GEOARCHAEOLOGICAL INVESTIGATIONS IN PAPHOS HARBOUR, 1996

(PLATE XV)

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INTRODUCTION

In late May and early June, 1996, further investigation of the Hellenistic-Roman port of Nea Paphos in southwestern Cyprus, consisting of geological drilling north of the present seafront, was undertaken by the authors as part of the Paphos Ancient Harbour Exploration Project (PAHEP) (Fig. 1, Pl. XV: 1).[1] The need to initiate such a long-overdue geoarchaeological study of the ancient inner harbour was immediate, since work had already begun in mid 1996 to transform this area of the archaeological site into a paved, landscaped parking lot for tourists, in accordance with the "Paphos Master Plan".[2] To collect data on the paleogeography of the ancient harbour and the process of deterioration within the harbour basin, a series of machine-driven and hand-augered bore holes were drilled for core analysis of the subsurface strata.[3]

Historical and archaeological background

The sites of ancient harbours in Cyprus are collectively one of the island's most self-defining

1. The 1996 study area comprised the low-lying terrestrial area between the present seafront and the embankment upon which runs Kyriakos Nicolaou street. This study area is separated into distinct western and eastern sub-areas by the street, Apostle Paul "East". The actual street name, "Apostle Paul", is here employed in text and figures with the qualifiers, "South" and "East", for purposes of clarity. The embankment or ridge at the back of the study area is demarcated in the west by a line of trees, and in the east by a line of tall reeds. The western area is that presently being developed as a parking lot; the eastern area lies behind the rows of shops along Apostle Paul "East" and Poseidon Avenue. N.B., These western and eastern study areas (Fig. 1) should not be confused with the ancient harbour's western and eastern internal basins, discussed below (Fig. 4), which were divided by a natural bedrock ridge.
For results of the Paphos Ancient Harbour Exploration Project, which since 1991 has been studying and mapping the ancient harbour's underwater archaeological remains, see: R.L. Hohlfelder, *RDAC* 1992, 255-6; J.R. Leonard and R.L. Hohlfelder, *RDAC* 1993, 365-79; R.L. Hohlfelder and J.R. Leonard, "Underwater Explorations at Paphos, Cyprus: The 1991 Preliminary Survey", *ASOR Annual* 51 (1994), 45-62; J.R. Leonard *et al.*, *RDAC* 1995, 237-48; and R.L. Hohlfelder, "Ancient Paphos Beneath the Sea: A Survey of the Submerged Structures", in V. Karageorghis and D. Michaelides (eds), *Proceedings of the International Symposium, Cyprus and the Sea* (Nicosia 1995), 191-208.
Ceramic evidence of ancient shipwrecks in the Paphos area has also been recorded by PAHEP (1993-94) on reefs outside the harbour: R.L. Hohlfelder, "The Cave of the Amphoras", *Biblical Archaeologist* 58/1 (1995), 49-51; R.L. Hohlfelder, J.R. Leonard (forthcoming, *IJNA*).
A full geological report on the 1996 study of Paphos harbour is currently being prepared by RKD.
2. S. Hadjisavvas, "Cyprus Department of Antiquities, 60 Years After. The Monuments Branch", *RDAC* 1995, 5-6, fig. 1.
For PAHEP's agenda of future work at Paphos, of which the 1996 geological study is in partial fulfillment, see Hohlfelder (*Cyprus and the Sea*), *op. cit.* (n. 1), 205.
3. The authors would like to extend their gratitude to the Director of the Department of Antiquities of Cyprus, Dr Sophocles Hadjisavvas, as well as past Director, Dr Demos Christou, for supporting this latest phase of the study of the ancient harbour in Paphos. Mrs Riana Daniel of the Paphos Works Department and Mr Takis Hadjiyannis of the General Contracting Company also provided valuable assistance in 1996, and graciously tolerated our albeit well-intended complication of their work, for which we express our sincere apologies and deep appreciation. We owe a special debt of thanks to our colleagues Dr George Constantinou, Director, and Dr George Petrides, Senior Geologist, of the Cyprus Geological Survey Department, as well as to their expert team of drillers, Mr Panayiotis ("The Chief") Hadjisotiris, Mr Christakis Krasias, Mr Angelos Kyriakou, and Mr Bambos Christodoulou, all of who made the work possible in the first place and warmly reminded us why professional collaboration can be so rewarding. Conversations with Prof. Demitrios Michaelides during final editing of the manuscript were very beneficial and are here gratefully acknowledged.
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cultural resources. Just as Cyprus today is a shipping center well equipped with modern marine facilities serving commerce, industry, and tourism, so during antiquity was Cyprus —in the words of the Roman writer Ammianus Marcellinus— an *insula portuosa*:[4] an island abundant in harbours.[5] Beginning at least as early as the Late Bronze Age, the island of Cyprus, with its plentiful resources and central thalassic position, was often a familiar stop for ships sailing the eastern Mediterranean Sea. During subsequent centuries between Late Antiquity and the premodern era, Cypriot coasts continued to play host to a diverse succession of seafarers, including early Christians, Arabs, Crusaders, Venetians, Ottoman Turks, pilgrims bound for the Holy Land, and western adventurers and antiquarians. Large-scale renovation of Cyprus' age-old harbours, and the development of modern port facilities, began in the late nineteenth century with the arrival of the British administration on the island.[6]

The port of Nea Paphos itself, following its foundation in the late fourth century B.C., quickly became a key Ptolemaic naval base.[7] In the second century B.C., Nea Paphos supplanted the eastern city of Salamis as the capital or *metropolis* of Cyprus, in which capacity it flourished well into the Roman period as the island's primary maritime centre. A devastating earthquake in the mid-fourth century A.D. leveled much of "Paphos" (as the city had become known to the Romans), an event that may have contributed to Salamis' reemergence as Cyprus' principal port city and capital. Nevertheless, a small Christian community persisted at Paphos, while the harbour, despite further seismic shocks and gradual delapidation, continued to function through the Byzantine, medieval, and premodern eras into the present day.

Historical information on the ancient harbour at Paphos is sparse, but the works of several authors do bear significance for the geological study of the site and here deserve review.[8] One of the most intriguing and variously interpreted references is that of the anonymous Roman writer "*Stadiasmos*", who attributes to Paphos a "*tripartite harbour suitable for all winds*" (*λιμένα τριπλοῦν παντὶ ἀνέμῳ*).[9] Daszewski has suggested this means Paphos had three internal basins, but was also "tripartite" in possessing a main (internally subdivided) harbour and two external anchorages, one outside the eastern breakwater and another northwest of the city on the opposite side of the peninsula (Fig. 1).[10] Alternatively, Hohlfelder and Leonard have suggested Stadiasmos' description simply refers to an internally tripartite *main* harbour, although external anchorages were indeed also in use.[11] PAHEP's own geological study in 1996 now requires that these various interpretations be reconsidered.[12]

Seismic activity at Paphos is recorded by Roman and Early Christian writers, including Dio Cassius,[13] who writes that following an earthquake in 15 B.C., Paphos received money for disaster relief from the emperor Augustus. Orosius[14] describes another earthquake in A.D. 77, which again required the city to be restored. Then, about A.D. 390, after a series of destructive earthquakes

4. 14.8.14.
5. For Cypriot ancient harbours (other than Nea Paphos), see Karageorghis and Michaelides (eds), *op. cit.* (n. 1), esp. J.-Y. Empereur, "Le Port Hellénistique d'Amathonte", 131-7; J.R. Leonard, "Evidence for Roman Ports, Harbours, and Anchorages in Cyprus", 227-45; A. Raban, "The Heritage of Ancient Harbour Engineering in Cyprus and the Levant", 139-88; and M. Yon, "Kition et la Mer a l'Epoque Classique et Hellénistique", 119-28. Also, J.R. Leonard, "Harbour Terminology in Roman Periploi", in S. Swiny, R.L. Hohlfelder, H.W. Swiny (eds), *Res Maritimae; Cyprus and the Eastern Mediterranean: Prehistory to Late Antiquity* (CAARI Monograph Series, Vol. 1) (Atlanta 1997), 163-200.
6. Α.Γ. Μαραγκού, *Τα Λιμάνια της Κύπρου* (Λευκωσία 1997).
7. The history and archaeology of the port of Nea Paphos have already been examined (*RDAC* 1993, *op. cit.*, [n. 1], with bibliography), but are here in part reconsidered, along with archaeological data from the 1950s *not* previously discussed, to elucidate those questions we have sought to answer through the 1996 geological study of the coastal site.
8. For full discussion of the historical sources relating to Paphos harbour, see Leonard and Hohlfelder, *op. cit.* (n. 1), 368-70; also Hohlfelder and Leonard, *op. cit.* (n. 1), 46-8.
9. *Periplus Maris Magni*, 297 (1st c. B.C. – 4th c. A.D.).
10. W.A. Daszewski, "Port glowny i przystanie pomocnicze w Nea Paphos w sietle obserwacjii podwodnych" ("The main harbour and auxiliary anchorages of Nea Paphos in light of underwater observations"), *Meander* 6 (1981), 332, 334.
11. Leonard and Hohlfelder, *op. cit.* (n. 1), 378.
12. See below, pp. 155f.
13. 54.23.7-8 (2nd-3rd cents. A.D.).
14. 7.9.11 (5th cent. A.D.).

in the fourth century,[15] St. Jerome reports that Paphos lay in ruins.[16]

Byzantine and medieval sources provide further literary evidence of seismic activity. St. Neophytos records in the late twelfth century that a powerful earthquake ruined the harbourside church of *Limeniotissa* ("Our Lady of the Port" or ironically "Protectress of the Port") in about A.D. 1160.[17] Oliverus Scholasticus[18] relates that an even larger earthquake in 1222, which also rocked Limassol and Nicosia, had such a devastating effect at Paphos that the harbour "dried up". Ludolph von Suchen,[19] in the second quarter of the fourteenth century, describes Paphos as "well-nigh destroyed by frequent earthquakes". And Felix Faber gloomily observes in 1483 that Paphos:

> *is now desolate, no longer a city, but a miserable village built over the ruins; ...the harbour too is abandoned, and ships only enter it when forced to do so.... As the city was laid low by earthquakes, so it lies still...*[20]

The description of the harbour having "dried up", provided by Oliverus Scholasticus, holds particular relevance for the geological study of the harbour, since the possible processes behind this phenomenon would seem to include local tectonic uplift.

