On the Date of Construction of Lechaion, Western Harbor of Ancient Corinth, Greece

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Lechaion, the western harbor of ancient Corinth, was an artificial harbor excavated in a marshy area and connected to the open sea through a channel with revetment walls. It was probably the most important harbor of this type in antiquity, and one of the most important harbors in Greece for more than one millennium. Yet, the date of construction of this harbor is a matter of debate; 600 B.C., ca. 44 B.C., and A.D. 350 are the most probable dates. Geomorphological and biological investigations, in combination with AMS radiocarbon dating of exposed marine shells found in the walls of the channel leading to the inner basin of the harbor indicate that the channel was open to the sea before a seismic land uplift that probably occurred sometime in the fifth to third century B.C. These data indicate that the construction of the harbor began in ca. 600 B.C., the period of Corinthian expansion to the Ionian Sea and southern Italy.

INTRODUCTION

Harbor remains at the present-day Lechaion, a coastal suburb of the modern city of Corinth, have been identified as parts of Lechaion, the western harbor

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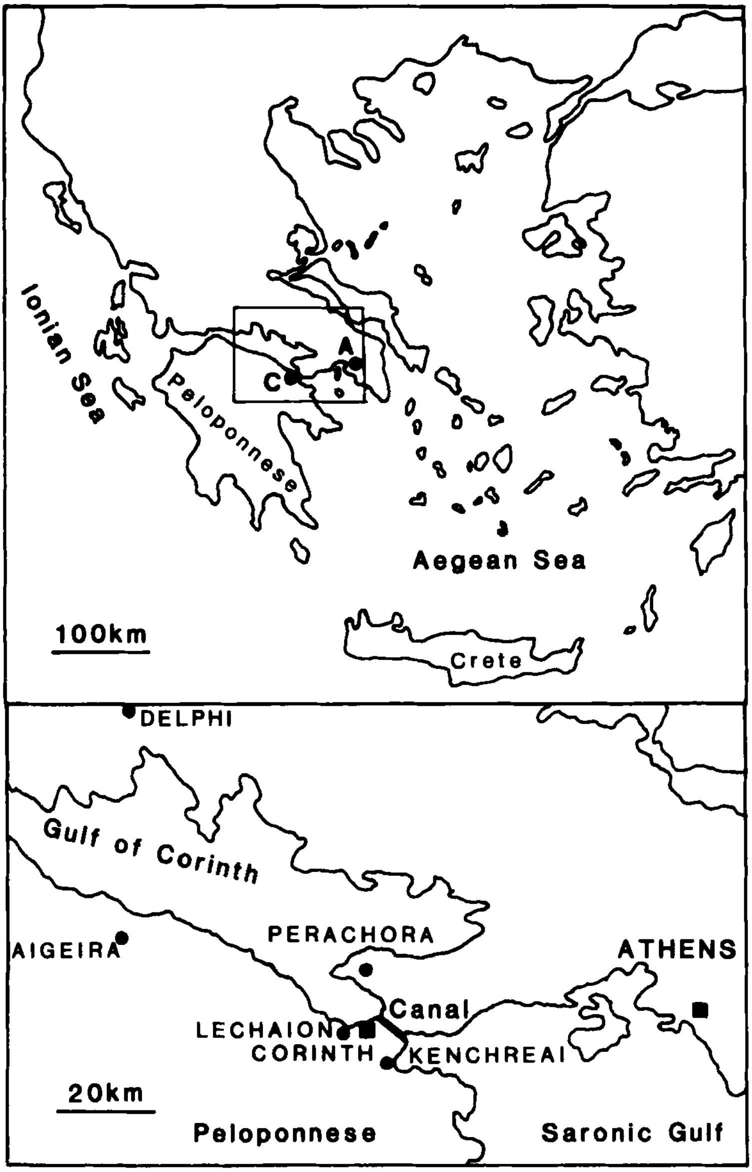

Figure 1. Location map. A and C stand for Athens and Corinth, respectively.

of ancient Corinth (Figure 1), a city that flourished in the archaic (700–600 B.C.) and Roman (44 B.C.–A.D. 400) times. Archaeological and historical data reveal that Lechaion was in use as a harbor at least between 500 B.C. and

