *Heptastadium*, produced the curved coastline seen in this section of the harbour today. Consequently, the existence of all port structures in this sector of the *Portus Magnus* was determined by the *Heptastadium* and the connection between the mainland and the island of *Pharos*. It comes as no surprise that a port was established opposite the *Heptastadium*, sheltered by the island of *Pharos* – in the spot where fishermen now find shelter from the dominant winds of the western to northern area.

A port made up of several small harbours has indeed been discovered opposite the *Heptastadium* ('Tikka' sector). Most of the structures here appear to have been built from limestone blocks. Architectural elements were also uncovered during underwater surface cleaning. The results show four islets featuring jetties that were faced with stone. The archaeological excavations and differences in sedimentation have been used to define the seafloor in the ports and suggest that there were navigable routes inside the area demarcated by the islets. An extremely well preserved curved structure cut out of the natural rock appears to be a dyke.

Port structures have also been uncovered in the 'Yacht Club' sector. These structures (quays, docks, etc.) were built upon piles and oak planks (*Quercus* sp.), now 3.5 m under water (Figures 5.9–10). The piles are square (7 x 7 cm), spaced approximately 50 cm apart and support a structure made of limestone blocks. A dozen piles lying south-west to north-east have been uncovered. Two columns were also found, which may have been part of the structure. C14 dating has been carried out on the items, which suggests that the piles and planks[30] date from between AD 69–217.[31] The numerous architectural elements uncovered include limestone blocks, column bases and drums, fluted columns and quartzite and pink granite blocks. In this same area limestone slabs have been excavated from beneath 40–70 cm of sand and over a surface area of 20 m^2. The overall plan drawn up from surface excavations shows a series of structures more or less parallel to the shoreline. The arrangement of the limestone blocks appears to correspond to the initial foundations of the buildings. The quay is built from limestone and sand debris supported by three tightly spaced rows of wooden posts. The last post, which was in contact with the water, was made from pile-planks and appears to be covered with limestone slabs. A fourth row of posts can be seen on the other side of the slab arrangement. A number of items found beneath form part of a colonnade that would have stood here. These structures indicate that the land was significantly reshaped, with the ground levelled and extended into the sea. Similar forms of burial seem to have occurred throughout the sector, although this has not disturbed the substructures. These archaeological observations may be compared with the results of core drilling carried out 'on land' to verify the make-up of the *Heptastadium* and how it changed over time. The Hellenistic structure at the top of the tombolo, which definitively separates the eastern bay from the western bay, appears to have considerably accelerated the rate of change in the landscape: 'In the early Roman era, silting was observed throughout the sector. The accretion of the seafloor and growth of the tombolo accelerated. Exposed beaches developed along the *Heptastadium*.'[32] This advance on the sea may explain the construction of port structures in the 'Yacht Club' sector – and potentially the 'Ball Trap' sector as well – most likely in the early second to early third centuries AD.

The port structures identified to the east, in the 'Ball Trap' sector, feature foundations made of large blocks of mortar and limestone debris contained in a formwork of piles and planks. The piles are square (15 x 15 cm), with notches on both sides to accommodate the pile-planks, 2 cm thick by 30 cm long. Analysis has shown that little care was taken in choosing the mortar ingredients, which were both natural (quartz sand, various rock fragments) and anthropic (plant fragments, charcoal and ceramic debris, by-products of lime calcination). The diameters are also quite varied – from several tenths of a mm to 2 cm. Yet great care was taken in producing and mixing the mortar to ensure an even consistency, which explains its strength. Note that the broken tile mortar technique – a highly water-resistant mixture of lime and pozzolana (volcanic ash) or ground ceramic dust – used frequently by the Romans from the first century BC onwards, is not found here.[33] Wood samples have been taken in two places for analysis. Close to the shore, now 3.5 m under water, the oak piles (*Quercus* sp. [*alnifolia* or

Figure 5.9 Port structures assembled from piles and oak planks (*Quercus* sp.), now 3.5 m under water, in the 'Yacht Club' sector, of the western part of the *Portus Magnus*. (Photo: Fernando Pereira © Franck Goddio/Hilti Foundation.)

Figure 5.10 Port structures assembled from piles and oak planks (*Quercus* sp.), now 3.5 m under water, in the 'Yacht Club' sector of the western part of the *Portus Magnus*. (Photo: Fernando Pereira © Franck Goddio/Hilti Foundation.)

coccifera or *ilex*]) and the pine planks (*Pinus* sp.)[34] date from AD 135–333.[35] At the end of the dock, now 5.75 m under water, the oak piles (*Quercus t. ilex*) and the pine planks (*Pinus* sp.) date from AD 83–229.[36] [37] Pieces of paving, especially limestone slabs, have been identified in the sector to the south of the mortar block arrangement (Figure 5.11). These would have originally been positioned on the mortar. To the south of the paving, around 20 limestone blocks (approximate dimension: 100 x 50 x 30 cm) have been uncovered on the sand.

