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Letter

Harbour geoarchaeology of Lechaion (Corinth area, Greece) sheds new light on economics during the Late Bronze Age/Early Iron Age transition

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ABSTRACT

Lechaion in Corinth, Greece, is the largest ancient port in Greece. Harbour geoarchaeological investigations, based on ^{14}C-dated palaeoenvironmental archives taken from a well-studied inner basin (Basin 3) and a still unknown outer basin (Basin 4), revealed anthropogenic lead excesses starting from the 12th century BCE, associated with brown coal fragments, for the first time discovered in such an ancient archaeological context. Given that historical sources trace the foundation of the port back to the 7th century BCE, these results attest to protohistoric industrial use of the site and push back its chronology by over five centuries. The existence of such ancient port activity not only extends the chronological horizon for harbour activity in the Corinthian area, but also provides new insights for the Late Bronze Age/Early Iron Age (LBA/EIA) transition, including potential trading routes that may have transited through Lechaion, likely spanning across the Gulf of Corinth and possibly even beyond, to western Mediterranean urban centers.

1. Introduction

The Late Bronze Age/Early Iron Age (LBA/EIA) transition (12th–8th century BCE) in Greece is a pivotal period that laid the foundations for the emergence of Greek civilization in its “classical” form. Up to recently considered a “dark age”, this transition had been seen as a period of decline in the Aegean world. Research tends to revisit this view (Lemos, 2006; Ben-Yosef, 2019) and Greek sites from the Early Iron Age show that commercial exchanges, particularly with the Levant, did not disappear (Bintliff, 2012; Mazarakis-Ainian and Coulson, 2011). During these centuries, port activities have certainly played a central role in the expansion of the Phoenicians and Greek colonies in the Mediterranean. However, no sedimentary evidence of such ancient port activity has yet been discovered in Greece. Located in an ancient river outlet, Lechaion was the primary harbour of ancient Corinth, spanning an area of approximately 0.7 km^2. It is the largest ancient port in Greece and its strategic location played a vital role in the economic and military growth of the ancient city (Rothaus, 1995) (Fig. 1A&1B). While historical sources suggest that the port was established in the 7th or 6th centuries BCE, the presence of an older protohistoric, i.e. Bronze Age, port in the Corinthian region has long been suspected by archaeologists (Blegen, 1920; Tzonou and Morgan, 2019). Evidence of commerce across the Gulf of Corinth during Bronze Age is provided by remains and settlements established near the Lechaion coastline, such as the prehistoric site of Korakou (Fig. 1A), which demonstrates contacts with Achaea and Italy until it was abandoned around 1050 BCE (Tzonou and Morgan, 2019). Although regional archaeological evidence attests to the continuity of settlement over the centuries of the Late Bronze Age/ Early Iron Age (LBA/EIA) transition , the question of an active protohistoric port that could have been open to the Gulf of Corinth and the western Mediterranean remains unresolved (Tzonou and Morgan, 2019). To address this topic and to shed new light on the”muted” topic of the LBA/EIA transition (Ben-Yosef, 2019), geoarchaeological investigations took place in the harbour area of Lechaion in which two sediment cores, Tar11, and Drill2, were taken in harbour basins 3 and 4, respectively (Fig. 1A). In combination with multivariate analysis (MVA) we conducted Attenuated total reflectance Fourier transform infrared spectroscopy (FTIR-ATR), portable X-ray fluorescence spectrometry (pXRF)

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Fig. 1. A. The Lechaion harbour area and the drilling locations. The pre- and protohistoric site of Korakou, which was occupied until the end of the Bronze Age, is located on top of a hill, west of the harbour area. **B.** Location of the sites and pre- and protohistoric silver-lead mines mentioned in the text (Vaxevanopoulos et al.,

Fig. 1.—*continued*
2022; Morin and Photiades, 2005). The brown coal (lignite) sources in the Peloponnese (Kavvadas et al., 2020). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

and sedimentological analyses on core sediment samples at high resolution. These tools are used to reconstruct palaeo-environmental changes and Pb palaeo-pollution signal likely to have trapped traces of early port activities (Delile et al., 2017; Delile et al., 2018). We also conducted SEM-EDS analyses on brown coal materials found in Drill2 (Fig. 3)

2. Physical setting

The geographical and geomorphological framework of the port of Lechaion has been the subject of numerous studies since the 1990s. Lechaion is located in the eastern part of the Gulf of Corinth, <3 km north of the ancient city. The Gulf of Corinth is an active asymmetric rift zone (with some of the highest extension rates in the world), and seismic activity is significant in the area (Armijo et al., 1996; Charalampakis et al., 2014; Moretti et al., 2003). At this location, the northern shore of the Peloponnese experiences ongoing uplift during the Quaternary period (numerous uplifted marine terraces are present in the Corinth region), and the coastline of Lechaion, as well as the harbour itself, have experienced multiple co-seismic uplift events during historical periods (Apostolopoulos et al., 2015; Morhange et al., 2012; Stiros et al., 1996). Marine dynamics such as longshore drift, swells, and waves are powerful and occasionally morphogenic in this area (Hadler et al., 2013; Vött et al., 2018; Mourtzas et al., 2014).

