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# Piraeus, the ancient island of Athens: Evidence from Holocene sediments and historical archives

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## ABSTRACT

The famous Greek geographer Strabo wrote in the first century A.D., that Piraeus was formerly an island and lay ‘over against’ the mainland, from which it got its name. To validate Strabo’s hypothesis, cartographic and historical data were compiled with multiproxy paleoenvironmental analyses and radiocarbon dating from a series of boreholes drilled in the Cephissus coastal plain, southwest of Athens, Greece. The results of this interdisciplinary geoaerchaeological research demonstrate the reliability of Strabo’s text by revealing that Piraeus was indeed an island. In early Holocene time, the rocky hill of Piraeus was linked to the mainland of Attica. During the late to final Neolithic Period (4850–3450 B.C.), Piraeus became an island in a shallow marine bay, due to sea-level rise in the Holocene. Between 2850 and 1550 B.C., in the Early and Middle Bronze Age, Piraeus was separated from the mainland by a wide lagoon. In the fifth century B.C., Themistocles, Cimon, and then Pericles connected Athens to Piraeus by building two “long walls” partly built on a residual coastal marsh called the Halipedon. This study reveals an impressive example of past landscape evolution.

## INTRODUCTION

In the first century A.D., the Greek geographer Strabo wrote, “Piraeus was formerly an island and lay ‘over against’ [beyond, on the other side] the mainland, from which it got the name it has” (*in Jones, 1960, p. 216–219, our brackets; Chantraine, 2009*). Many centuries before Strabo visited Attica, the idea of Piraeus as an island to the southwest of Athens was present in the oral tradition of the Athenians. We know that the rocky island of Piraeus was connected to the

mainland during the fifth century B.C. (Strabo, *in Jones, 1960, p. 216–219; Plutarch’s Lives of Cimon, in Perrin, 1985, p. 444–447; Conwell, 2008; Garland, 1987*). First Themistocles (Plutarch’s *Lives of Themistocles, in Perrin, 1985, p. 54–55*), then Cimon and Pericles (for the later middle wall) built two “long walls” connecting the city of Athens with the harbors of Phaleron Bay and Piraeus. The objective was to fortify all the territory between Athens and its main harbor Piraeus, creating a fortress with access to the

sea (Steinhauer, 2000; Papahatzis, 1974). However, the question remains, was Piraeus already connected to the plain of the Cephissus River during the construction of the long walls, or was it necessary to fill in the marine or lagoon areas in between?

In order to obtain answers, it was essential to understand the natural and cultural processes that affected the sedimentary sequences deposited between the hill of Piraeus and the plain of Cephissus (Fig. 1). The main factors that feature in the evolution of the Piraeus coastal landscape are the Holocene sea-level rise, which was a reaction to glaciohydroisostatic changes (Blackman, 1973; Kelletat, 2005; Lambeck et al., 2004; Lambeck, 1995, 1996; Lambeck and Bard, 2000; Lambeck and Purcell, 2005; Loven et al., 2007; Peltier, 2004), the tectonic stability of the area documented by the relative absence of earthquakes during the past few thousand years (Pirazzoli, 2005; Flemming et al., 1973; Flemming and Webb, 1986; Papazachos, 1990; Stocchi and Spada, 2009; Lekkas, 2001), the low tidal range ( $\pm 0.25\text{--}0.30$  m) (Andritsanos et al., 2000), and the progradation of the deltaic fan of the Cephissus River.