Development and operation of the port

The results of the archaeological work in the Bay of Alexandria demonstrate that a detailed knowledge of its physical geography is essential to understanding the development and operation of the *Portus Magnus*. The discoveries in the eastern Bay of Alexandria show that

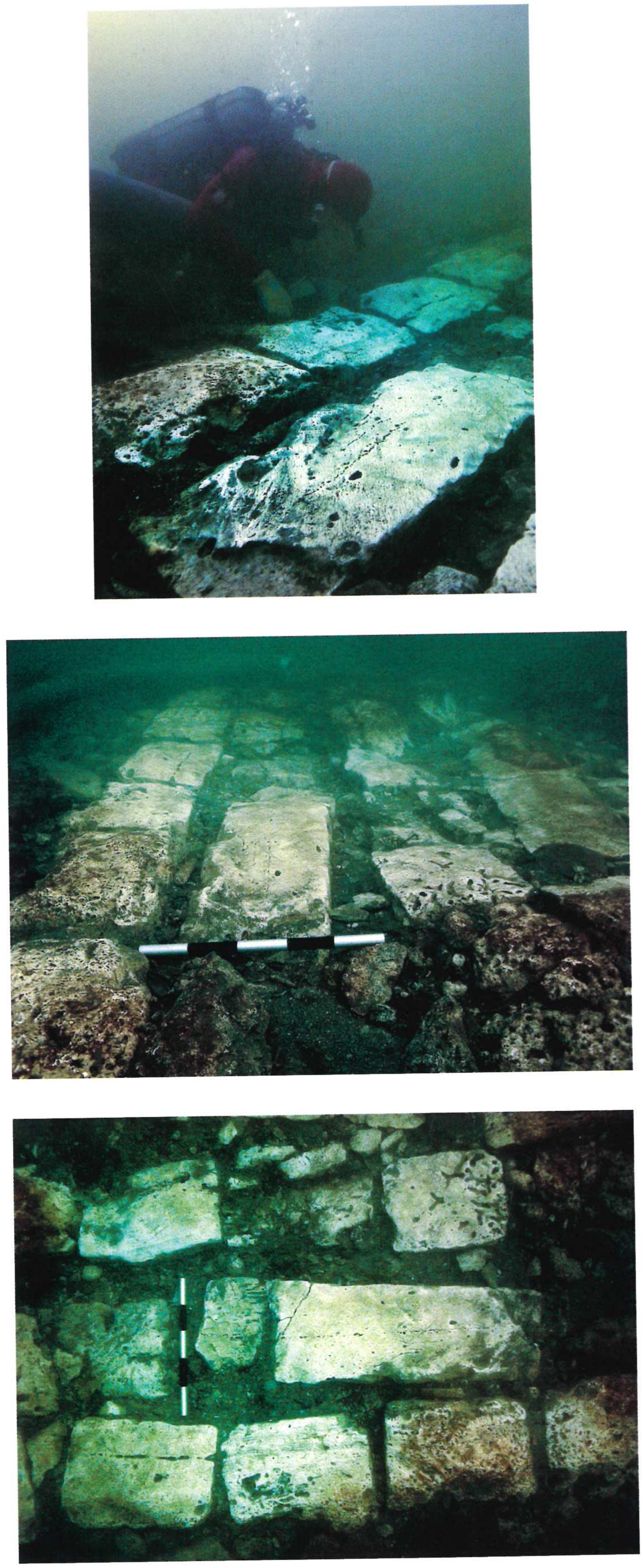

Figure 5.11 Limestone paving blocks in the 'Ball Trap' sector of the western part of the *Portus Magnus*. (Photo: Fernando Pereira © Franck Goddio/Hilti Foundation.)

the entire port infrastructure was designed to optimise the natural environment; beginning in the Hellenistic period, harbour construction and urban development resulted in dramatic changes to the coastline. This forces us to consider the logic behind the transformation of an enclosed natural bay into a series of harbours. Furthermore, this artificial growth raises more general questions regarding the relationship between societies and their surroundings and the scale of human impact on their local areas.

The sedimentary and geological cores that were drilled along the shore help to supplement the archaeological information, which can be difficult to interpret. The results obtained from the cores enable us to retrace the silting history of the Eastern Port and follow the progradation of the coastline. It appears that 'natural sedimentary accretion of the tombolo, and the construction of the *Heptastadium* causeway, significantly affected the types and rates of sedimentation to the east by protecting the Eastern Port and trapping fine particles coming from the Nile, which inevitably led to the rapid silting of the ancient harbours'.[38] The scale of port developments in the eastern bay may be explained by the geomorphological data. Since the harbours tended to trap fine particles, silting rates were in the order of 10 mm/year. In the arsenal sector to the south of the eastern bay, therefore, parts of the port structures were probably silted. Any clearing operations to maintain the harbours would have merely slowed the rate of this change[39] (which in turbulent periods would have been quite rapid). Nevertheless, the organisation of the *Portus Magnus* infrastructure uncovered by the IEASM may indicate that this 'risk' of rapid silting was taken into account in ancient times. This hypothesis is even more convincing in that it explains the overall layout, workings and development of the Eastern Port.

As a result it is necessary to take into account the morphodynamic profile of Alexandria's coast, which is a major factor for navigation. 'It is made up of several rocky islets and high seafloors linked to the presence of a Pleistocene infralittoral ridge. The alignment of this ridge parallel to the coast contributes to the dissipation of wave energy. This submerged or exposed obstacle provides natural protection to the shores of the Western and Eastern Port, which are less vulnerable to unknown factors and to the excessive impact of the high seas, in particular the geostrophic rotating current of the eastern Mediterranean. This current moves counter-clockwise and affects waters from the Strait of Sicily to the coasts of the Levant.'[40]

It has been shown that the construction of the *Heptastadium* led to two major changes in terms of currents: 'the Western channel became much calmer. The overall volume of water coming into the bay has been reduced (...). On either side of the *Heptastadium*, the currents move south to north on the west side and north to south on the east side (...). The east side is exposed to a stronger current, but this current rapidly slows towards the south, as one comes closer to the ancient city.'[41] Maps of the points of stress on the seafloor caused by the currents (and the resulting models[42]) provide clues as to the intensity and direction of the transfer. These maps show that when the *Heptastadium* was built, creating two separate harbours, the hydrodynamic conditions were radically modified. The eastern bay remained exposed to a high rate of sediment re-suspension and would have been characterised by turbulent waters. This fact may explain the partitioning of the port around the eastern bay. In other words, even after the construction of the *Heptastadium* causeway, the eastern bay remained subject to significant movement of water and sediment. These hydrodynamic phenomena explain the large size of the harbours and port structures of the *Portus Magnus*. The perimeter of the bay would have been partitioned into multiple harbours to protect the area from swells, currents inside the bay and water turbidity. The plastic mud is of an even consistency and coarse elements over 6 m thick were not brought into the bay during storms. Historically, therefore, the harbour appears to have functioned effectively. This evidence also shows the large dimensions of the structures, which would have been continuously maintained over time, at least in the Hellenistic and Roman periods.[43]