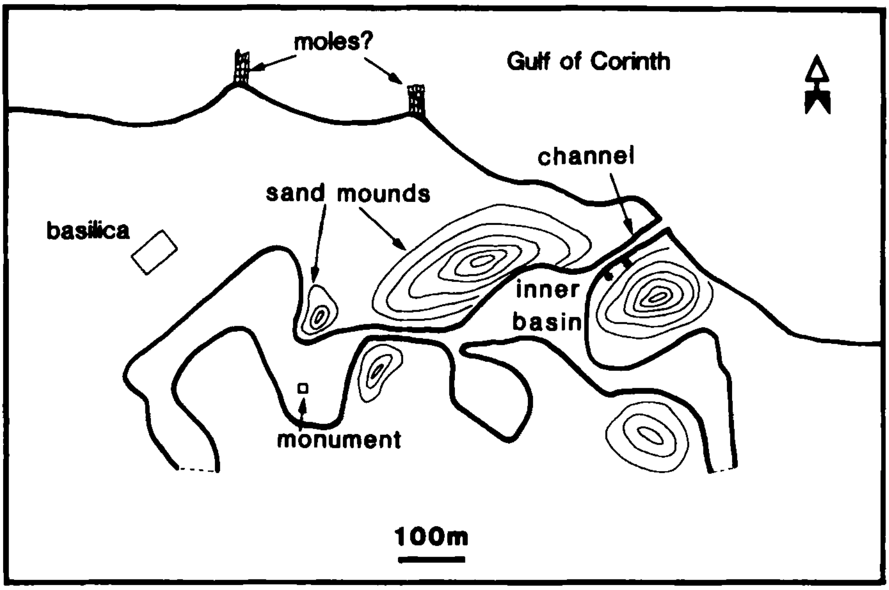

Figure 2. Plan of the Lechaion harbor, simplified after Georgiadis (1907). An arrow points to the wall at the channel leading to the inner basin where the samples (marked with stars) were collected.

A.D. 400 (see Appendices I and II) and was probably the most important harbor in western Greece for at least one millennium.

The area is today dominated by a number of mounds of sand and pebbles excavated during the construction of the inner basin of the harbor in an uncertain period in antiquity. These mounds survived quarrying associated with railroad construction during the last century (Figure 2) (Georgiadis, 1907) and do not probably represent a single activity, but a continuous dredging that would have been necessary to keep the harbor usable.

Remains of the harbor installations visible today are two moles that possibly formed an outer harbor, a stone-lined channel from the shore to the inner harbor, and the foundation of a rectangular construction ("monument") in the middle of the inner basin (Georgiadis, 1907; Shaw, 1969). Around the harbor, remains of sixth to fourth century B.C. cemetery, various Roman building ruins, and the ruins of a monumental fifth century Christian basilica complex (the largest of the period ever discovered in the Mediterranean) have been brought to light (Figure 2) (for a summary of information, see Papachatzis, 1974; Sakellariou and Faraklas, 1971; Wiseman, 1978; Salmon, 1984; Rothaus, 1995).

Yet, because of the meager historical and archaeological information (see Appendices I and II), the palaeotopography and history of this site remain to

Figure 3. The entrance (channel) leading to the harbor, view from west. The blocks where the samples were collected are at the right end of the photo. The photo was taken before a dirt coastal road was opened in 1992.

a substantial degree unknown. The date of construction of the harbor remains unknown and is a matter of debate: The most probable dates include the period of prosperity and expansion of Corinth to the west, in the Ionian Sea, and southern Italy, especially ca. 600 B.C.; the years shortly after the refounding of Corinth by Romans in 44 B.C.; or even ca. A.D. 350, when major works at the harbor were epigraphically attested (Papachatzis, 1974; Sakellariou and Faraklas, 1971; Wiseman, 1978; Salmon, 1984; Rothaus, 1995). Some important public buildings and fortifications were also constructed by the Corinthians in the second middle of the fifth century B.C. (E. Gebhard, pers. comm., 1995).

In spite of its importance as a historical site and as the largest and oldest, possibly, artificial harbor in the ancient world, the harbor of Lechaion has never been excavated; this is why no archaeological answers can be given to the problems of its topography and history. Yet, an alternative and simple way to shed some light on these problems is to correlate the surface archaeological remains with the geomorphological changes the Corinth area is known to have undergone during the last hundred thousands of years; these changes continue even in the last decades, as geodetic data reveal (Mariolakos and Stiros, 1987; Stiros, 1988a, 1988b). The study of coastal changes, which may provide an upper limit for the construction of the harbor in its surviving form, are the subject of this article; the details on the environmental changes of the site will be discussed elsewhere (Stiros et al., in prep.).