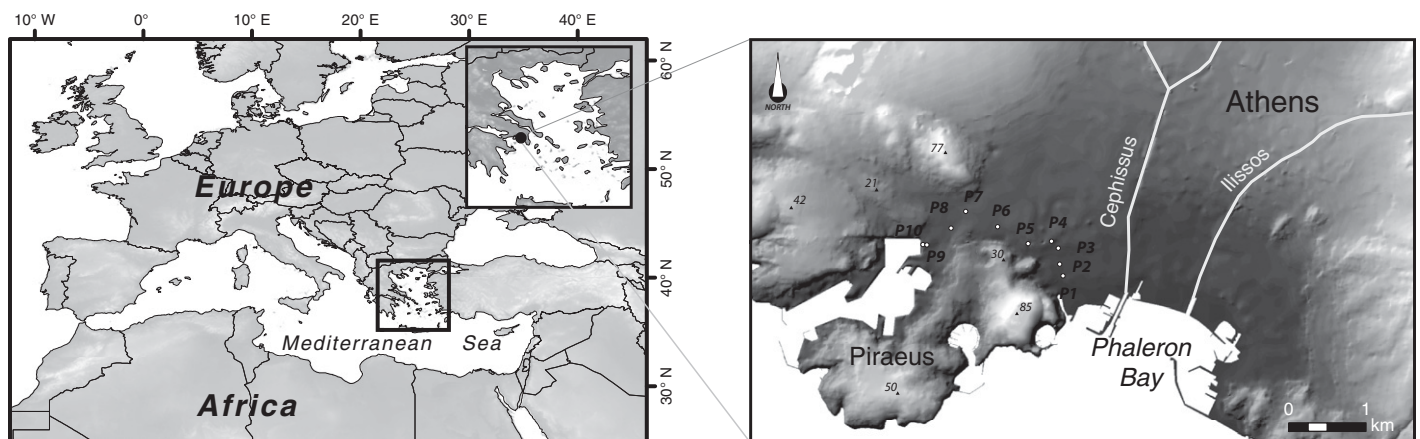
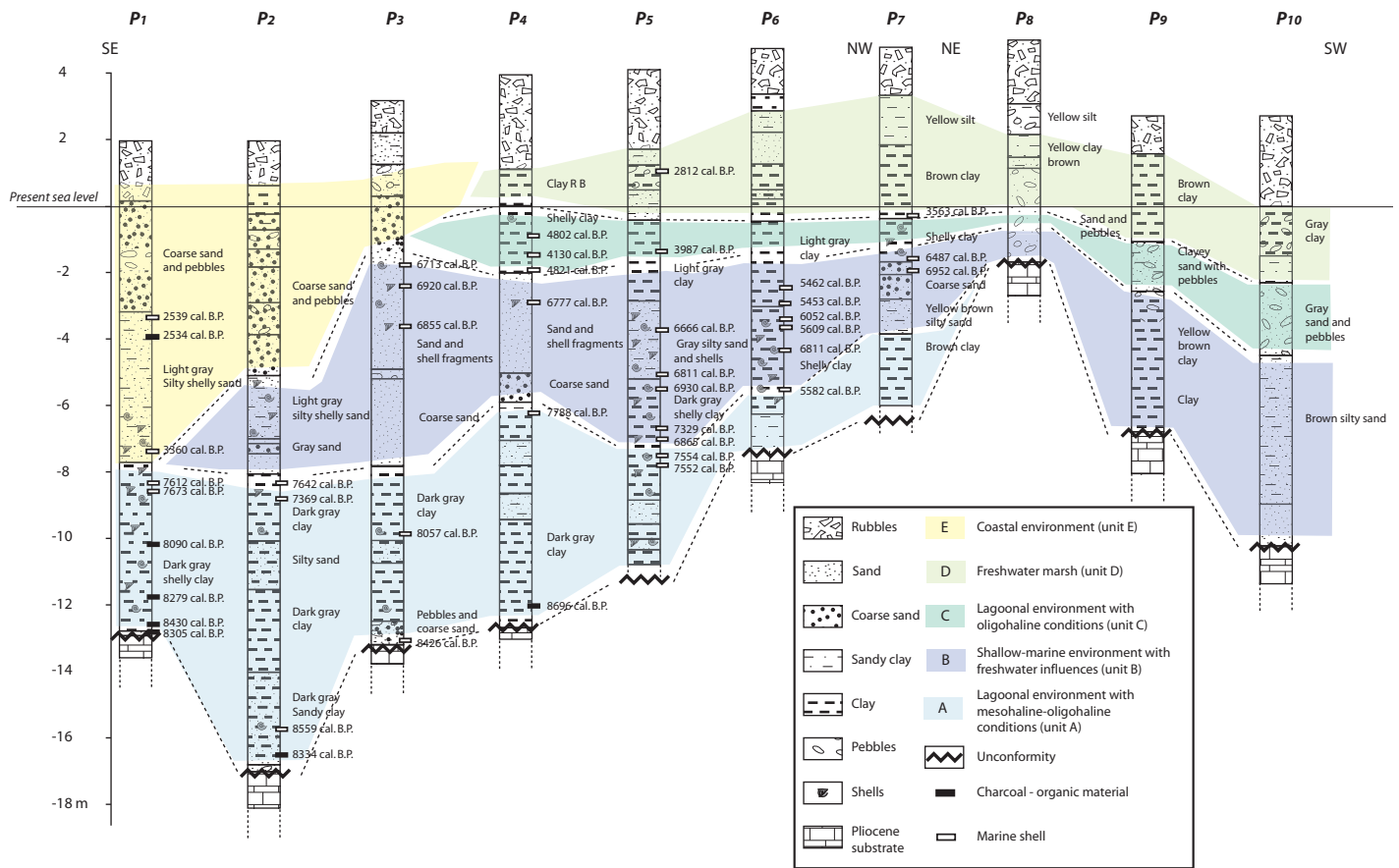