Maritime dynamics also hint at the historical workings of the *Portus Magnus*. The map of submerged port structures in the Eastern Port of Alexandria suggests a vast bay surrounded by a group of similarly sized harbours. J.-P. Goiran correctly notes: 'Due to the specific organisation of the bay, initially too vast to provide natural shelter, a group of small harbours was needed along the far end of the bay (...). The purpose of these was to break up the coastline as seen in modern marinas.'[44] Alexandria's *Portus Magnus* benefited from its specific geography. The archaeological structures found are cut out of the substrate or constructed in the form of straight or curved sea walls. Similarly, the extremely developed coastline has been somewhat artificially extended. The Romans more than likely optimised these structures. Indeed, Diodorus of Sicily notes that the Romans worked proactively: 'They [Alexander's successors] enhanced it, some building magnificent palaces, others constructing arsenals and ports, others adding religious monuments and magnificent buildings, so that in the eyes of most people it was the first or second city of the inhabited world'.[45]

In the late Roman period, between the fourth and early seventh centuries AD, the artificial protection led to rapid progradation of the coastline in the south-western sector of the eastern bay, which was subject to an increased rate of silting. The Greco-Roman port structures were probably covered by this sand alluviation. Probably around the ninth century AD the area of the Greco-Roman port suddenly opened up, suggesting that the eastern Bay of Alexandria was affected by one or more major hydrodynamic events – that is, storms or tsunamis[46] – which brought activity in this area to an end.

The Alexandrian model and the question of port development ex nihilo

The IEASM's map of the submerged structures in the Eastern Port of Alexandria (Figure 5.1) shows a vast bay surrounded by a group of harbours. The Romans probably optimised the structures cut out of the substrate, dykes, jetties, curved sea walls and so on, inherited from the Ptolemaic period. This development of the coast may be defined as an Alexandrine port model. It is not completely possible to establish a convincing parallel between the Eastern Port of Alexandria and the Classical port models, such as the ports with connected lagoons or *cothon*-type ports. At most, very general similarities may be found with the Port of Tyre.[47] Yet the Port of Alexandria forms part of a series of major port developments that began in the sixth century BC and may be attributed to maritime projects and the ambitions of great tyrants.[48] The Greek approach was applied to the Bay of Alexandria, by which a man-made port was created or a natural port was enlarged using jetties to provide shelter from the winds, facilitate landing and to protect the ships. The jetties were often curved in such a manner as to form a port. In some cases, an islet in the bay was used as the base for a single large sea wall: Alexandria's *Heptastadium* is the best example of this. By Greek standards these structures alone constituted a 'man-made port'. But there were also ports dug by hand, at least in the Hellenistic period. Such was the case, in Alexandria, for the port known as the 'Box' (*kibôtos*).[49]

Pharaonic Egypt does not seem to have had 'constructed' ports on its shores. At most there would have been landing piers and/or anchorage points,[50] with the exception of the coastal lakes such as Thonis-Heracleion.[51] Does this mean that the Port of Alexandria was developed *ex nihilo*?

A number of converging factors suggest that the Bay of Alexandria was developed before the arrival of Alexander. The wooden port structures (quays and jetties) discovered by the IEASM in the axis of the eastern – and main – section of the island of Antirhodos have been dated as pre-Ptolemaic.[52] The data need to be correlated with recent analyses of the lead contained in the sedimentary archives for the harbours in the eastern Bay of Alexandria, which contradict the notion that Alexandria was constructed *ex nihilo*.[53] These results corroborate certain accounts in the ancient texts, which state that the Bay of Alexandria offered an anchorage point well known to sailors. A passage from Homer's *Odyssey* written in the eighth century BC constitutes the earliest of these accounts:

> *And indeed, there exists, before this Egyptos, amidst stormy waves, an island by the name of Pharos. It lies at a distance crossed in a single day by a fast ship with the high wind in its sails. There is a good harbour there, from which one can cast off again to sea.*[54]

We may also wonder whether the word *Timonium* finds its earliest echoes in the Egyptian word *ta-menyt*, meaning 'quay' or 'landing stage'.[55] While the *Timonium* itself was the isolated palace built by Anthony following the defeat at Actium, when he withdrew to Alexandria and resolved to live a solitary existence similar to the misanthrope Timon,[56] this linguistic association may have been suggested to a Greco-Roman audience with knowledge of Egyptian.

The Port of Alexandria and maritime / commercial zones

In addition to the main navigation routes well known from Roman times, Alexandria lay at the end of a coastal navigation route from Cyrenaica, certainly known since early ancient times.[57] From a geographical viewpoint, it is reasonable to explore the influence of the coast and its hinterland on navigation, as well as the importance of the physical conditions of the coastal region around the Port of Alexandria. Without giving too much emphasis to this, the Bay of Alexandria and the island of *Pharos* seem to correspond to the 'Mediterranean pattern' – an inlet sheltered from the winds, with a small plain culminating in an often hilly hinterland. These features encouraged cooperation and facilitated local interrelationships.