The frequency with which medieval travellers also describe the "bad air" (i.e., malaria) encountered at Paphos further indicates that in the post-antique period some portion of the ancient harbour basin had become a shallow, stagnant haven for mosquitoes, either due to siltation or tectonic uplift. This process of deterioration continued into the nineteenth century, since Ali Bey writes in 1806 that the harbour at Paphos is "*small and blocked with sand, so that only the smallest boats can enter*".[21] In 1910, dredging operations were finally undertaken by the island's British administration, to prepare the ancient port at Paphos for modern commerce.[22]

The presence of bedrock within the harbour at Paphos was first recorded by the British archaeologist Hogarth, who noted in 1888 that the harbour is "*...shallow and...bottomed with solid rock.*"[23] Another archaeologist, J.S. Last, of the British Kouklia Expedition, further encountered bedrock in 1951 when he excavated fourteen 2m.^{2} soundings (designated A-J, R-T, WA) in the level area between the sea and *Saranda Kolones*, the same area now covered by the new tourist parking lot.[24] The ten trenches A-J were laid out in three approximate lines parallel to the seafront (A-E, F-H, I-J: progressing seaward) (Fig. 2).[25] Trench J was located near the distinctive standing column still to be seen today in the middle of this area (Pl. XV: 2). Last excavated three other trenches (R, WA, T) in a line perpendicular to the seafront at the western edge of the low level area, while the

15. D. Soren, "Earthquake. The Last Days of Kourion", in J.C. Biers, D. Soren (eds), *Studies in Cypriot Archaeology* (Los Angeles 1981), 117-33; D. Soren, E. Lane, "New ideas about the destruction of Paphos", *RDAC* 1981, 178-83; R. Jensen, "The Kourion earthquake: Some possible literary evidence", *RDAC* 1985, 307-11; D. Soren, J.R. Leonard, P. Molinari, "University of Arizona excavations at Kourion 1984-1987", *RDAC* 1988, 171-8.
16. *Vita S. Hilarionis*, 42: PL, col. 52.
17. Cited in A.H.S. Megaw, "Reflections on Byzantine Paphos", in *ΚΑΘΗΓΗΤΡΙΑ: Essays Presented to Joan Hussey* (Athens 1988), 147, n. 34. See also J. Mlynarczyk, *Nea Paphos* III: *Nea Paphos in the Hellenistic period* (Warsaw 1990), 33-4.
18. *Historia Damiatina*, in J.G. von Ekhart, *Corpus Historicum Medii Aevii, sive Scriptores Res in Orbe Universo*, II (Leipzig 1723), col. 1450; also Leonard and Hohlfelder, *op. cit.* (n. 1), 369, n. 42.
19. C.D. Cobham, *Excerpta Cypria: Materials for a History of Cyprus* (Cambridge 1908), 18.
20. *Idem*, 45.
21. *Idem*, 408.
22. G. Jeffrey, *A Description of the Historic Monuments of Cyprus* (Nicosia 1918), 405.
23. D.G. Hogarth, *Devia Cypria: Notes of An Archaeological Journey in Cyprus in 1888* (London 1889), 7.
24. J.S. Last, "Soundings at Nea Paphos, for the Kouklia Expedition", 1951 Unpublished Report, Department of Antiquities of Cyprus, pp. 1-2; J.H. Iliffe, T.B. Mitford, "Excavations at Aphrodite's Sanctuary of Paphos (1951)", *Liverpool Bulletin* 2:1 & 2 (1952), 29-66, esp. 32, 53; *AnnRepCypr* 1951, 14; *AnnRepCypr* 1952, 13; A.H.S. Megaw, "Archaeology in Cyprus, 1951", *JHS* 72 (1952), 115; *Idem*, "Archaeology in Cyprus, 1952", *JHS* 73 (1953), 133; J. Bérard, "Recherches archéologiques à Chypre dans la région de Paphos: la Nécropole d'Iskender", *RA* XLIII (1954), 5ff.
    On the circumstances of the survival and initial dissemination of Last's 1951 report and site plan, see D. Michaelides, "A Statue of Orpheus in Paphos Museum", in *50 Years of Polish Excavations in Egypt and the Near East*, S. Jakobielski, J. Karkowski (eds) (Warsaw 1992), 234 and n. 4.
25. Our Fig. 2 showing the locations of Last's 1951 trenches is based on a rough site plan accompanying his unpublished report: *supra*, n. 24. Although this 1951 site plan provides the general positions of Last's trenches, their precise locations cannot be determined without excavation.

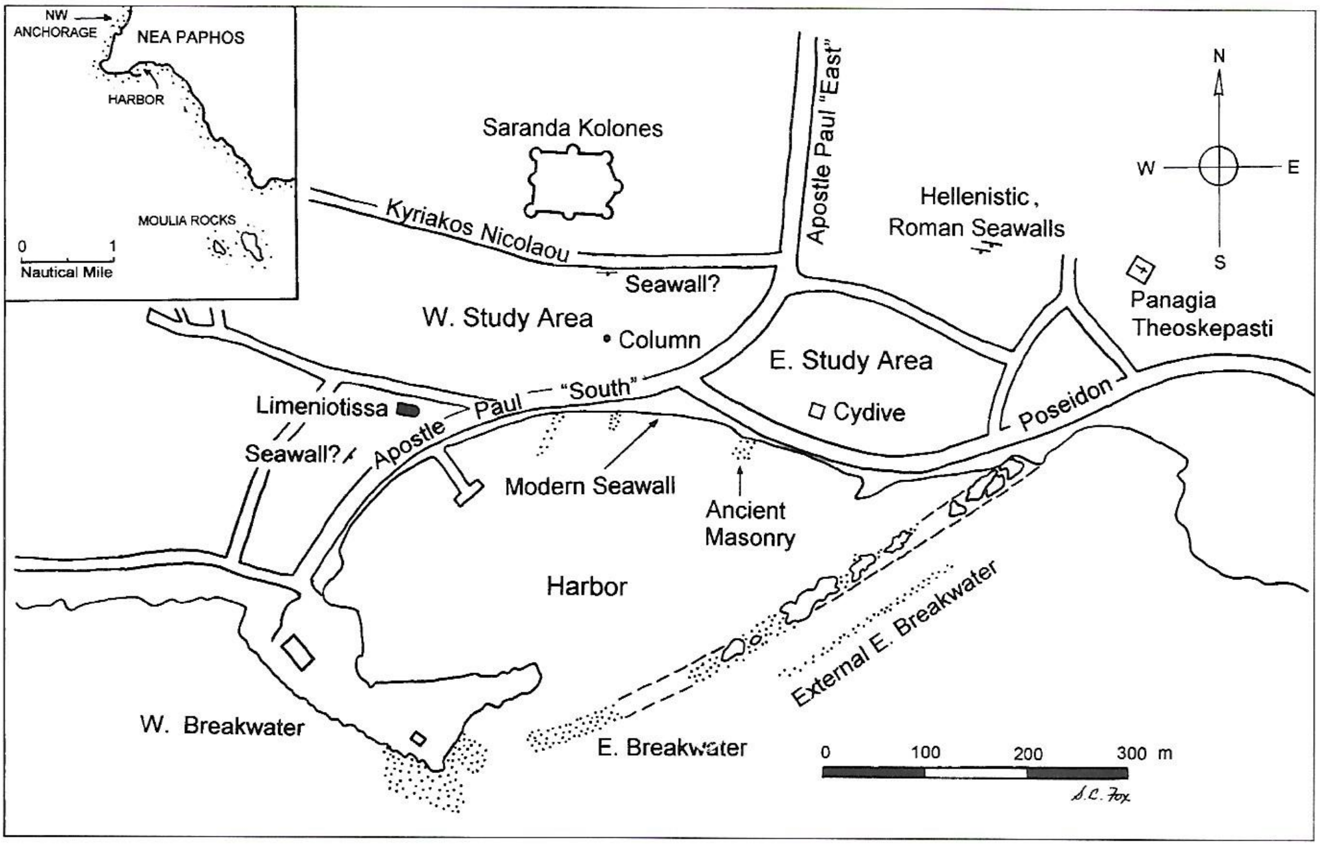

Fig. 1. Paphos harbour, 1996 study area.