Figure 1. Location map.

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**Figure 2.** Lithostratigraphical transect with direction of southeast to northwest, and then northeast to southwest, and descriptions of 10 boreholes. Five main lithostratigraphical units (from oldest to youngest, A–E) were defined. Unit A consists of gray to dark gray clay with silty sand layers and is dated at between ca. 8700 and 7500 cal. yr B.P. (Late Mesolithic to Middle Neolithic Period, 6750–5550 B.C.); it represents a mesohaline–oligohaline lagoonal environment with freshwater inputs. Unit B consists of shelly silty sand to sand, grayish in eastern part and grayish to yellowish-brown in western part. It is dated at between ca. 6800 and 5400 cal. yr B.P. (Late Neolithic to Final Neolithic Period, 4850–3450 B.C.), and represents shallow-marine environment. Unit C consists of light gray to gray clay with sand and pebble layers in the western part, and is dated at between ca. 4800 and 3500 yr cal. B.P. (Early to Middle Bronze Age, 2850–1550 B.C.); it represents oligohaline lagoonal environment with freshwater inputs. Unit D consists of brown to yellowish-brown clay and silt. It is younger than 2800 cal. yr B.P. (including the Classical Period of the fifth century B.C.), and represents marshy environment that corresponds to deposits of Cephissus River, which overflowed its banks and classical archaeological strata. Unit E consists of light gray, medium to coarse sand. It ranges between 3400 and 2500 cal. yr B.P. and represents high-energy coastal environment. Rubbles in lithostratigraphy of top of cross section correspond to human deposits of past centuries.

We drilled and sampled in detail 10 rotational boreholes (see the GSA Data Repository<sup>1</sup>). The core samples were analyzed for microfaunal content and radiocarbon dating. Topographic and bathymetric data from recent and old maps (Curtius and Kaupert, 1881) and references in ancient authors (Strabo., in Jones, 1960, p. 216–219; Plutarch’s Lives of Cimon, in Perin, 1985, p. 444–447) were combined with the results of the detailed analysis of core samples.

**RESULTS AND DISCUSSION**

The grouping of sedimentary facies determined in the boreholes provided five well-dis-

tinguished lithostratigraphical units (units A–E in Fig. 2). The lowermost unit A consists of gray to dark gray clay with silty sand layers. Based on the available radiocarbon dating, the unit was determined to have been deposited between ca. 8700 and 7500 cal. (calendar) yr B.P. and is present in boreholes P<sub>1</sub> to P<sub>8</sub>. The microfauna record presents fluctuations between marine foraminiferal species (mainly represented by Miliolidae, and to a lesser degree by *Discorbis* spp., *D. patteliformis*, *Asterigerinata*, *Neonorbina*, *Gyroidinoides*, *Nonion*, *Globulimina*, *Hanzawaia*, *Valvulineria*, *Globulina*, *Stainforthia*, *Nonionella*, *Bolivina* spp., *Bulimina* spp., *Rosalina* spp.) and euryhaline species (mainly represented by *Ammonia* spp., large- and small-sized, *Elphidium* spp., *Haynesina* spp., *Aubignyna perlucida*) (Figs. 3 and 4) that indicate an alternating mesohaline–oligohaline lagoonal environment (Bronnimann et al., 1992; Loeblich and Tappan, 1994).