To grasp the maritime significance of Alexandria, we must also take into account the proximity of the large river that flowed into the sea, the Nile, which facilitated trade. Alexandria seems to have been founded as a large commercial port, but it was not necessarily a 'natural port' lying in a bay well sheltered from storms. Instead, a major commercial port was developed in a good commercial location, that is at the junction of an overland route (road or inland waterway) and a maritime navigation route. The port was to reach its high point during the Imperial period.[58] Yet in explaining aspects of the creation of Alexandria it is important to note that Egypt's Mediterranean coastlines were not all equally suitable for maritime activity. Generally speaking, there were few options for setting up an effective port on the Delta coast, except on a coastal lake.[59] This was the case for the city of Thonis-Heracleion, which was established at the mouth of the branch flowing through Canopus, over one of the 'lower basins of the arms of the Nile from the location where the lateral offshoots form at the end of the lower branch of the Delta and empty into the coastal lagoons, while the single upper arm empties into the open sea'.[60] The northern swamps formed a kind of autonomous buffer zone that protected Egypt. The currents, headwinds, high seafloors and sand bars along the northern sea coast would have made the route unfavourable to coastal shipping. The narrow coastline is ill-suited to the berthing of visiting ships, but is ideal for coastguard surveillance and for wreckers – with the exception of the mouths of the Nile at Canopus and Pelusium, which were so-called 'false mouths', leading sailors into dead-end lakes, mazes of floating islets and unknown channels, sedges and reeds that blocked the view and muddy seafloors where boats could become stranded.[61] Diodorus of Sicily writes of the difficulty he experienced in navigating the coast on the way to Syria along the Egyptian coastline:

> *From Paraetonium in Libya, to Joppa in Cœlo-Syria, for a stretch of almost five thousand stadia [over 900 km], there is not one safe harbour to be found, except Pharos. There is a sand bank along almost the entire coast of Egypt, not discernible by sailors unacquainted with the places. When they believe they have escaped the danger of the seas and ignorantly head towards land with joy, they are suddenly and unexpectedly shipwrecked. Others, because the coast lies so low, do not see the land in time and are unknowingly carried either into swamps or a deserted coast.*[62]

Therefore, low-lying coasts such as that of the Egyptian Delta may in some cases have been more dangerous, or at least more treacherous, than rocky coasts. This fact may help explain why these coasts were often avoided in favour of intermediary lake routes linking the maritime and overland routes. Alexandria offered a 'safe harbour' and provided access to the branch of the Nile flowing through Canopus via the Lake Mariout (Mareotis) canal. This route makes a difficult crossing of the city at the mouth of the Nile unnecessary.[63]

At the same time, Alexandria inherited the administrative and economic structures of Thonis-Heracleion. The locality was frequented by sailors from the Hellenic world for many centuries before the arrival of Alexander the Great.[64] Under the Saïtes, the Persians and the last three local dynasties, Thonis was the border crossing, customs post and *emporium* through which Greek imports passed on their way to the trading posts of Naukratis.[65] According to Pseudo-Aristotle, these administrative and economic powers were transferred to Alexandria under unsavoury circumstances. Kleomenes of Naukratis, who was assigned to build up and populate the metropolis where the majority of trade was to be conducted, extracted enormous sums from priests and businessmen in the city and misappropriated trade.[66] The goods traded and the impact and importance of long-distance trade and navigation routes to the west, widely attested in Roman times, will not be discussed in detail here. For now the new Egyptian capital can be described as having inherited one or more communications networks and well-established interregional trade. According to ceramic evidence, trade links existed with Corinth, Ionia, the Cyclades and Attica. There was also trade with Phoenicia, for the purposes of which locations inside the latter country seem to have been used as bases, as was the island of Cyprus.[67]

'Emporium of the inhabited world'

Alexandria consequently obeyed an economic and political logic that had gradually developed over the centuries. It initially inherited a regional economic system that enjoyed a privileged navigational zone and a 'preferential market'. In time, in the words of Strabo, the city was to become 'the largest *emporium* of the inhabited world'.[68] Due to its population size and their activities, Alexandria quickly attracted a large share of Mediterranean and Red Sea trade after the maritime world began to expand in the first millennium BC. This would have required substantial port infrastructure and thus the port was well-equipped with harbours, quays, warehouses and water supply points. Alexandria was a centre of eastern navigation in the Hellenistic period and its commerce benefited from the state organisation of the Ptolemaic economy. Later, during the Roman period, Egyptian grain shipped from Alexandria was used as a genuine political weapon by emperors and claimants to the imperial throne alike. Alexandria's status of *emporium*, however, meant that ongoing security and a whole range of conditions were necessary to enable commercial activity. The commercial role of political powers in the trading hubs would have favoured the inflow of goods from producer regions and guaranteed peace and stability at the trading site.[69] It is important to stress the resemblance between trading hubs like Alexandria, the *emporium* – where maritime, river and overland routes came together – and so-called 'gateways'. It must also be noted that political powers in such places played a very similar role to political powers in the 'ports of trade' defined by Karl Polanyi. These ports of trade handled the transport, storage and trade – and sometimes processing – of goods between several producer and consumer regions.