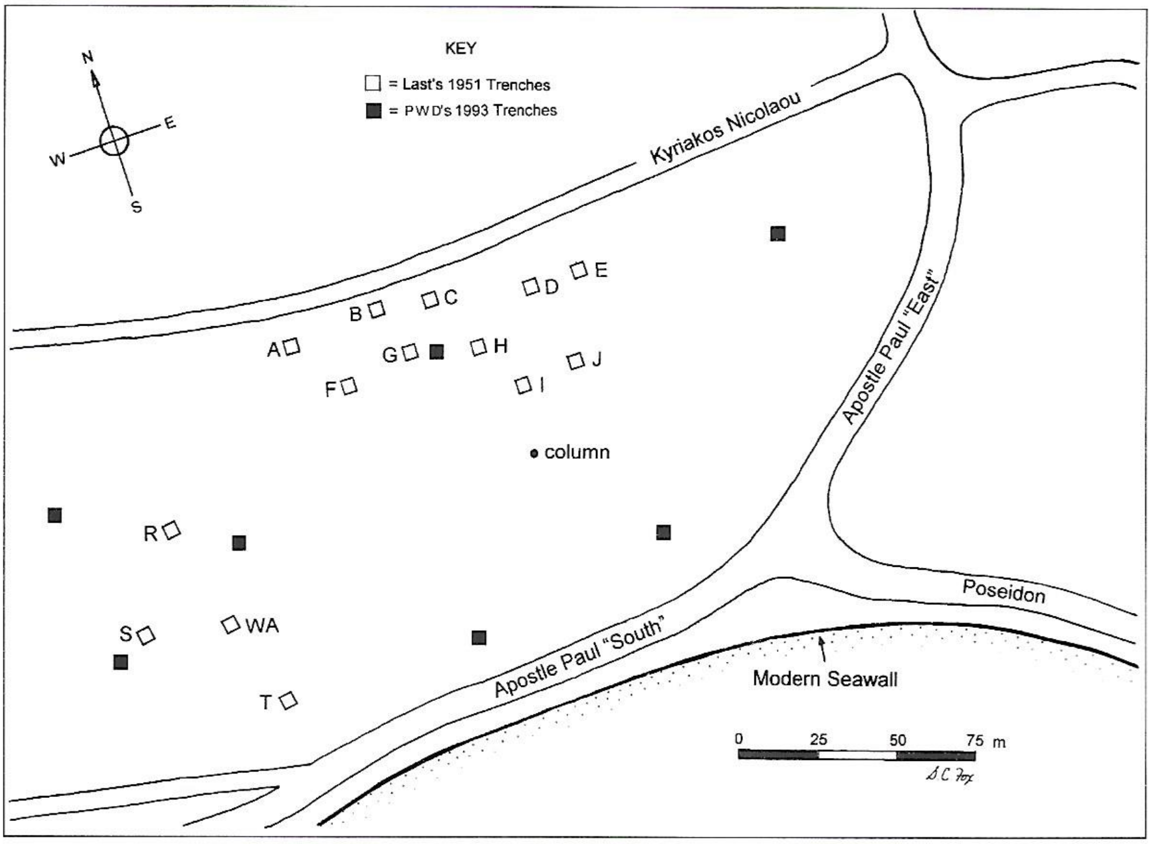

Fig. 2. Last's 1951 harbourside trenches; PWD's 1993 trenches.

fourteenth trench (S) was placed on the rising ground to the west. All of the trenches were dug to bedrock, with the exception of trench T, which —being close to the sea— revealed brackish water at 1.27m. below ground surface. Last's measurements of depth to bedrock within each trench[26] are listed below (Table 1):

Table 1. Depth to Bedrock in Last's 1951 Trenches (in metres below ground surface).

A:	1.90	F:	0.96-1.25	R:	1.10
B:	0.10	G:	1.19	S:	0.50
C:	1.05-1.31	H:	1.38	T:	water at 1.27
D:	3.09	I:	1.40	WA:	1.50
E:	3.27	J:	1.95		

Last's discoveries in Trench I initially seem noteworthy for the geology of the coastal site, since he uncovered in this trench the square shaft of a well cut into the bedrock, within which the water table (sometimes reflective of sea level) lay at 1.47m. below the surface of the bedrock (2.87m. below ground surface).[27] If it were determined that the paleoshoreline was landward of the position of Last's trench I, then under ideal conditions the data from trench I could attest to the height of bedrock above local relative sea level, which in turn could be indicative of local tectonic uplift.[28]

All of Last's fourteen trenches (A-J, R-T, WA) contained "Hellenistic" or "Roman" material including masonry, sherds, ceramic water pipes, or rock-cut drainage channels.[29] Of the eight trenches containing masonry (A,C,D,F,G,H,I,J), four (A,C,D,H) revealed walls built directly on top of the bedrock. In contrast, the walls in trenches I and J —closest to the sea— were founded on rubble, with the "substantial... stepped foundation" in trench J having been overlaid by a smaller later wall. Trench E exposed five water pipes, while the shallow trench B produced only a few sherds. The grey soils noted by Last in the three westernmost trenches (R, WA, T) are consistent with an anaerobic silted environment.

To summarize, Last's two lines of trenches furthest from the sea (A-E, F-H) reveal a period (which we interpret as possibly Hellenistic or early Roman) when harbourside structures were built directly on the bedrock, while finds from trenches I and J appear to attest to subsequent phases (which we interpret as possibly representing mid-to-late Roman, Byzantine, or even early Medieval occupation) when structures were built atop the remains of earlier buildings or walls that may have accumulated following earthquakes.[30] Last's westernmost trenches (R, WA, T) appear to have penetrated a silted portion of the former harbour basin itself. In recording his excavation, however, Last employed no elevation datum, instead merely citing depths below present (1951) ground surface. On the basis of Last's archaeological data alone, therefore, no determination can be made concerning the position of the shoreline during antiquity, or where the structures he discovered may have originally stood on the shore in relation to the sea.

Daszewski's fundamental 1965 study of Paphos harbour also recorded important topographical features of the coastal site that have since been obscured (or obliterated) by modern development.[31] Of particular singificance is Daszewski's observation of a "dying" freshwater stream in the northeastern quarter of the harbour basin, where its mouth was then (in 1965) blocked by a marshy delta separated from the sea by an embankment or "alluvial bar" of accumulated gravel, sand, and

26. Last, *op. cit.* (n. 24), 1-4.
27. *Idem*, 2; Megaw, *op. cit.*, (n. 17), 144, n. 21.
28. The geological significance of Last's Trench I data, in light of PAHEP's 1996 study, is assessed below, p. 154.
29. Last, *op. cit.* (n. 24), 1, concerning the date of his finds, sweepingly asserts, "In almost every pit were found remains of buildings, nothing earlier than Hellenistic nor later than Roman, as represented by great quantities of postsherds". N.B., the following information on the 1951 excavation all comes from pp. 1-4 of Last's unpublished report.
30. Although Last, who was primarily seeking Mycenaean remains, states that nothing in his trenches postdates the Roman period (*supra*, n. 29), it seems likely that he was also including later material under the broad rubric "Roman" (D. Michaelides, personal communication, 1998). Without further excavation, we cannot know which of the many architectural features that Last uncovered belong to the Hellenistic, Roman, or even later eras (note esp. Last's remarks on p. 6 of his report concerning associations between his finds and the adjacent Byzantine-early Medieval site of *Saranda Kolones).*
31. Daszewski, *op. cit.*, (n. 10).

sea grass.[32] Today, intermittent patches of reeds,[33] a high water table in the immediate area,[34] and freshwater seepage from the seabed just off-shore are all that mark the continued presence of this now-subsurface stream.

Daszewski also recorded in 1965 a wide "ridge" or "plate" of solid rock in the northern central area of the inner harbour basin.[35] He rightly surmised that this expanse of rock was an original feature of the bay's topography and served as a natural barrier between distinct basins within the harbour.[36] Ruined masonry preserved (in 1965) on top of the rock may represent the remains of a quay that further distinguished the internal subdivision of the harbour.[37]

In Nicolaou's 1966 topographical study, he first suggested that the ancient harbour basin at Paphos had originally included not only the existing water area of the modern marina but also the low-lying areas to the north and east of the present (1966) seafront.[38] Archaeological evidence supporting this new interpretation of the harbour's original topography, however, was not discovered until the 1980s.

Two lengths of what appear to have been ancient seawalls were revealed by Michaelides in 1981 in the eastern part of the harbour: one dating to the Hellenistic period, *ca.* 150m. from the present shoreline; the second of mid/late Roman date, *ca.* 10m. further seaward (Figs 1, 4).[39] In 1987, Michaelides unearthed a third section of possible seawall associated with a tower in the west behind the modern Customs House, *ca.* 40m. from the present storeline.[40]

Still another substantial wall, a portion of which was exposed in the embankment below Kyriakos Nicolaou street during a 1995 excavation by the Cypriot Department of Antiquities, may also represent a section of ancient seawall (Figs 1, 4; Pl. XV: 3).[41] Further study must be undertaken, however, before this stepped wall can positively be dated or its function determined.[42]

Following Michaelides' discoveries, cartographic representations of the harbour's original landward extent began to appear in the archaeological literature on Nea Paphos.[43] The incomplete nature of the evidence, however, left to conjecture the position of the ancient harbour's inner shoreline. Similarly, site plans of Nea Paphos that include the harbour area have previously shown only approximations of the ancient breakwaters, for these partly inundated features of the archaeological site had never —before 1991— been systematically studied or entirely recorded. The *raison d'être* for PAHEP's efforts since 1991, culminating in the geological study of 1996, has been this clear need to map precisely the ancient harbour's previously uncharted submerged remains, and to establish with greater certainty the full extent and character of the original harbour basin.