COASTAL UPLIFT IN THE CORINTH AREA

The north coast of Peloponnese has long been recognized as an area of uplift, having a rate among the highest in the world: Marine Quaternary sediments

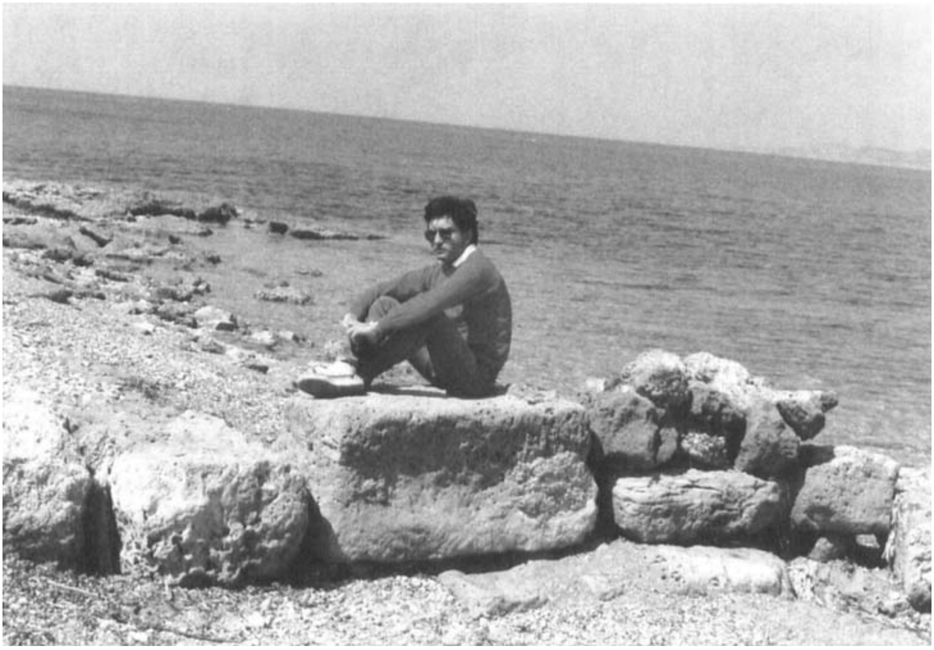

Figure 4. Blocks of the wall bounding the channel to the southwest. Situation before 1992. Drilling of *Lithophaga* on blocks, possibly not *in situ*, are clearly seen.

are at heights more than 1600 m above sea-level (Philippson, 1892). Because of this spectacular rate of uplift (which made the area famous and attractive for earth scientists all over the world), the coastal landscape of north Peloponnese is characterized by a number of marine terraces (Keraudren and Sorel, 1987); the modern and ancient cities of Corinth lie on two of these terraces.

Geomorphological, biological, and archaeological evidence indicates that the coast around Corinth continued its uplift in the last few thousand years: Uplifted notches corresponding to fossil shorelines in the Perachora area (Pirazzoli et al., 1994; Stiros et al., in press); exposed beachrocks, lying on top of ancient constructions at the western exit of the Corinth canal (Mariolakos and Stiros, 1987); exposed marine strata containing pottery fragments of undetermined age in the area of Corinth (von Freyberg, 1973); and uplifted harbor remains and marine fauna in the harbor of ancient Aigeira (Papageorgiou et al., 1993).

The signs of a recent relative sea-level drop are present also at Lechaion: Higgins (1965) observed mollusc borings in blocks at the entrance of the harbor, as well as marine sediments formed at the bottom of the inner basin of the harbor that are now exposed at the height of more than 1 m above present sea-level.

The pioneering work of Higgins (1965) reveals that the area of Lechaion has undergone important environmental changes, including a more than 1 m uplift

Figure 5. A detail of the wall of Figure 3. Meter to the left of block where sample Gif-A-91LE1 was collected.

and possibly oscillations of relative sea level. Our work confirmed these observations, as will be shown below.

ENVIRONMENTAL CHANGES AT LECHAION

In this article we focus on the channel connecting the open sea with the inner basin of the harbor. This channel was originally at least 150 m long and about 12 m wide, vested with dry-masonry walls. Two or three rows of hewn, limestone blocks were visible until recently along a distance of more than 10 m in both the northeast and southwest wall. A coastal dirt road that crossed the channel was opened in 1992 and the blocks of the southwest wall of the channel were then buried or moved away and heaped above each other in a place between the road and the coast.