Prior agreement between the parties was necessary to guarantee supply and the protection of the life and property of foreigners. This was usually based on formal treaties. Such agreements would certainly have included provisions regarding landing, shipping, transport, storage, the classification of goods and the fixing of rates and would have been enforced by the local authorities.[70] There is no doubt that the port structures uncovered in the western part of the Bay of Alexandria, in the 'Tikka', 'Yacht Club' and 'Ball Trap' sectors, contributed to the workings of Alexandria's commercial port. Note that the reference made by Strabo to 'what is known as the *Emporium*' is obscured by his subsequent reference to an '*emporium*' to the west of the *Caesareum* which may have been located at 'Cleopatra's Needles'.[71] It is tempting to suppose that there were several commercial areas, one corresponding to an area of warehouses and arsenals close to the *Heptastadium* and another located at the base of the peninsula of the Royal Ports.[72] Commercial areas would have surrounded the port, with the necessary facilities (halls, warehouses, markets, inns, etc.), which would have included a specific administration. It should be noted that the *emporium* was a place of trade, not a market for local producers to sell their goods directly to consumers. Goods were brought here from quite a large economic region to be sold for export to distant locations, where they would be sold to regional buyers. The *emporium* could also have been a port. The port, as the place where ships dock, is distinguished from the *emporium*, the place of trade. Therefore, in large commercial ports the *emporium* is a clearly defined zone which, while close to the port, is not to be confused with it.[73] Alexandria's *emporium* was an area near the port, close to what is referred to in the ancient texts as the *exairesis*,[74] that is the quays and sea walls used to unload the ships uncovered by archaeological excavations.

The zones of the *Portus Magnus* – the *emporium* and the royal ports, military ports and shipyards (which are not discussed in detail here) – were designed as places of transit and transfer. These zones are distinguished by their technical, political and economic dimensions.[75] The research currently being completed should provide clues as to the layout of these areas crossed by ancient ships. We should also gain insight into the cultural organisation or implicit hierarchies in the *Portus Magnus*. From a technical viewpoint, the results of topographical work in the *Portus Magnus* of Alexandria raise questions regarding the port layout, taking navigating conditions (winds and swells) and the types of vessels accommodated (sailing ships or row boats) into consideration. Two technical premises should be kept in mind for subsequent research:[76]

1. The size of the ships determines the acceptable level of sea turbulence caused by swells and whether it is necessary to build a breakwater to protect against storms, while the number of ships determines the quayside frontage and harbour surface area required.

2. The draught of the ships determines the quay depth and therefore the quay height and structure, while the materials available locally (wood, stone and mortar) and construction methods determine the specific structures for a region and period.

From a theoretical viewpoint, the zones of the Eastern Port are at the core of more general questions regarding the major political and economic intermediary players in the organisation, regulation and administrative and legal structures which served to define trade: all the economic and political structures that inter-connected Alexandria and Egypt – if Alexandria is to be considered as separate from Egypt (*Alexandria ad Aegyptum*) – with other lands in the context of 'international' relations.

Notes

1. An initial study was published in 1998: Goddio and Darwish 1998, 1–52. See also Goddio 2006, 38–53 (= Goddio 2008, 26–39). A full study of the excavations carried out by the IEASM is currently in preparation: Goddio *et al.* forthcoming.
2. The studies being carried out will significantly improve our knowledge of the topography of the site, toponymy, periods of occupation and types of activity (anthropic and natural). The work conducted since 1996 in the Bay of Aboukir has determined the contours of the region of Canopus now underwater, the position of the main archaeological sites and the course of the ancient eastern branch of the Nile. See Goddio 2007; Stanley 2007.
3. See, for example, the survey work carried out in the Western Delta: Sadek 1978, 67–80; Petruso and Gabel 1983, 62–63, 76–77; Rodziewicz 1983, 199–210; Rodziewicz 1990, 62–81; El-Fakharani 1983, 175–186; El-Fakharani 1991, 23–28, figures 3–4; El-Fakharani 2000, 204–205; Butzer 1976, 12–25; Abdel-Fattah 2000, 63–71. See also prospecting carried out on the Libyan coast: Snape 1998, 1081–1084; Snape and Wilson 2000; Thomas 2000, 522–529; Bates 1977, 123–197; White 1985, 3–17; White 1986, 51–84; White 1989, 87–114; Cornwell 1987, 25–34; Hulin 1989, 115–126; Nibbi 1998, 203–212.
4. With regard to these methodological problems, see Blackman 1982, 79–104, 185–211; Briand and Maldonado 1997; Franco 1996, 115–151; Raban 1985; Raban 1988; Provansal 2000, 3–5; Fabre 2004a, 47–49; Fabre 2004b, 47–49; Blackman 2007.
5. In recent years, significant amounts of data have been added through the work of: Marriner *et al.* 2008, 377–400; Millet and Goiran 2007, 167–176; Veron *et al.* 2006, 1–4; Goiran *et al.* 2005, 61–64; Goiran and Morhange 2003, 645–667; Goiran *et al.* 2003, 319–324; Goiran 2001; Goiran *et al.* 2000, 83–90; Goiran and Morhange 1999, 560–566.
6. Since the sixteenth century, the topography of Ptolemaic Alexandria, especially the section now under water in the *Portus Magnus* and the adjoining royal quarter, has been drawn in numerous maps. For example: Ortelius 1603; D'Anville 1776; Gardner Wilkinson 1843; El-Falaki 1872; Neroutsos 1866; Vaujany 1888; Botti 1898; Sieglin 1907; Breccia 1914. See also Jondet 1921 and refer to the observations of Fraser 1973; Tkaczow 1993; Goddio and Darwish 1998; Tzalas 2000; McKenzie 2007.
7. Recent research in particular has provided evidence of the impact of the *Heptastadium* and the artificial growth of the tombolo on the silting rate of the harbours and the qualitative and quantitative variations of the coastal fauna communities: Marriner *et al.* 2008, 377–400; Millet and Goiran 2007, 167–176; Goiran and Morhange 2003, 645–667; Goiran *et al.* 2003, 319–324; Goiran 2001; Goiran *et al.* 2000, 83–90; Goiran and Morhange 1999, 560–566.
8. *cf.* Goddio this volume; Goddio 2007.
9. *cf.* Franco 1996, 115–151; Flemming 1981.