The Underwater Topography: Siltation, Renovation, Earthquakes

The western breakwater of the ancient harbour at Paphos was originally *ca.* 270-280m. long by *ca.* 10-15m. wide. These dimensions are based on Daszewski's observations in 1965,[44] recorded before the ancient western breakwater was largely buried beneath modern improvements. A spur

32. *Idem*, 329, 334-5. D. Michaelides (personal communication, 1998) notes that as recently as the early 1980s, residents of Paphos still spoke of catching freshwater eels in the marshy northeastern area of the harbour.
33. *ca.* 50m. from the present seafront.
34. Indicated by standing water and the operation of pumps in the open foundations of nearby buildings under construction in 1991.
35. Daszewski, *op. cit.* (n. 10), 329, 332.
36. *Idem*, 334.
37. *Idem*, 332-3.
38. K. Nicolaou, "The Topography of Nea Paphos", in *Mélanges offerts à Kazimierz Michalowski* (Warsaw 1966), 578.
39. D. Michaelides, personal communication, 1991; Megaw, *op. cit.* (n. 17), 149, fig. 1.
40. V. Karageorghis, "Chroniques des fouilles et découvertes archéologiques à Chypre en 1987", *BCH* 112 (1988), 855; Megaw, *op.cit.* (n. 17), 143, fig. 2; Michaelides, personal communication, 1991.
41. S. and H.W. Swiny, personal communication, 1995.
42. This potential seawall was revealed in the north end of a long trench that extended northward from the standing column (Pl. XV: 2). The column itself may have been placed in its present secondary context during Byzantine or Medieval times. We extend our sincere thanks to Mr I. Ionas, for sharing results and photographs from the Department's excavation, and to the Director of the Department of Antiquities, Dr S. Hadjisavvas, for kindly allowing us to include them in this report.
43. F.G. Maier and V. Karageorghis, *Paphos: History and Archaeology* (Nicosia 1984), 227, fig. 208; Mlynarczyk, *op. cit.* (n. 17), 288, fig. 1; Megaw, *op. cit.* (n. 17), 137, fig. 1; Leonard *et al.*, *op. cit.* (n. 1), 237, fig. 1.
44. Daszewski, *op.cit.* (n. 10), 330.

wall, *ca.* 50-70m. long,[45] jutting southward from the main western breakwater, appears to have been designed to provide the harbour entrance with additional protection from the predominant western wind and waves.[46] The eastern breakwater, including the separate seaward section severed by dredging in modern times, was *ca.* 600m. in length and, according to Daszewski,[47] *ca.* 5-10m. in width. The height of the breakwaters is unknown, but may have been as high as 4.5m. above sea level, based upon the comparative evidence of a modern seawall observed by Daszewski in the 1960s atop the western breakwater.[48] More exact dimensions of the ancient harbourworks, as well as the dating of their phases of construction or restoration, can only be determined through excavation, perhaps in a later stage of PAHEP's investigation of the harbour.

The subsidiary wall outside the main eastern breakwater may have some functional connection with the deterioration of the inner harbour, for this shorter, less massive breakwater (*ca.* 199m. long × *ca.* 5m. wide) seems to have been a secondary feature of the harbourworks —installed by the Romans as part of a scheme to lessen the problem of siltation within the harbour basin.[49] A distinct channel, noted originally by Daszewski,[50] appears to have been cut through the main eastern breakwater to allow sediment-laden water inside the harbour —circulating clockwise from the harbour entrance— to flow out.[51] The external eastern breakwater may have been built to protect the mouth of this outflow channel.[52] Other smaller outflow channels in the main eastern breakwater —not yet discovered— may have also existed and been sheltered from the open sea by the subsidiary breakwater.

If the external eastern breakwater, the outflow channels, and perhaps also the western spur wall were indeed Roman modifications to the Hellenistic harbour, these improvements may have been made following the severe earthquakes of the first century A.D., when the harbour was already undergoing repair and restoration.[53]

The earthquakes of the fourth century, however, particularly the event of A.D. 365, were so much greater in their devastation of the port city that the Paphians were subsequently unable to recover as before. The probable rupturing of the harbour's breakwaters during this seismic event, in combination with a subsequent decline in maintenance of the ruined harbour, could have greatly contributed to the expanse of sand and silt now visible along the northern and eastern sections of the harbour's inner basin.[54]

Nea Paphos' historical and archaeological records attest to the Graeco-Roman city's varying fortunes and seismically active past. To gain greater insight into the coastal site's paleogeography and the evolution of sedimentary environments within the ancient harbour, PAHEP began the collection of geological data in 1996.

THE 1996 GEOLOGICAL STUDY

Regional Geology and local conditions

The site of Nea Paphos is situated in the Mamonia Terrane of southwestern Cyprus, which consists of Paleocene-Miocene age chalks and marls, as well as Pleistocene Epoch terrace deposits. The rocky, irregular shoreline in this part of Cyprus is generally characterized by outcroppings of the Pleistocene terrace in the shoreface and, locally, by small sand and gravel pocket beaches. Stream valleys are narrow and steep, containing thin Holocene alluvial-colluvial gravel, sand, silt, and clay.

45. *Idem*, 331; also Daszewski, "Nicocles and Ptolemy —Remarks on the Early History of Nea Paphos", *RDAC* 1987, 174, n. 39.
46. See harbour site plan: *RDAC* 1993, *op. cit.* (n. 1), 374, fig. 2.
47. Daszewski, *op. cit.* (n. 10), 330-1.
48. *Idem*, 330-31. This former, straight-sided seawall ran along the spine of the western breakwater seaward of the restored castle, but was removed by the Cyprus Ports Authority during modifications in the 1980s.
49. Leonard and Hohlfelder, *op. cit.* (n. 1), 375; Hohlfelder in *Cyprus and the Sea*, *op. cit.* (n. 1), 204-5.
50. Daszewski, *op. cit.* (n. 10), 331.
51. Hohlfelder and Leonard, *op. cit.* (n. 1), 58.
52. Leonard and Hohlfelder, *op. cit.* (n. 1), 377; Hohlfelder and Leonard, *op. cit.* (n. 1), 59. But see below, p. 156, for the possible multi-functionalism of the external eastern breakwater.
53. Hohlfelder in *Cyprus and the Sea*, *op. cit.* (n. 1), 199.
54. See below, p. 154 and nn. 72-3, for further comment on the possible effects on sedimentation of accidental ruptures or intentional cuts through the breakwaters.

Wind-driven waves are common from the west and south, while less common from the east. Winter storm waves can be very high, sometimes —as Daszewski has noted— topping the old 4.5m. high western breakwater.[55] In 1996, we observed recent storm deposits 2-3m. above sea level in various areas along the southern Cypriot coast. Residents of Kato Paphos also described to us winter flooding of the low coastal plain below the ancient sea walls (discovered by Michaelides) on the eastern side of the harbour, prior to construction of the modern sea wall. This is the same area in which Daszewski reported a sandy barrier beach,[56] located approximately in the same position as the present seafront street, Poseidon Avenue (Fig. 1). This beach separated (in the 1960s, before its burial beneath the modern seafront) the shallow water embayment from the relatively flat sandy plain that leads to the foot of a topographic break, above which, in the west, the urban ruins of Nea Paphos (and the later *Saranda Kolones* site) are situated.

A local relative sea-level curve does not exist for the area of Nea Paphos. We have opted instead to employ the sea-level curve of Kayan, which he believes is applicable throughout the Eastern Mediterranean, and which constitutes the only potentially-regional curve we are aware of for the area.[57] This curve may deviate slightly from a local relative curve for Nea Paphos, but we are using it here to aid in deriving tentative dates for various stratigraphic horizons (via the age vs. depth relationship of the sea-level curve). The curve indicates that during the past 2000 years local relative sea level was no lower than about 0.2m. to 0.3m. below the present level. Sea level *ca.* 3500-3000 years BP was about 2.0m. below the present level, but a rapid rise occurred between 3000 and 2000 years BP, resulting in sea level within about 0.2m. to 0.3m. of the present level at 2000 years BP.[58]

Geology of Paphos harbour area

The ancient city and inner harbour of Nea Paphos are built upon Pleistocene Epoch terrace deposits comprising calcarenites (calcite-cemented sandstone), sands, and gravels. Surface material in the western study area —primarily the area of the present parking lot— is predominately Holocene epoch alluvium-colluvium and fill, mixed with storm washover deposits.[59] Slope-wash has produced a seaward thinning deposit of clay, silt, sand, and gravel derived from the archaeological site. Storms regularly flooded the low-lying plain (prior to construction of the modern seawall), and storm washover sediment is interbedded with the material derived from the archaeological site. The alluvial-colluvial material also contains abundant archaeological remains, including fragmentary roof tiles, ancient and medieval pottery, glass sherds, charcoal, and whole or fragmentary building stone.