At that time, Piraeus was connected with the mainland by a narrow isthmus, and a long sandy beach ridge developed in the southern part of the lagoon (Fig. 5A). Unit A has not been recorded in the western part of the coastal plain (boreholes P<sub>8</sub>, P<sub>9</sub>, P<sub>10</sub>; Fig. 2), reinforcing the above-mentioned hypothesis.

Unit B, dated at between 6800 and 5400 cal. yr B.P., consists of gray to yellowish-brown shelly silty sand and was recorded within all boreholes. The microfauna consists mainly of marine foraminiferal species (Figs. 3 and 4). However, euryhaline species such as *Haynesina* spp., *Ammonia*, and Elphidiidae are present, suggesting a shallow-marine paleoenvironment that also exhibits lagoonal features. In this period, Piraeus was an island in the center of a wide, shallow marine bay (Fig. 5B).

Unit C, determined in boreholes P<sub>4</sub>–P<sub>10</sub>, is distinguished by light gray to gray clay with sand

<sup>1</sup>GSA Data Repository item 2011172, materials, methods, and Table DR1 (radiocarbon results), is available online at www.geosociety.org/pubs/ft2011.htm, or on request from editing@geosociety.org or Documents Secretary, GSA, P.O. Box 9140, Boulder, CO 80301, USA.

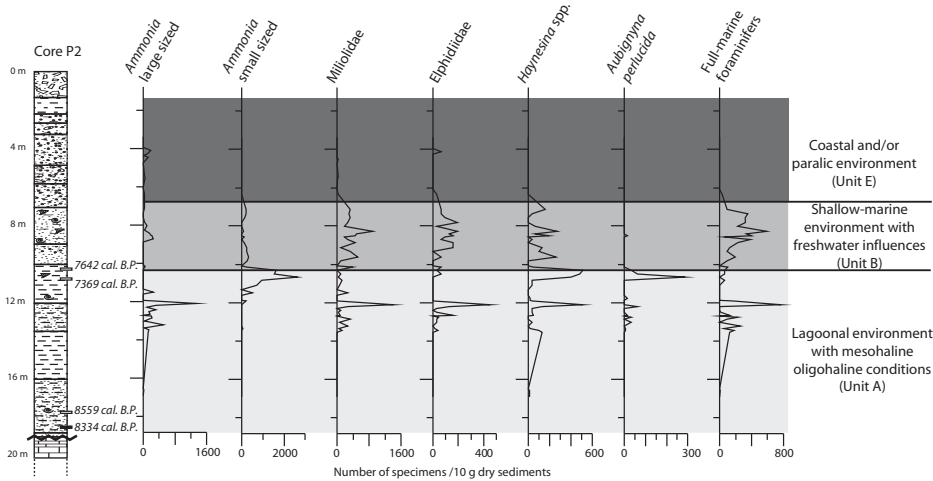


Figure 3. Foraminiferal relative abundances in borehole P<sub>2</sub>.

and pebbles. It is dated to between ca. 4800–3500 cal. yr B.P. The microfaunal content reveals the minor presence of *Ammonia* and *Haynesina* spp. (Fig. 4), suggesting an oligohaline paleoenvironment. In this period, a wide lagoon became established that was separated from the sea by beach barriers (Fig. 5C).

Unit D, younger than 2800 cal. yr B.P., consists of brown to yellowish-brown clay and silt. This unit is absent in the eastern part of the Cephissus plain (boreholes P<sub>1</sub>–P<sub>3</sub>, Fig. 1). The microfauna is characterized by the minor presence of *Ammonia* and *Haynesina* spp. (Fig. 4), and indicates a marshy oligohaline paleoenvironment.