10. The average rate of subsidence over the last 7,500 years is in the order of 0.5 +- 1 mm/year in the western sector of the Delta (Stanley 1988; Stanley 1990). This rate increases towards the eastern part of the Nile Delta. See also the hypothesis of *Early Byzantine Tectonic Paroxysm* which appears to have affected numerous eastern Mediterranean coastlines around 1550 BP (Pirazzoli 1986; Pirazzoli *et al.* 1996; Kellelia 1991).

11. Guidoboni *et al.* 1994. See also Douglas 1991, 6981–6992; Abraseys 1962; Taher 1998; Soloviev *et al.* 2000.

12. Bousquet 1984.

13. Guidoboni 1994.

14. *cf.* the observations of Fraser 1973; Yoyotte 1998; McKenzie 2007.

15. *cf.* Majcherek this volume.

16. *cf.* 'Though we do not know the land or water topography of Ptolemaic Alexandria'. This is the conclusion of P. Fraser in his chapter 'Ptolemaic Alexandria': Fraser 1973.

17. This work will be published by the Oxford Centre for Maritime Archaeology, University of Oxford: Goddio *et al.* forthcoming.

18. Strabo, *Geography* XVII. 28.

19. Strabo, *Geography* XVII. 1, 6–10.

20. Caesar, *The Alexandrian War* I.

21. Caesar, *Civil War* III. 111.

22. Strabo, *Geography* XVII. 1, 9.

23. Geomagnetic prospecting has shown that nineteenth- and twentieth-century developments did not completely cover the area submerged after the subsidence and collapse that occurred from the fifth and sixth centuries AD through to the present time. Generally speaking, the 'ancient coast' may be observed under water from Cape Lochias to the peninsula, towards the south-west, to the middle of the *Portus Magnus* where it has unfortunately disappeared under the modern embankment of the coastal road.

24. Strabo, *Geography* XVII. 50, 9.

25. *Letter of Aristeas*, 301, translation by Hadas 1951, 216–219. See Barlett 1985, 16–17; Schürer 1986, 677–687; McKenzie 2007, 45.

26. Strabo, *Geography* XVII. 1, 6; Caesar, *Civil War* III. 312.

27. *cf.* Blackman 1982, 198–202; Graauw 1998; Goiran *et al.* 2005, 61–64.

28. Fraser 1961, 134–138; Fraser 1973, 21.

29. Caesar, *Alexandrian War* XVII, XIX, XXI.

30. Pile: Archéolabs laboratory Ref. No. ARC01/R2622C. ARC 2073 dating, Conventional 14C age: 1840 ± 40 BP (d13C estimated at -25.00‰ vs PDB). Calibrated 14C date: AD 80 cal-AD 315 cal ('IntCal98' calibration curve, Stuiver *et al.* 1998). Probability of the date calibrated: from AD 80 cal to AD 115 cal: 9.9%; from AD 115 cal to AD 255 cal: 82.3%; from AD 255 cal to AD 315 cal: 4.8%.

    Plank: Archéolabs laboratory Ref. No. ARC01/R2622C. ARC 2072 dating, Conventional 14C age: 1920 ± 40 BP (d13C estimated at -25.00‰ vs PDB). Calibrated 14C date: 20 cal BC–AD 215 cal ('IntCal98' calibration curve, Stuiver *et al.* 1998). Probability of the date calibrated: from 20 cal BC to AD 15 cal: 4.3%; from AD 15 cal to AD 135 cal: 81.1%; from AD 135 cal to AD 215 cal: 12.3%.

31. Conventional 14C datings were combined using OxCal 4.1 (Bronk Ramsey 2009) using the IntCal 09 calibration curve (Reimer *et al.* 2009).

32. Goiran *et al.* 2005, 62–63; see in particular figure 4 which shows the geomorphological features in the early Roman period. The recently excavated sectors to the north-west of the eastern bay border the structures excavated by the IEASM in the 'Yacht Club' sector.

33. Archéolabs laboratory Ref. No. ARC00/R2384G3. Mortar samples have been taken within the scope of the Roman Maritime Concrete Study (ROMACONS) project. These samples will be analysed to shed light on the problem of port structure forms containing hydraulic or non-hydraulic mortar and to determine their chronology. Regarding the ROMACONS project, see Oleson *et al.* 2004.

34. Oak pile: Archéolabs laboratory Ref. No. ARC01/R2622C. ARC 2077 dating, Conventional 14C age: 1730 ± 40 BP (d13C estimated at -25.00‰ vs PDB). Calibrated 14C date: AD 225 cal-AD 415 cal ('IntCal98' calibration curve, Stuiver *et al.* 1998).

    Pine plank: Archéolabs laboratory Ref. No. ARC00/R2384C/5. ARC 2011 dating, Conventional 14C age: 1795 ± 50 BP (d13C estimated at -25.00‰ vs PDB). Calibrated 14C date: AD 80 cal-AD 345 cal (calibration curve by Stuiver and Becker 1986). Probability of the date calibrated: from 80 cal BC to AD 125 cal: 6.5%; from AD 125 cal to AD 270 cal: 65.6%; from AD 270 cal to AD 345 cal: 23%.

35. Conventional 14C datings were combined using OxCal 4.1 (Bronk Ramsey 2009) using the IntCal 09 calibration curve (Reimer *et al.* 2009).

36. Oak pile: Archéolabs laboratory Ref. No. ARC01/R2622C. ARC 2078 dating, Conventional 14C age: 1835 ± 40 BP (d13C estimated at -25.00‰ vs PDB). Calibrated 14C date: AD 80 cal-AD 320 cal ('IntCal98' calibration curve, Stuiver *et al.* 1998). Probability of the date calibrated: from AD 80 cal to AD 115 cal: 8.4%; from AD 115 cal to AD 255 cal: 83.2%; from AD 255 cal to AD 320 cal: 6.7%.