In most of the blocks that line the channel walls borings of marine molluscs *Lithophaga lithophaga* L. can be observed; in some their shells are still preserved. A macroscopic examination revealed that these molluscs are found only on the face of the wall that was in contact with sea-water, and in blocks of different provenance. These molluscs therefore drilled the blocks after the construction of the wall, and certainly are not fossils synchronous with the deposition and formation of the sediments from which the blocks were cut; this conclusion is confirmed by the radiometric dating. On the other hand, for most

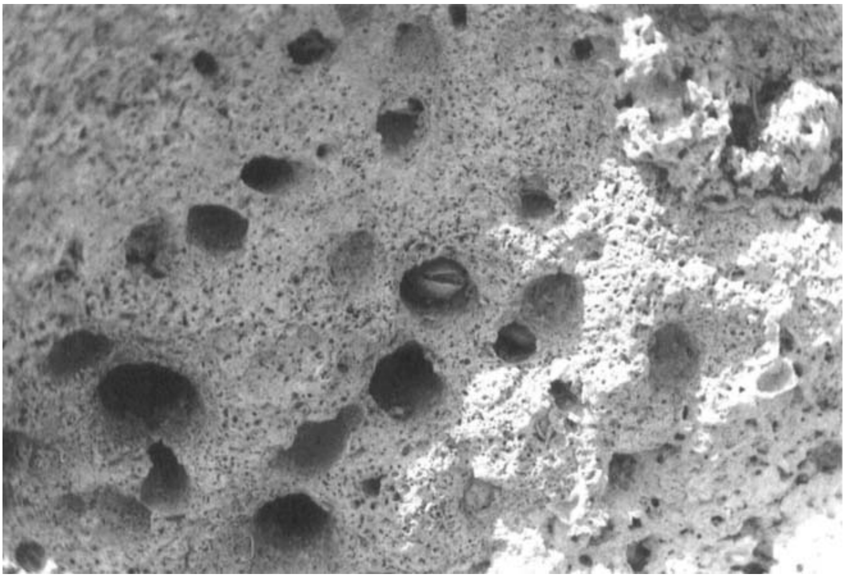

Figure 6. Close-up view of *Lithophaga* articulated shells preserved in the blocks of Figure 4 at the entrance of the harbor.

blocks we can largely exclude the possibility of reuse, as Scranton and Shaw (1978) stated, although this is not possible in all instances.

Evidence of a sea level higher than at present is ubiquitous in the area, and can be documented by various biological and morphological observations, as has been noted by Higgins (1965) and is analyzed in detail elsewhere (Stiros et al., in prep.).

SAMPLE DESCRIPTION AND ANALYSIS

Two different samples of marine fossils were collected from the blocks of the east row of blocks at the entrance of the harbor basin (for location, see Figure 2). Sample Gif-A-91LE1 was collected in June 1991 from the upper, southernmost block exposed in the wall, and sample Gif-A-90SS4 was collected in 1990 from a block at the middle of the same wall. All of this part of the wall appeared to be *in situ*, and samples were collected from a height approximately 1.1 m above the water. The first sample was identified as *Lithophaga lithophaga* L., and the second sample simply as *Lamellibranch*, probably *Lithophaga*. These species have a lifespan ranging between a few and a few tens of years.

From the field examination, both samples correspond to marine organisms that drilled the limestone blocks after the construction of the wall, when the latter was still in the water. Both fossils were collected in living position: Their

Table I. Results of AMS radiocarbon analysis at Gif-sur-Yvette, based on the calibration curve of Stuiver et al. (1986) and the assumption of a reservoir effect of 320 ± 25 yr for the Mediterranean.

Sample	Fossil	Conventional ^{14}C Age ± 1σ	Calibrated Age ± 2σ
Gif-A-90SS4-A	*Lamellibranch*	2530 ± 90	560–100 B.C.
Gif-A-90SS4-B	*Lamellibranch*	2400 ± 45	340–50 B.C.
Gif-A-91LE1-A	*Lithophaga*	2620 ± 50	600–340 B.C.
Gif-A-91LE1-B	*Lithophaga*	2430 ± 50	360–70 B.C.

For details see Stiros et al. (1992) and Pirazzoli et al. (1994).

two valves were connected to each other but not cemented to the block, and there was no evidence of a sedimentary matrix in their holes.