Shortly before we began geological drilling in 1996, the western study area was leveled (by developers using a bulldozer), resulting in most of the alluvial-colluvial and fill cover being removed. Prior to this leveling, the ground surface had sloped seaward (south) from a high of 5-6m. above relative sea level (RSL) in the north, to about 1-1.5m. above RSL in the south (landward of the Apostle Paul "South" road grade) (Fig. 1).[60] Trenches previously excavated (and subsequently backfilled) by Last (1951) and the Paphos Public Works Department (1993) (hereafter PWD) provide information on sedimentology and stratigraphy of the original upper 1-2m. of alluvium-colluvium in the western area, and in some cases values for the depth to bedrock.[61]

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55. *Supra*, n. 48.
56. Daszewski, *op. cit.* (n. 10), 329, 334-5.
57. I. Kayan, "Holocene Geomorphic Evolution of the Besik Plain and Changes in Environment of Ancient Man", *Studia Troica* (1991), 79-92.
58. The question of *eustatic* sea-level variation is a subject often considered in the marine archaeological literature. Since local relative sea level is the pertinent factor at Paphos (where no local relative sea-level curve can yet be cited), we have selected to employ the potentially-regional sea-level curve cited above, and to leave the problematic issue of eustacy for a more appropriate forum.
59. "Fill" is defined here as any material deposited by humans, including discarded or abandoned artifactual or architectural waste and engineering fill such as road grade. For definition of the 1996 study area: *supra*, n. 1.
60. We have employed the water level in the harbour as our datum for measuring the elevation of our drill holes; we define this datum as local relative sea level.
61. Last, *op. cit.* (n. 24). Information on the PWD's 1993 probe trenches is contained in an unpublished report, a copy of which was kindly provided to PAHEP by Mrs R. Daniel.

Truck-mounted rotary drilling with additional hand-augering enabled us to recover cores from fifteen bore holes (NPD01-15), which provide data on sedimentology, stratigraphy, and depth to bedrock. We obtained twelve cores (NPD01-12) in the western half of the study area, south of the Kyriakos Nicolaou road embankment, and two cores (NPD13, 14) on the embankment itself along the approximate alignments of the ancient sea walls, as indicated by the preserved remains in the eastern study area (Figs 1, 3). NPD14 was recovered just north of Kyriakos Nicolaou Street. The eastern study area was largely inaccessible to drilling, due to modern overbuilding, but we were able to obtain one core (NPD15) from the area's approximate centre, an open expanse of ground behind the CyDive scuba shop.

Using the core data, we have mapped the topography of the bedrock surface, which dips seaward from about 0.5-1.0m. above RSL in the vicinity of the eastern seawalls and Kyriakos Nikolaou Street, to about 0.0m. RSL *ca.* 30m. south of the seawalls, to about 1.5-2.0m. below RSL near the street Apostle Paul "South". In core NPD15 behind CyDrive, we encountered bedrock at 1.3m. below RSL.

The Bedrock Ridge

The most significant topographic feature of the bedrock is a north-south trending ridge that occurs in the western study area. This bedrock ridge extends off the bedrock high upon which the ancient city is built, with its northern end located 45-50m. west of the intersection of Kyriakos Nikolaou street and Apostole Paul "East" (Fig. 4). The ridge reaches a maximum elevation of at least 1.0m. above RSL, and extends to the south beneath the street, Apostle Paul "East". If the ridge continues on this same course, it intersects that area of the site where today a number of large rocks lie in shallow water at the foot of the modern seawall. This is the same ridge whose southern end Daszewski noted in the mid 1960s.[62] Daszewski also observed that the rocks scattered in the water at the ridge's *terminus* exhibit traces of treatment and may have been part of the quay he postulated once stood atop the bedrock ridge.[63] Henceforth, we will call the area of the harbour east of the bedrock ridge the "eastern basin," and the area west of the ridge the "western basin" (Fig. 4).

Western Harbour Basin

In the ancient harbour's western basin, sediments above the bedrock surface comprise shelly, medium to coarse-grained sand with abundant marine molluscs (bivalves and gastropods [snails]) and shallow marine to brackish microfossils (mainly foraminifers). This lowest sedimentary lithofacies[64] is interpreted as a shallow marine deposit. Deposition resulted from sand being transported to the area by wind-driven waves and longshore transport: a system of fairly high energy. The local calcarenite bedrock was probably also eroded by wind-driven waves, which introduced sand to the shallow marine environment. The basal few centimeters of this shelly sand lithofacies, which are typically coarse sand and gravel with broken shell material, constitute a transgressive lag deposit that formed as the area was initially flooded (*ca.* 3000 years BP) and as the shoreline migrated landward.

The shelly sand lithofacies is overlain by a mud or sandy mud[65] with abundant marine molluscs, marine microfossils, and very small unidentifiable ceramic fragments.[66] The abundance of mud itself indicates deposition in shallow and relatively quiet water. We interpret this mud lithofacies as having been deposited in the shallow peripheries of the harbour basin, and in back-barrier settings. The back-barrier environment may have fluctuated seasonally from a very shallow lagoon to a dry, locally swampy plain. Storm overwash of the sandy shoreline supplied mud and sand to this back-barrier environment. Sand lenses within the mud are indeed common, and are a product of short-term high energy deposition: most likely

62. *Supra*, nn. 35-7.
63. *Supra*, n. 37.
64. The term "lithofacies" (lith- ə -'fā-sh[ē-]ēz) is used herein to mean a three-dimensional sedimentary body deposited under similar conditions and distinguishable from adjacent sedimentary bodies.
65. "Mud" being a combination of silt and clay.
66. Pottery recovered in the 1996 geological cores consisted mostly of very small fragments, the dates of which —unless specified otherwise— were indeterminable.

during storm surge. We conclude that the deposition of the mud lithofacies is a result of the construction of the two artificial breakwaters, and of the subsequent cut-off of a significant longshore current that previously swept the coastline and prevented deposition of silt and clay. Deposition of this lithofacies marks the onset of siltation in the harbour. If we assume no vertical tectonic displacement, the base of the mud lithofacies occurs at a depth corresponding to approximately 2300 years BP. This date fits well with Daszewski's proposed construction date of the harbour, soon after 316 B.C.[67]

The uppermost deposit in cores from the central area of the western basin consists of silty sand that contains marine molluscs and microfossils, as well as abundant archaeological material at various horizons. This archaeological material includes charcoal, as well as very small fragments of brick or roof tile and unidentifiable pottery. In some cores, relatively clean sand laminae are found within the silty sand.

This silty sand lithofacies is interpreted as a mixed very shallow marine and alluvial deposit. Deposition was probably due largely to two sources: storm waves that topped a low-lying barrier beach (resulting in washover deposits, particularly sandy horizons with marine molluscs) and alluvial material that washed off the archaeological site from the north and west. The additional deposition of fill during antiquity by people intent on building in the area is also very probable. Within the silty sand lithofacies the amount of alluvium-colluvium and fill increases upward, whereas the amount of washover sand decreases. The architectural foundation courses discovered by Last in 1951 may have been associated with this lithofacies. The exact positions of Last's findings are unclear, however, since (as discussed above) Last provides no provenience data for his excavations, other than depths below ground surface.

The stratigraphic sequence described above (shelly sand; mud; silty sand) is characteristic of the central area of the western basin. Around the margins of this basin, to the east and west (against the bedrock ridge), and possibly to the north (see discussion below), the shallow marine, shelly sand lithofacies is overlain by a well-sorted, medium-to-coarse-grained sand that contains marine molluscs, marine microfossils, and Roman pottery and glass fragments. This sand lithofacies is interpreted as a beach deposit, which has a transitional contact with the underlying shallow marine sand. The beach deposit pinches out toward the central part of the basin, where the mud lithofacies predominates. In all core locations, the silty sand lithofacies and washover material recovered in the top of cores was —prior to leveling by the developers' bulldozer— overlain by more alluvial-colluvial material and fill.

Seismic uplift vs. siltation

Analysis of three-dimensional stratal relationships indicates that the combined package of the shallow marine sand lithofacies and the mud lithofacies occurs *entirely* below 0.0 m. RSL in our more seaward (southern) cores, but that in core NPD07 located about 30m. south of the ancient seawalls this package has a *base* below 0.0m. RSL and a *top* as much as 1.6m. above present RSL.

These data could be interpreted as potential evidene of co-seismic uplift of the harbour area. Close examination of the deposits, however, including sediments, molluscs, and microfossils, reveals that the shallow marine sand lithofacies in the more landward area (core NPD07) grades into a barrier-beach and storm washover deposit. This barrier-beach and back-barrier deposit may have been deposited a few decimetres to perhaps one meter or more above RSL.