    Pine plank: Archéolabs laboratory Ref. No. ARC00/R2384C/5. ARC 2010 dating, Conventional 14C age: 1880 ± 40 BP (d13C estimated at -25.00‰ vs PDB). Calibrated 14C date: AD 30 cal-AD 230 cal ('IntCal98' calibration curve, Stuiver *et al.* 1998). Probability of the date calibrated: from AD 30 cal to AD 50 cal: 3.6%; from AD 50 cal to AD 185 cal: 76.7%; from AD 185 cal to AD 230 cal: 15.9%.

37. Conventional 14C datings were combined using OxCal 4.1 (Bronk Ramsey 2009) using the IntCal 09 calibration curve (Reimer *et al.* 2009).

38. Goiran *et al.* 2000, 90. On the location of the *Heptastadium*, see Hesse 1998, 1–33.

39. Goiran 2001; Goiran *et al.* 2005, 63.

40. Goiran 2001, 44, which refers to Nafaa and Frihy 1993 and Smith and Abdel Kader 1988.

41. Goiran 2001, 101.

42. See Goiran 2001, 104–112; Millet and Goiran 2007, 167–176.

43. Goiran 2001, 138.

44. Goiran 2001, 140.

45. Diodorus of Sicily, *Historical Library* I. 50. 7.

46. Goiran 2001, 247.

47. Bernand 1998, 47; Marriner *et al.* 2008, 377–400.

48. For example, the work of Polycrates in Samos. Over a century later Herodotus still admired the two sea walls which were built atop the seafloor 35 m deep (in reality 18 m) and spanned over 300 m (*Histories*, III, 60). The Port of Delos underwent very progressive development: in the archaic period, pilgrims landed in the inlets to the north-west and north-east. In the early sixth century BC, the development of a larger cove began, open to the west with a 100 m sea wall to offer protection from the dominant wind and paved quays raised only slightly above sea-level. Over the next four centuries a small sea wall was built to the south, quays were developed over 1,700 to 1,800 m in length and secondary harbours created to the south, including three harbours lined with *horrea*. The dual harbour at *Pharos* offered the typical ancient system of anchorage. As demonstrated by L. Robert, it was, 'for an ancient city, a preferred site where, thanks to a peninsula and an isthmus, two harbours could be created, whose differing expositions guaranteed shelter depending on the direction of the wind' (Robert 1960, 263–266). Athens possessed the three ports of Piraeus, Zea and Munichia, not including Phaleron and the other ports of Attica. In this sense, Carthage, Ephesus, Cyzicus, Knossos (that is the ports of Knossos, since the city was not on the coast) and Miletus had two or more ports. Syracuse should also be mentioned here – although the site was highly unsuitable, two ports were developed here in antiquity (Robert 1948, 69–76).

49. On Alexandria's *Kibôtos* see Fraser 1973, Vol. 2, note 182; Tzackow 1993, 58 note 6; McKenzie 2007, 176; Clauss 2005.

50. *cf.* Fabre 2004a, 19–35; Fabre 2004b, 19–35.

51. See below. It is true that we have only very sporadic information on the harbours or anchorage points which the Egyptians may have developed or preferred to use. Explained in Fabre 2004a and Fabre 2004b, with bibliography.

52. The dimensions of the piles are relatively uniform, with the majority of them measuring 14 x 14 cm and others 18 x 14 cm. They are all cut from elm (*Ulmus* sp.) with 33 to 75 rings. These have been C14 dated to 410 BC (+/– 45 years) (Archéolabs laboratory ref. ARC97/R1927C/2). The pile-planks, on average 4 cm thick, are made of pine (*Pinus* sp.) with 18 to 35 rings. They have been C14 dated to 395 BC (+/– 45 years) (Archéolabs laboratory ref. ARC97/R1927C/2). See Goddio and Darwish 1998, 31.

53. Véron *et al.* 2006, 1–4; Goiran 2001, 223–224. See also the palynological studies carried out in the region of Alexandria which provide evidence of the presence and expansion of cultures in the Western Delta prior to the foundation of Alexandria in the fourth century BC: Goiran 2001, 224, 243. Stanley and Landau, this volume.

54. Homer, *Odyssey* IV. 354–369. A village located to the south-east of Lake Mareotis also retained traces of a settlement created by the Athenian Chabrias around 360 BC, according to Strabo, *Geography*, XVII, 1, 22. *cf.* Fabre forthcoming.

55. The 'quay' or 'landing stage' *meny.t/mery.t* is also used for the market or commercial dealings (see for example Davies and Faulkner 1947, 40–46; TT 57, Lepsius 1970, III, 76 = Wreszinski 1923, 199–200; Edgerton and Wilson 1936, 55 note 24a; Janssen 1961, 68, *AnLex* 77.1787, 79.1274; Cerny 1973, 93–97; Janssen 1980; Eyre 1992, 277–281; Ventura 1986; Erman and Ranke 1923, 587–591; Castle 1992, 239–277; Müller-Wollermann 1985, 140–145; Eyre 1998, 177). One of the areas of Naukratis was named in Egyptian 'the house of the port' (*Pr-mry.t*) (Yoyotte 1991–1992, 634–645). The presence of quays may confirm the hypothesis of L. Basch, which states that such quays could have been used to unload certain ships using lifting equipment (Basch 1978, 109). It is interesting to note that such ports are recognised, not just by ancient Egyptian texts in Memphis, but additionally in Hermopolis, Coptos and Thebes. The *mry.t* ports are also referred to outside Egypt, in the Mediterranean. The land of Djahy, which extends from the coastal plain to the Egyptian border as far as Jaffa, at least, possessed such ports, including some which at times fell under Egyptian control. But the best-known are obviously those visited by Wenamun during his voyage across 'the great sea of Kharou': Dor, Tyre, Sidon and obviously Byblos. See Fabre 2004a, 30–32, 47–49; Fabre 2004b, 30–32, 47–49.