The samples were split in two parts (A and B), and each one was analyzed separately with the AMS technique at Gif-sur-Yvette (France), with the techniques and calibration procedures described in Stiros et al. (1992). The results are shown in Table I.

DATING AND CAUSE OF THE UPLIFT

The calibrated ages of samples of Table I represent the intervals in which the datings of shells can be determined with a probability of 95%. All four intervals are between 600 and 50 B.C.; hence any age younger than 50 B.C. or older than 600 B.C. is rather unlikely and should be rejected. Furthermore, all four intervals contain the date of 340 B.C. We suggest that this last date is the most probable age for the fossils analyzed. The selection of the common date included in all radiocarbon datings as the most probable one is quite reasonable on the grounds of probability theory, and proved successful in the case of the uplift of Crete at ca. A.D. 350; this last date was confirmed by stylistic archaeological datings as well (Pirazzoli et al., 1996).

However, given the uncertainties in the radiocarbon dating (which are a matter of debates and discussions concerning the chronology of the Aegean archaeology [Renfrew and Puchelt, 1990]) and the uncertainties in the calibration of the radiocarbon datings for marine organisms in the Mediterranean (Stiros et al., 1992; Pelc, 1995), the accuracy of the estimate for the age of samples collected is not expected to be better than, say, 100–150 years. This interval far exceeds the life span of the species dated.

The next step is to clarify the relationship between the age of the fossils and the history of the harbor. As has been documented elsewhere (Stiros et al., 1992; Papageorgiou et al., 1993; Laborel and Laborel-Deguen, 1994; Pirazzoli, 1996) the upper limit of living *Lithophaga* defines a rather sharp horizontal line lying close to the mean sea level determined by tide gauges. This line corresponds to the upper limit of certain species and the lower limit of others. Hence, it determines the limit between the sublittoral biological zone (in which these species can live relatively protected from bioerosion), and the midlittoral biological zone (in which these species cannot live because of desiccation, nor be preserved because of bioerosion). The line that marks the limit between these two zones is characteristic for each site and known as biological mean sea level (BMSL) in the following. If for a certain reason (for instance, due to a seismic land uplift) living *Lithophaga* and other species are found above BMSL (i.e., in the midlittoral biological zone), they die and their remains are quickly obliterated by midlittoral erosion.

These fossils, however, may escape midlittoral erosion and be preserved above the water if the uplift was rapid and great enough (depending on tide range, local surf conditions etc., but usually at least a few tens of centimeters) so that they can be found at an elevation (more precisely another biological zone) where erosion is limited (e.g., supralittoral zone). Alternatively, they may be covered by a sedimentary matrix, landslide debris, etc. (Laborel and Laborel-Deguen, 1994; Stiros et al., 1994b; Stiros, in press). This last possibility should be rejected for the Lechaion samples which were collected in living position (see above).

Hence, we can conclude with much certainty that the fossils at the entrance of the harbor at Lechaion were killed by an episodic land uplift with an amplitude of at least a few tens of centimeters; this uplift probably occurred between 500 and 200 B.C. according to the radiometric data.

IMPLICATIONS FOR THE HISTORY OF THE LECHAION HARBOR

The construction of the entrance of the harbor obviously predates the seismic uplift documented above. We can therefore conclude that the inner harbor, or at least a part of it, was excavated before the Roman colonization in 44 B.C., a result consistent with lack of masonry remains similar to those found in the nearby, uplifted Roman harbor of Aigeira (Papageorgiou et al., 1993; Stiros et al., in prep.).

It is reasonable to suggest that a remarkable technical work, such as the harbor of Lechaion, could only have been constructed in a period of flourishing of the city of Corinth. The colonization of the coasts of the Ionian Sea and southern Italy by the Corinthians in the seventh and sixth centuries B.C. would make likely the need for a major harbor in the Gulf of Corinth. The period between 600 and 500 B.C. therefore appears as the most reasonable date for the construction of at least a major part of the harbor.

Evidence presented here indicates that probably sometimes between the fifth and third centuries B.C. the area suffered an uplift associated with one of the destructive earthquakes that frequently hit the area. This uplift would have had important effects on the topography and functionality of the artificial harbor, where the water depth was obviously shallow and any significant local sea-level fall would have prevented ships from using it. Especially if the amplitude of land uplift was around 1 m, an enormous amount of sand would have to have been dredged and deposited in the sand mounds around the harbor basin in order to restore and use at least some sections of the harbor.