Both units C and D transition laterally to unit E, toward the eastern part of the Cephissus plain. Unit E consists of light gray, medium to coarse sand, representing a high-energy coastal environment. It spans the centuries between 3400 and 2500 cal. yr B.P. and contains rare, mostly broken, marine foraminiferal specimens (Fig. 3), which are considered to have been mainly transported; we therefore interpret this unit as representing a paralic environment.

Our paleoenvironmental interpretation suggests that between 6800 and 5400 cal. yr B.P.,

Piraeus was an island in the center of a shallow marine bay (Fig. 5B). Until ca. 3500 cal. yr B.P., a wide oligohaline lagoon separated the island of Piraeus from the mainland (Fig. 5C). This lagoon was filled in periodically by the deltaic fans of the Cephissus and Korydallos Rivers. It is difficult to say exactly when Piraeus became connected to the mainland, but it was certainly after 3000 cal. yr B.P. and before the sixth century B.C.; during the fifth century B.C., when the long walls were constructed, Piraeus was connected to the mainland. A freshwater marsh remained at the northern part of the long walls (Halipedon), while beach ridges developed in the eastern part of the Piraeus peninsula (Fig. 5D). The marshlands north of the beach ridges would have become filled with coarse material during the construction of the long walls, as is mentioned in Plutarch’s text (see Perrin, 1985, p. 444–447).

CONCLUSIONS

The geoarchaeological research has proven Strabo’s statement, that Piraeus was formerly an island, to be true. However, it is interesting to note that this was only factually accurate

many millennia (ca. 7000–5000 cal. yr B.P.) before Strabo ever visited this region. Two main hypotheses could be proposed to explain Strabo’s accuracy in this matter. The first is based on oral tradition (Thomas, 1989) that perpetuated the collective memory of the island of Piraeus for several millennia. Strabo pieced together the oral history with “Piraeus” etymology, i.e., “peran” meaning “beyond” or “on the other side” (Chantraine, 2009).

The second hypothesis implies that the landscape was so flat around the former island, even during the first century A.D., that, as a geographer, Strabo deduced that Piraeus had been an island. It was impossible for him to date the connection between the mainland and the former island, but he could see the remnants of a former marsh and knew that the long walls had been built during the fifth century B.C. In this case, Strabo did not rely on the ancient stories about the sea surrounding the island, but rather on his own understanding and experience of past marine conditions deduced from the landscape (Morton, 2001).

There could also be a synthesis of these two hypotheses (Aujac, 1966), illustrating the two sides of Strabo’s knowledge: he was both a good reader of the landscape, as well as being a good listener to the histories of the location, using the oral accounts to supplement his deductions.