56. Strabo, *Geography* XVII. 1. 9; Plutarch, *Anthony* 69.

57. See Fabre 2004a, 33–35; Fabre 2004b, 33–35. Strabo gives a clear and accurate presentation of this coastal maritime route (Strabo, *Geography* XVII. 1, 14). See Charvet *et al.* 1997, 102–103; Daszewski 1995, 11–29.

58. See Rougé 1966, 38.

59. See Fabre 2004a, 45–75; Fabre 2004b, 45–75.

60. Yoyotte 2001. See Goddio 2007.

61. Yoyotte and Chuvin 1983, 52–62.

62. Diodorus, *Historical Library*, I, 31, 2–5. From the translation by Bernand 1970, 22.

63. Read the description by P. Jallois (a civil engineer on the French expedition to Egypt in 1798) of this voyage of a few dozen kilometres from Alexandria to the entrance of the Rosetta arm. Jollois 1822, 333–360, cited by Bernand 1970, 497–498 and Fabre 2004a, 25; Fabre 2004b, 25. With regard to the canal connecting Alexandria to the branch of the Nile flowing through Canopus, see Strabo, *Geography* XVII. 1. 16. See Fraser 1973, 26, 80, 143–144; Rodziewicz 1998, 96–103; McKenzie 2007, 179, n. 29; Clauss 2005.

64. On the statements from Thonis: Calderini and Daris 1935–1996, Vol. 2, fasc. 4, 301. See Yoyotte 2001, 24–34; Fabre 2006, 194–203; Fabre 2008, 219–234.

65. Yoyotte 1958, 427. See Fabre 2006, 194–203; Fabre 2008, 219–234. On Naukratis, the history of excavations, recent research on the site and difficulties in defining the workings of commerce and industry in the city in Pharaonic times, see Yoyotte 1991–1992, 634–644; Boardman 1980, 143–156; Bernand 1970, 575–863; Möller 2000. See also Fabre 2003, chapter on 'Administrative and Economic Structures: Customs'.

66. Pseudo-Aristotle, *Economics* II. 33e. Thonis-Heracleion retained its special religious aura in the Ptolemaic period, as seen by both archaeological discoveries and ancient texts. See Goddio 2007; Yoyotte 2001; Fabre 2004a and b; Fabre 2006, 68–77, 86–93, 110–113; Fabre 2008, 58–59, 66–67, 72–73, 91, 138–139, 152–158, 178–182. We cannot exclude the possibility that the (economic) 'decline' of Thonis-Heracleion was caused in part by a geomorphological modification of the Delta at the mouth at Canopus.

67. Fabre 2006, 198–199; Fabre 2008, 225–226; Grataloup 2006, 220–224; Grataloup 2008, 246–252; Grataloup this volume. For the close commercial ties between Cyprus and Alexandria, see Karageorghis 1982, 173–175; Karageorghis 1995, 113.

68. Strabo, *Geography* XVII. 1, 13.

69. From a theoretical viewpoint the commercial port is an interface between socio-economic worlds in which reciprocity, redistribution and trade are economic, political and social realities. Note that this concomitance of various trade modes must be considered in the context of a political and economic system, either in terms of procedures or ideologies. See qualifications, methodological precautions, and references to previous work in: Liverani 1990; Zaccagnini 1993, 127–143; Zaccagnini 1994, 213–223. On the *emporium* itself and forewarning against systematic assimilation of the *emporium* into the Polanyian 'port of trade', see the excellent summary by Bresson 1993, 163–231.

70. Revere 1975, 71–92.

71. Strabo, *Geography* XVII. 1. 6–10.

72. Note also that Alexandria's *emporium* contained several sectors. An inscription from the second century BC describes a person carrying out surveillance of the section of the *emporium* reserved for foreign trade: SB I, 5021. See Schubart 1912, 369–371; Velissaropoulos 1980, 34. In Alexandria the *emporium* defined the port's trade area and the warehouses needed for the redistribution of goods (Strabo, *Geography* XVII. 1. 1); it was a district in the city (Strabo, *Geography* XVII. 1. 9). See Étienne 1993, 33; Rouillard 1993, 40; Counillon 1993, 51.

73. Such as, for example, the *emporia* of Alexandria (Strabo, *Geography* XVII. 794). Note that the *emporium* therefore may only be considered part of the port if the entire city is classified as a port, such as in Pollux of Naukratis (Pollux, *Onomasticon* IX. 34). In the Red Sea, in the *Periplus of the Erythraean Sea*, the *emporia* are always carefully distinguished from ports. Some of these are located far from the coast, such as Coloe, described as an ivory *emporium* (*Periplus Maris Erythraei* 4; 6; 7; 8).

74. The *exairesis* in Alexandria is mentioned in two papyruses: *P. Tebt.* I, 5, line 26 (Grenfell and Hunt 1902–1938); *BGU* VIII, 1742, line 16–17, according to Vélissapopoulos 1980, 31.

75. Compare with Rickman 1985; Rickman 1988; Horden and Purcell 2000.

76. See Graauw 1998.

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This monograph contains the joint proceedings of the first two conferences organised by the Oxford Centre for Maritime Archaeology. The volume comprises 23 papers arranged into two sections. The first part concentrates on the archaeological and historical evidence for the city of Alexandria and other settlements in the North-Western Delta, including those now submerged in the Bay of Aboukir. The second part of the monograph offers detailed studies into the material culture of these settlements.

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