However, the data from the channel discussed here do not permit an estimation of the amplitude of the uplift, since the relative sea-level fall observed today may have been the cumulative result of several earthquakes, as well as of oscillatory movements discussed by Higgins (1965) and Stiros et al. (in prep.). This last possibility is supported by historical data mentioning Lechaion as a harbor in the fourth, third, and first centuries B.C. as well as the first and second centuries A.D. (see Appendix II).

SOME PARALLELS FOR THE UPLIFT OF THE LECHAION HARBOR

The harbor of Lechaion is certainly not the only ancient harbor found above the water in the Mediterranean. In the Gulf of Corinth, the Sacred Harbor of Perachora was uplifted by 1.1 m between A.D. 190 and 440 (Pirazzoli et al., 1994; Stiros, in press), while the harbor of Aigeira was uplifted by at least 2 m in the last 2,000 years (Papageorgiou et al., 1993; Stiros et al., in prep.). The most spectacular, however, case of uplift is the harbor of Phalasarna (and probably other harbors in west Crete), where the land was uplifted by 6–9 m about 1500 years ago (Pirazzoli et al., 1992, 1996).

Uplifted ancient harbors have been identified in Turkey as well: The ancient Greek harbor of Seleucia Pieria was uplifted about 1.7 m 2500 years ago, and about 0.7 m during the A.D. 526 earthquake (Erol and Pirazzoli, 1992; Pirazzoli, 1996).

Except for these harbors, whose date of uplift was determined by radiocarbon and stylistic archaeological analyses, there are at least two modern harbors with some importance for archaeology that have been uplifted during this century. The harbor of Poros, Cephalonia, which, according to some investigators, was close to the palace of Odysseus in Homeric Ithaka, was uplifted by around 0.6 m during the 1953 earthquakes (Stiros et al., 1994a). Finally, in the harbor of Pozzuoli, near Naples, Italy, famous for the columns of Serapeion drilled by *Lithophaga* up to a height of 7 m (Lyell, 1847), gradual uplifts of about 1.5–2.0 m occurred in 1970–1971 and 1982–1984 (Cortini et al., 1991). These last uplifts were not, however, associated with earthquakes but with volcanic (tectonomagmatic) processes ("bradisismo") and brought the slipways above the water. However, they were not fatal to the harbor.

APPENDIX I: ARCHAEOLOGICAL EVIDENCE FOR THE DATING OF THE HARBOR AT LECHAION

The style of construction of the visible archaeological remains at Lechaion is not characteristic of any specific period; they may date as early 600 B.C., but they may also be purely Roman or even later in date. Typical Roman harbor constructions (as in the Aigeira harbor) are not observed, but the foundations of the various harbor works are not exposed.

Sherds dated to ca. 600 B.C. were found among the stones in the area between the basilica and the inner harbor basin (Pallas, 1961/1962; Sakellariou and Faraklas, 1971), but their significance for the dating of the harbor is uncertain.

Remains of sixth to fourth century B.C., as well as of Late Roman and post-Roman periods are visible in many places around the harbor (Wiseman, 1978).

Swallowtail clamp cuttings on a monument in the inner harbor indicate construction in the first to second centuries A.D. (Shaw, 1969; Rothaus, 1995).

There is epigraphic evidence that between 345 and 343 B.C. quarried rocks were exported from Corinth to Delphi; the most probable route was transporting the stone by ship from a harbor in the gulf of Corinth, probably from Lechaion (Bousquet, 1989).

A major reconstruction of the harbor was undertaken in A.D. 353–358, as an inscription (IG IV 209) from a base of a monument erected to honor the Roman governor of Peloponnese, "benefactor and constructor" of the harbor indicates (Papachatzis, 1974). Yet, the exact nature of these works remains unknown.

At around A.D. 500, a Christian church, one of the largest of the period, was constructed next to the harbor, indicative of the importance of the site (Papachatzis, 1974; Pallas, 1977; Wiseman, 1978).

APPENDIX II: HISTORICAL EVIDENCE FOR THE DATING OF LECHAION HARBOR

The earliest reference to the site in the late sixth or early fifth century B.C. is related to a myth (Simonides, 545).

The site is mentioned in various war reports between 392 and 217 B.C. by Xenophon (Hell. 4.4), Diodorus Siculus (14.86–15.68), Polybius (5.2–5.28), and others.

Lechaion existed as a harbor in ca. 44 B.C. (Strabo, 8.6.22), the first century A.D. (Plutarch, 146D2), and the second century A.D. (Pausanias 2.2.3).

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