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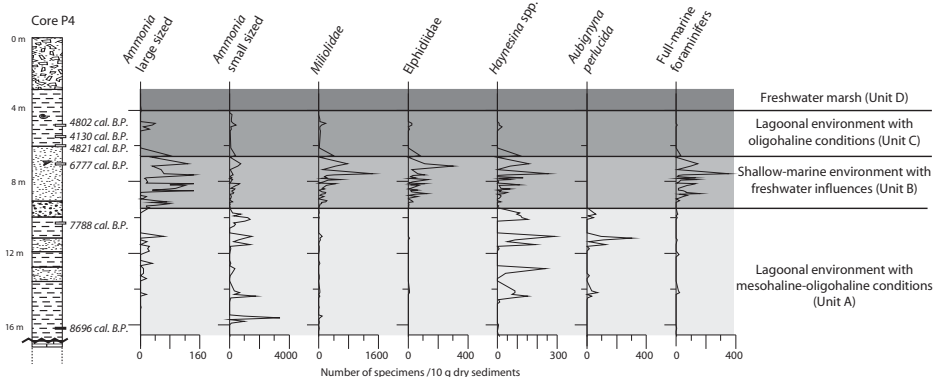
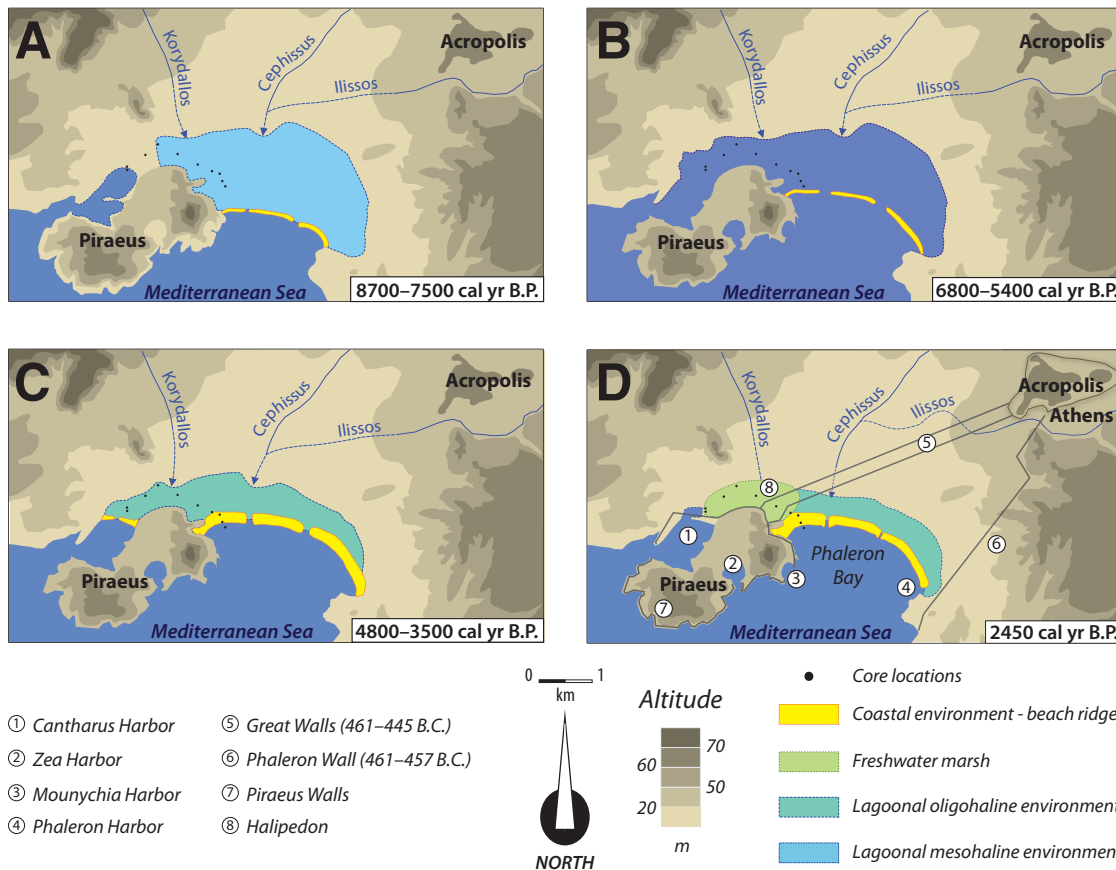


Figure 4. Foraminiferal relative abundances in borehole P<sub>4</sub>.



**Figure 5.** Four maps showing paleogeographical evolution of Piraeus during Holocene. **A:** Late Mesolithic to Middle Neolithic Period, between 8700 and 7500 cal. yr B.P. (6750–5550 B.C.). **B:** Late Neolithic to Final Neolithic Period, between 6800 and 5400 cal. yr B.P. (4850–3450 B.C.). **C:** Early to Middle Bronze Age, between 4800 and 3500 cal. yr B.P. (2850–1550 B.C.). **D:** Classical period of fifth century B.C., 2500 cal. yr B.P.

- ① Cantharus Harbor
- ② Zea Harbor
- ③ Mounychia Harbor
- ④ Phaleron Harbor
- ⑤ Great Walls (461–445 B.C.)
- ⑥ Phaleron Wall (461–457 B.C.)
- ⑦ Piraeus Walls
- ⑧ Halipedon

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