It is impossible to ascertain precisely the original depositional elevation of these deposits. We can only note that the elevation of the entire sequence (barrier-beach sand; washover muddy sand; back-barrier mud) seems to be at or slightly above the expected depositional elevation (i.e., within 1-2m. of RSL). Although we cannot therefore state definitively, based upon our 1996 data, whether or not seismic uplift has in fact occurred, nor what the total amount of that uplift might have been, we can suggest that if uplift did occur, it

67. Daszewski, *op. cit.* (n. 45), 175.

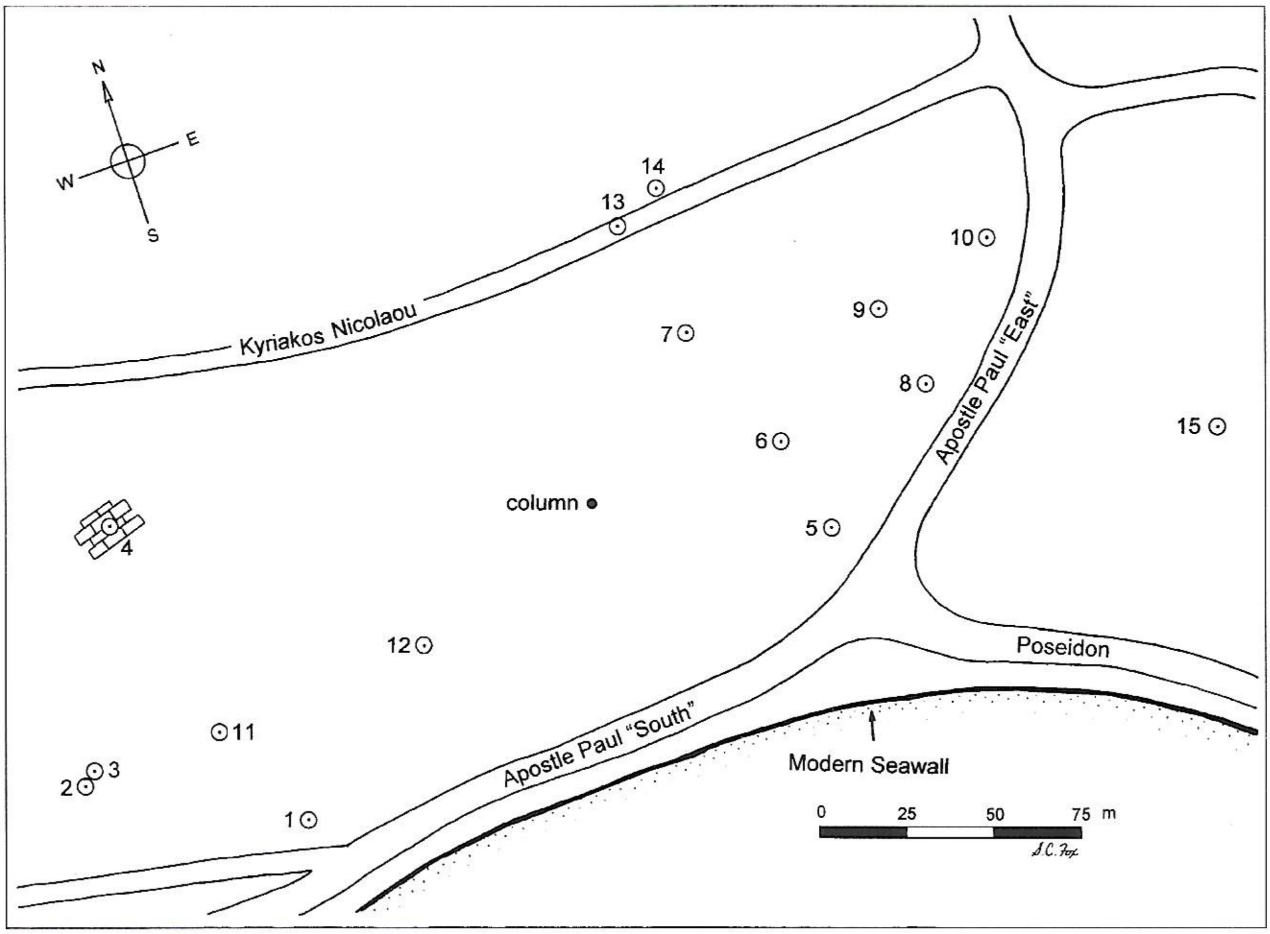


Fig. 3. 1996 Geological study. Drill holes.

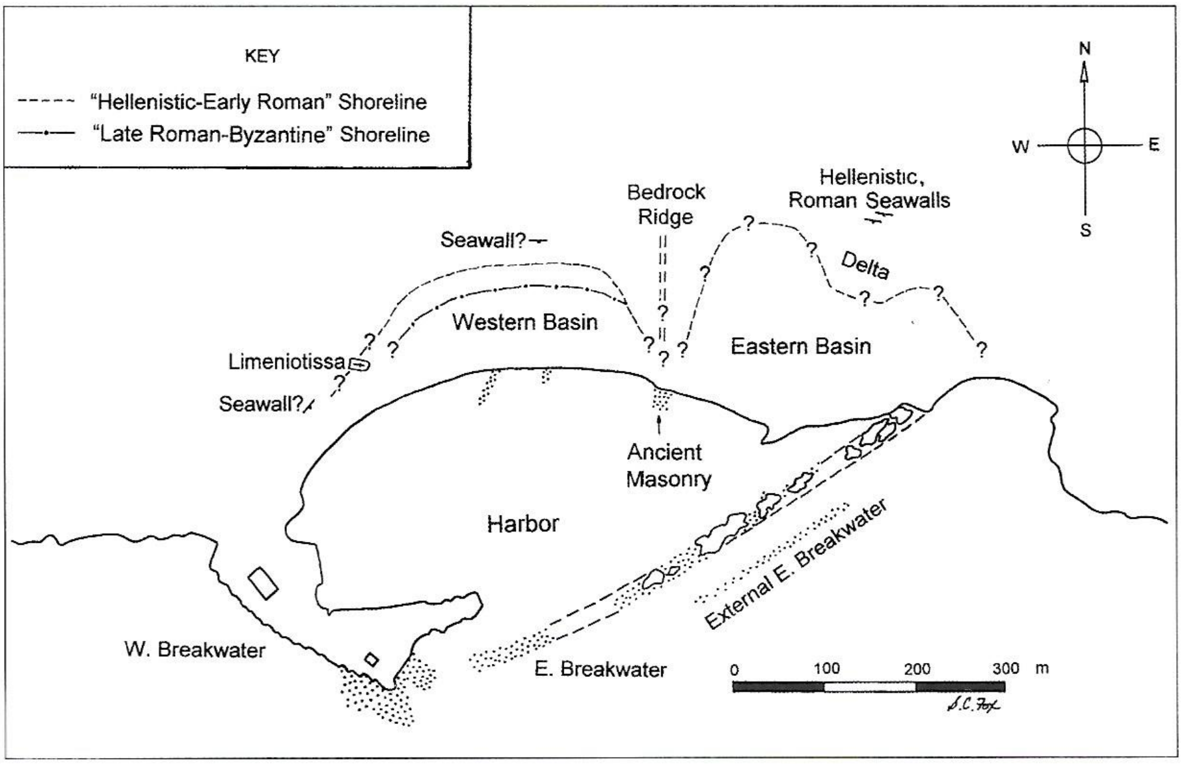


Fig. 4. Paphos harbour. Paléogeography.

was minor and amounted to less than *ca.* 0.5-0.7m. Such a total vertical displacement may have resulted from a series of uplift events, not from a single event.

Analysis of stratal relations, together with Last's Hellenistic-Roman architectural evidence, suggests that the earliest shoreline in existence after the harbour's late fourth century B.C. foundation (which we shall call the "Hellenistic-early Roman shoreline") was located seaward of Last's trenches A-H, but landward of trenches I and J.[68] Subsequent uplift of this paleo-shoreline cannot have been more than *ca.* 0.5-0.7m.

If we assume no uplift has occurred in the area of Paphos harbour, the sedimentology and stratigraphy of our most landward cores indicate that the harbour's northern shoreline in the Hellenistic-early Roman era, a sandy beach, lay within about 30m. of the projected line of the preserved seawalls (Fig. 4). Water depth in the northern part of the western basin would have been about one metre, deepening seaward. This depth would have been sufficient for the relatively shallow draft (1.0-1.5m.) of Roman harbour vessels and small-to-medium ships. Larger ships would have moored further seaward in the harbour's deeper water, or outside the harbour in one of the external anchorages. A fairly wide sandy beach around the harbour's inner perimeter was available for access to the water, and for temporary beaching of craft. If the eastern walls found by Michaelides are indeed remnants of the Hellenistic and (mid/late) Roman seawalls, they were probably constructed on alignments back from the water's edge, thereby allowing the aforesaid access to the beach, while also protecting harbourside buildings behind the beach from possible storm surge.

By the late Roman or Byzantine period, the shoreline had prograded to a position further seaward (Fig. 4).[69] Mud containing abundant marine mulluscs and microfauna in cores NPD06 and NPD12 suggest that the sandy shoreline was still north of these two cores during later antiquity. Furthermore, in core NPD11, the relatively shallow depth to bedrock, which is overlain by sandy mud with organic remains, indicates that the northwestern portion of the western basin was relatively shallow (0.5-1.0m. water depth), and that localized swampy areas may have developed in the extreme northwestern area of the former harbour. In addition, evidence of pavers overlying shallow marine and beach sand, recovered in nearby core NPD04 (Fig. 4), suggests not only that the shoreline in this area had prograded seaward, but also that by later Roman or Byzantine times some attempt had been made to create a hard surface or apron atop the low-lying, perhaps locally swampy, back-barrier environment.

Alternatively, if we assume that minor uplift (*ca.* 0.5m.) did occur during the large earthquakes of the first, fourth, twelfth, and thirteenth centuries A.D., then reconstruction of the harbour's paleogeography involves a shift of the shoreline by about 20m. further seaward. Thus, uplift associated with earthquakes would indeed have resulted in instantaneous seaward translation of the shoreline, but only on the order of about 20m. maximum.

Given that the base of the mud lithofacies occurs at a depth approximately corresponding to the Hellenistic and early Roman period (*ca.* 2300-2000 years BP), our core data appear to record the onset of siltation in the western harbour basin at the time when the breakwaters were constructed. This is significant because it indicates that the deterioration of the harbour through siltation, as often occurs in artificial harbours (both modern and ancient), was a product of the harbour construction itself. Our interpretations, though in part still tentative, indicate that the harbour was filled via siltation, as a result of the loss of strong currents that cleansed silt and clay from the system.

68. Our identification of this earliest intra-harbour shoreline as "Hellenistic-early Roman", and of the later, prograded shoreline as "late Roman-Byzantine" (Fig. 4) are based on a combination of the available archaeological and geological evidence. Although these tentative dates may have to be refined, as further geoarchaeological work is undertaken in Paphos, they are offered here to begin to pinpoint through time the ages of the harbour's prograding paleo-shoreline.

69. See previous note. The early Medieval shoreline (e.g., that which existed in the late 12th century when *Saranda Kolones* castle was established) may also be generally represented by our hypothetical, prograded shoreline shown in Fig. 4. As discussed further below, only additional geological and archaeological fieldwork can help to clarify our tentative chronology offered herein.

Our analysis of stratal relationships further indicates that uplift of the harbour must have been minimal and may have occurred during any one or combination of the several earthquakes that struck this coastal site in ancient or early Medieval times. One or more minor uplift events may have resulted in partial emergence of the harbour area (e.g., in A.D. 1222 when —according to Scholasticus— the harbour "dried up"), but the majority of environmental deterioration within the western basin is almost certainly a product of human interference with the natural coastal system and its ability to flush fine-grained sediment away from the immediate shoreline. Even the opening of channels in the main eastern breakwater during Roman renovations would have merely put off the inevitable.[70]

Eastern harbour basin

In the ancient harbour's eastern basin, we recovered 3.5m. of Holocene deposits overlying the bedrock surface. The stratigraphic sequence here comprises about 2.5m. of mud and peat, with brackish molluscan fauna, overlying the calcarenite bedrock. These mud and peat deposits are capped by recent backfill material that has been placed across the area (since the mid 1960s) to convert the former swampy environment into land suitable for building. The mud and peat are interpreted as having been deposited in stream, swamp, and back-barrier lagoon environments. This swamp-lagoon lithofacies, which probably extends across much of the eastern basin, interfingers with sand of barrier-beach origin to the south and west.

To the west, on the eastern flank of the bedrock ridge, an additional core (NPD10) contains the following sediments: a calcarenite base overlain by a thin deposit of coarse sand with abundant marine molluscs and microfossils, which in turn is overlain by a thin deposit of well-sorted, medium-grained sand devoid of archaeological material. Above this deposit is a medium-grained sand with marine molluscs and microfossils, and abundant fragments of Roman pottery, glass, and charcoal. The top of the core contained a silty sand. This stratigraphic sequence is interpreted as a transgressive lag and storm overwash deposit overlying the calcarenite bedrock, which in turn is overlain by beach sand containing archaeological material except in its lowest .20m. The silty sand above the beach sand is interpreted as an alluvial-colluvial deposit, predominately a product of slope wash off the archaeological site. As elsewhere in the study area, the surface material of alluvium-colluvium and fill had previously been thicker (prior to partial removal by the developers' bulldozer) in this eastern area.

Our geological drilling in the harbour's eastern basin bears out the previous environmental observations of Daszewski,[71] and indicates that a small sandy delta has separated a swampy-lagoon setting from the remainder of the harbour bay for most of the artifical harbour's existence. Much of the mud lithofacies (silt and clay) that is found in the harbour's western basin probably derives from the stream-delta system in the harbour's eastern basin.

It is somewhat surprising that the original Hellenistic development of the embayment into an artificial harbour, enclosed by massive breakwaters, did not also include diversion of the alluvium-bearing stream that spilled into the bay's northeastern area. Nevertheless, thick stream and swamp deposits attest to continuous deposition since at least Roman times, and no geological or other evidence that we are aware of can be cited for diversion of the stream to a course outside the enclosed harbour basin.

The beach and overwash deposits on the east side of the bedrock ridge indicate that west of the stream-delta a shallow embayment occurred, similar to that observed by Daszewski in the furthest eastern area of the eastern basin. It would seem, therefore, that the harbour's sandy-bottomed eastern basin was divided in antiquity along its north-

70. RLH, commenting on the intended function of the subsidiary, external eastern breakwater and the possible channels cut through the main eastern breakwater, noted there is no way to to judge the effectiveness of an ancient engineering solution to the perrenial problem of siltation within the enclosed harbour area. The evidence from our 1996 cores now suggests that this natural process was not permanently affected by any such anti-siltation efforts; see R.L. Hohlfelder, "Caesarea's master harbour builders: lessons learned, lessons applied?" in A. Raban, K.G. Holum (eds), *Caesarea Maritima. A retrospective after two millenia* (Leiden 1996), 98.

71. *Supra*, nn. 31-2.

central shoreline by the stream's shallow swampy delta.

Paleogeographic reconstruction, conclusions

Based on sedimentologic and stratigraphic data, we can state that, following sea-level rise and flooding of the shallow bedrock surface in the area of Nea Paphos (*ca.* 3000 years BP), a natural embayment was created south of the area of the later archaeological site (i.e., throughout much of the 1996 study area). The shoreline of this embayment extended north to about 30m. south of the position of the preserved Hellenistic-Roman seawalls found by Michaelides. A sandy shoreline existed around most of the embayment, as well as around the bedrock ridge, while a muddy sand shoreline probably dominated the stream-delta area. The embayment was open to wave attack, and storm surge would have topped the beach depositing sand and sandy mud as washover sheets behind the barrier beach. Waves and longshore currents swept the shallow marine environment, depositing coarse sand and removing fine-grained material from the system.

After the artificial breakwaters were constructed in the late fourth century B.C., this natural flushing system was interrupted, thereby allowing silt and clay —much of which derived from the northeastern stream— to begin filling the newly-enclosed harbour's internal areas. The harbour's northern and eastern Hellenistic and Roman seawalls appear to have been built 30-50m. behind the sandy shoreline to allow beach access, while also protecting the lower town from storm surge. The relationship between the paleo-shoreline and the possible seawall preserved in the west (Figs. 1, 4) presently remains conjectural, as we were unable to drill any core holes in that area of the commerically-developed modern seafront. As the ancient harbour gradually filled with silt, possible channels cut in the eastern breakwater during Roman times may have helped to flush the harbour of fine-grained sediment, although such alterations would have been insufficient to arrest siltation completely.[72] The harbour was becoming increasingly shallow throughout the Roman era, while at the same time the northern shoreline was prograding seaward (south) thereby decreasing the harbour's internal size (Fig. 4).

The archaeological and geological data provided by Last's 1951 and the PWD's 1993 excavations in the inner harbour area are limited and have therefore played only a minor role in the formulation of our conclusions. Last's lack of elevation data, combined with only a general dating of architecture, severely limits the usefulness of his results. Furthermore, too much ambiquity remains concerning the possible evidence for tectonic uplift in Last's Trench I: the bedrock surface may have been misidentified; the timing of the excavation (during the dry season) may have resulted in a low water table within the rock-cut well, as there may have been little recharge from the upland; or the brackish water in the well may not have related at all to the local water table/sea level, if the well were plugged at the bottom with sediments (as Last seems to indicate) and was therefore no longer in direct communication with the ground water table. In short, Last's trench I data can help us (in conjunction with geological data) to determine the position of the paleo-shoreline, but not the occurrence of local uplift.

Earthquakes and uplift are possible factors in the deterioration of the inner harbour, but we suggest these factors played a relatively minimal role, in comparison with the harbour's incessant problem of siltation. The rupturing of the breakwaters by earthquakes may —or may not— have contributed to increased siltation within the harbour, depending upon the site's particular hydrodynamics.[73] The possibility remains that some minor vertical displacement of the entire harbour floor, and of Nea Paphos, has occurred, but we believe such displacement was minimal, perhaps on the order of 0.5m. or less. What geological evidence we do have for minor uplift derives from cores in the northern part of the western basin, where shallow marine, beach, and overwash deposits are found up to 1.6m. above RSL. It remains impos-

72. Also, depending on the hydrodynamics within a particular harbour, such anti-siltation modifications to harbour structures may have actually had the converse effect of *increasing* siltation.

73. See previous note.

sible, however, to know the exact depositional elevation of these beach and overwash deposits; they may have been laid down 0.5-1.0m. above RSL, or slightly lower, then uplifted a few decimeters. Minor uplift of the area would have aided in diminishing the overall size of the harbour's internal area, but it (like the aforementioned rupturing of the breakwaters) would not necessarily have increased the rate of siltation. Therefore, we may conclude that despite minor uplift being a possibility, the harbour was already silting prior to any such tectonic movement, and the principal factor in the ancient harbour's deterioration was long-term siltation.

As a side note, there is little or no evidence in the area of Nea Paphos for late Holocene vertical displacement; i.e., no known faults or surface ruptures. The Moulia Rocks, *ca.* 4km. southeast of Paphos harbour (Fig. 1, inset), however, present an interesting bathymetric irregularity, where the topographic break across the Rocks may be a product of fault displacement. If this break is a fault trace, the line of the fault probably continues along the western shore of the Paphos peninsula. Perhaps this explains the dark line visible in the sea that runs from the Moulia Rocks to the western breakwater of Paphos harbour. In his 1966 study, Nicolaou cites a retired Paphian fisherman who described the submarine topography along this dark line, which actually demarcates a sharp topographical break in the surface of the seabed: on the seaward side of the break, the sea lies three fathoms deep; while on the landward side, the sea measures nine fathoms deep.[74] This same visible line in the sea has been the source of inspiration for the tireless legend of a colossal ancient harbour at Nea Paphos, whose supposed breakwater extended some 4km. from Paphos harbour to the Moulia Rocks![75] In fact, the submerged "breakwater" may be a product of fault offset. At present, however, this must all remain conjectural, since further research is necessary to determine whether an offshore fault at Paphos actually exists.

Within Paphos harbour, the bedrock ridge creates a natural separation in the now buried northern part of the bay (Fig. 4). The embayment to the west of this natural divider is about twice the size of the embayment to the east. These two natural embayments would have offered some degree of refuge to passing ships, even without the addition of artifical breakwaters. When the bay was eventually enclosed, however, the harbour of Nea Paphos appears to have had *two* —not three— internal basins. Previous interpretations concerning the harbour's internal layout[76] must therefore be reconsidered, in light of these latest geological findings.

The strike of the existing bedrock ridge, which we mapped in 1996, does not coincide with the orientation of the easternmost quay in the artist's reconstruction of the ancient harbour previously published by PAHEP.[77] Instead, the bedrock ridge strikes N-S, dividing a small, shallow, sandy harbour with a muddy deltaic area in the east from a larger, shallow, sandy harbour in the west. If an artificial quay was at some point erected in the centre of the western embayment to create two individual basins, the extensive series of cores drilled during the 1996 geological study revealed no subsurface evidence of such a structure. The data currently available indicate a shallow embayment that intially had a sandy substrate overlying a gently southward-dipping bedrock surface.

Three possible scenarios should therefore be considered in explaining the Roman period tripartite harbour reported by *Stadiasmos*. 1) When the artificial breakwaters were initially constructed they enclosed the two basins separated by the natural bedrock ridge; at some point in time, however, perhaps even as part of the original harbour construction, a masonry quay was installed as a divider in the harbour's larger western basin, thereby creating three internal basins. 2) *Stadiasmos* was referring *not* to three working basins inside the harbour that served various maritime functions, but instead to three actual parts or indi-

74. Nicolaou, *op. cit.*, (n. 38), 578, n. 44.
75. On the validity of this local legend, see Leonard and Hohlfelder, *op. cit.*, (n. 1), 371, n. 66, 378, n. 103; Hohlfelder and Leonard, *op. cit.*, (n. 1), 49. RLH suggests (*Cyprus and the Sea*), *op. cit.*, (n. 1), 196, that previous adherents of the supposed colossal breakwater may have placed too much stock in the legend through a misreading of aerial photographs, geological ignorance, or sheer overzealousness.
76. *Supra*, nn. 10-11.
77. *RDAC* 1993, *op. cit.*, (n. 1), 377, fig. 3.

vidual natural areas inside the enclosed harbour: the two basins divided by the bedrock ridge, and the small furthest eastern embayment divided from the rest of the eastern basin by the stream's slightly projecting delta. Or perhaps most likely, given the latest geoarchaeological data: 3) Only the two natural embayments separated by the bedrock ridge[78] were ever exploited inside the enclosed artificial harbour, while a third harbour facility lay outside the breakwaters, either on the seaward side of the main eastern breakwater or in the more exposed bay on the northwestern side of the ancient city of Nea Paphos (Fig. 1, inset).

Daszewski's suggestion that the (main) ancient eastern breakwater had vertical walls on both internal and external faces, presumably for anchorage on both sides,[79] takes on even greater significance if the water area outside the eastern breakwater were not merely a subsidiary external anchorage, but an integral tertiary component within the harbour's main tripartite scheme. We would agree with Daszewski that the harbour's internal western basin may have accommodated the main military (in Hellenistic times) and commercial facilities, while the eastern basin was perhaps relegated to industry such as ship building.[80] The southeastern, external harbour area in such a tripartite arrangement may have been used, especially in Roman times, for the daily anchorage of fishing boats and local commercial vessels (coasters), while the harbour's internal commercial area may have been reserved for the handling of long-distance maritime trade.[81] If this scenario for the tripartite harbour is the correct one, perhaps the subsidiary, external eastern breakwater served as a multi-purpose installation, not only for combatting siltation but also for providing some modest, sub-surface, temporary protection for ships and small boats while they berthed to transfer cargo in the southeastern anchorage.

Alternatively, the bay northwest of Nea Paphos (Fig. 1, inset) may have also been used in antiquity as an anchorage,[82] but thin sand combined with abundant outcrop of lithified terrace gravels and sands would have made this coastal area the least accessible to watercraft. Ships probably moored temporarily in this northwestern external anchorage, and then only when southerly to easterly winds made the southeastern harbour area outside the eastern breakwater too dangerous and passage into the enclosed harbour too risky.

Daszewski has suggested that Pleistocene terrace rock in the shallow water of this northwestern area may have been at sea level in antiquity, and that ships may therefore have had easier access to the shore.[83] No geological evidence supports this hypothesis, however, and, as discussed above, sea level 2000 years BP was probably only about .20-.30m. lower than present levels. Furthermore, these terrace deposits occur at various levels: below, within, and above the surf zone. Since it seems therefore very unlikely that this northwestern shoreline, within the past 2000 years, was ever more readily accessible, we conclude this area was never anything more than a subsidiary external anchorage, not a component in the tripartite harbour described by *Stadiasmos*.

Although the 1996 geological study has begun to clarify Paphos harbour's paleoenvironmental setting, and, therefore, may aid in refining future studies of the ancient part, our discussion above of three possible interpretations for the *Stadiasmos* passage illustrates how this important historical source continues to resist easy explication. In addition, due largely to the limitations discussed above in the currently available data, our chronology of the prograding paleo-shoreline must at this point remain tentative. Further archaeological or geological examination of the inner harbour area, however, has at present been averted by modern overbuilding. In the future, if the study of this portion of the archaeological site once more becomes

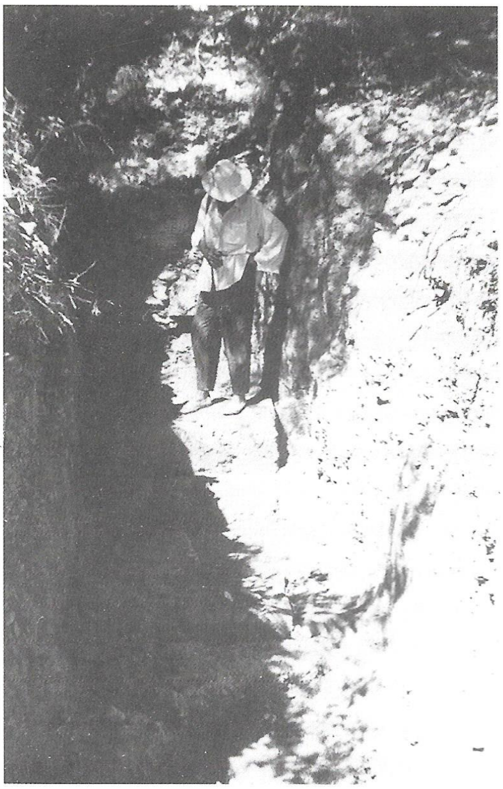
78. Counting the eastern harbour basin as only one general area, without regard for the small narrow embayment between the stream delta and the (main) eastern breakwater.
79. Daszewski, *op. cit.* (n. 10), 331. Architectural blocks suggestive of such vertical faces on both sides of the main eastern breakwater were recorded by PAHEP in 1991-92: Hohlfelder in *Cyprus and the Sea*, *op. cit.*, (n. 1), 204.
80. Daszewski, *op. cit.*, (n. 10), 334.
81. For the separation in Roman ports between long-distance and local commercial facilities, which were isolated in part to ease collection of the distinct tariffs levied against such diverse forms of trade, see: D.J. Blackman, "Ancient Harbours in the Mediterranean, Part II", *IJNA* 11.3 (1982), 194.
82. Leonard and Hohlfelder, *op. cit.*, (n. 1), 378. See also Daszewski's discussion *op. cit.*, (n. 10), 332, of ancient masonry preserved in the sea along the southern shoreline of the northwestern bay.
83. *Idem*, (n. 10), 333.

feasible, renewed excavation in the areas of Last's 1951 trenches may aid in determining whether structures were built on the harbour's internal shore only in the Hellenistic and Roman periods, or during Byzantine and Medieval times as well. Excavation will also assist in refining our conclusions on the chronology of the prograding shoreline, the positions of the sequential seawalls, and the internal division of the harbour. Furtheremore, the use of radiocarbon dating may allow periods of sedimentary environmental evolution within the harbour to be pinpointed more precisely.

For the present, PAHEP's 1996 geoarchaeological investigations indicate that, following an initial period when the natural embayment contained open water and high-energy conditions, the Hellenistic construction of the artificial breakwaters led to restricted circulation and low-energy conditons, thus triggering the still-ongoing problem of siltation within the harbour. Despite this process of natural deterioration, however, the harbour of Nea Paphos was, from an engineering standpoint, largely a success. The ancient harbour has continued to function into the present day, and now —with the associated remains of the Graeco-Roman city itself— stands as one of the great monuments to the martitime heritage of Cyprus.

1. Aerial photo: The 1996 study area.

2. Paphos, inner harbour area. Standing column.



3. Possible seawall in western study area, north of standing column.