Nowadays, the area corresponding to the ancient harbour extends both on land and underwater. Recent excavations (Lechaion Harbour Project) have allowed for the identification and naming of visible port structures (Loven et al., 2018; Athanasopoulos, 2020) (Fig. 1A). The inner port consists of three basins interconnected by canals. The connection to the sea is also facilitated by a canal. The outer port comprises 5 moles (L-M1 to L-M5) that are mostly submerged. The existence of a fourth basin (Basin 4) located between moles L-M1 and L-M2 was first revealed in this study. The meandering shape of the inner basins suggests that they were constructed downstream of a former river channel, perhaps in a small estuary or pre-existing delta or coastal marsh (Hadler et al., 2013; Vött et al., 2018; Morhange et al., 2012; Kolaiti et al., 2017).

3. Materials and methods

3.1. Coring and ^{14}C sampling

Tar11 core was performed in Basin 3 using a hand auger in order to minimize sediment compaction and Drill2 using a geotechnical drilling rig. In the field, the sediments were photographically documented into stratigraphic units based on texture and colour (using the Munsell code). For each ^{14}C sample, 20 g of sediment were collected and sieved (500 μm mesh) with distilled water. Organic remains were then individually identified (micro-charcoals, wood and plant remains) under a binocular microscope, extracted and sent for AMS dating.

3.2. Sedimentology and harbour units identification

110 samples were analyzed (60 from Tar11 and 50 from Drill2). Grain size-analyses were conducted by Laser Diffraction Spectroscopy and the organic content of the sediment was measured by LOI (Loss On Ignition) (Supplemental Material A and B).

Based on pXRF and FTIR-ATR analyses, we followed the methods of (Delile et al., 2014) and (Martínez Cortizas et al., 2021), respectively, to decipher geochemical and mineralogical compositions involved in the formation of sedimentary deposits of the ancient harbour basins of Lechaion (Supplemental Material D, Table S1 and Fig. S1). We also used Pb enrichment factors (EF_{Pb}) to identify harbour deposit levels from pre-harbour environment in the stratigraphy of cores (Supplemental Material C). Indeed, it has been established that ancient port sediments are characterized by traces of human activities, such as Trace Metal Element (TME) and lead (Pb) pollution seen as an urban change proxy of ancient cities (Delile et al., 2014, 2016, 2017).

3.3. Brown coal fragments analyses

After ultrasonic cleaning for 10 min, followed by drying during 24 h, the materials ($n = 5$) were analyzed using SEM-EDS (Scanning Electron Microscopy with Energy Dispersive X-ray Spectroscopy). Analyses are expressed in X-ray spectrum as well as weight percentage of oxides (Fig. 3). The method is only semi-quantitative, identifying the major elements present in the object. The mineral fraction, composed by Na, Mg, Al, Si, S, Cl, K, Ca and Fe remains below 5 wt% for all the EDS analyses. It should be noted that, due to the extremely high carbon content, the analyses were carried out under non-ideal conditions. The mass balances are therefore only overestimated (for O content) and in no way represent the precise content of the elements from the mineral fraction. Nonetheless, these results provide ample information on the present elements and their relative proportions.

4. Results

The port facilities that are visible today mainly date back to the Roman period and consist of three interior basins (Harbour basins 1, 2, 3) and an outer basin open to the sea (Harbour basin 4) (Fig. 1A). The morphology of the port during pre-roman periods is widely unknown. In both Tar11 and Drill2 cores, the radiocarbon datings, Pb enrichment factors ($EF_{Pb} > 1.5$) and geochemical compositions (redox conditions) of the sediments allow us to subdivide the stratigraphy into three main sedimentary units: pre-harbour (unit A), harbour (unit B), and post-harbour (unit C) (Fig. 2).

Pre-harbour deposits (Unit A) in Tar11 and Drill2 cores, ranged at a depth of 2.5 to 3.1 m below sea level (b.s.l.) and 2.3 to 9.3 m b.s.l., respectively, show lowest EF_{Pb} values ranging from 0.7 to 1.3 (mean value of 0.9) in Tar11 core, and 0.5–2.5 in Drill2 core (mean value of 1.2). These sediments of sandy muds and gravely muddy sands refer to detrital inputs dominated by silicate minerals (and carbonates in Drill2 core between 7.6 and 2.3 m b.s.l.) under weak anoxic water column conditions (Fig. 2). These alluvial deposits corroborate the hypothesis that the ancient port of Lechaion was built at the mouth of a coastal temporary stream (Stiros et al., 1996; Morhange et al., 2012; Kolaiti et al., 2017).

Both for the inner and the outer harbour basins, a surge of anthropogenic lead excesses (consistent $EF_{Pb} > 1.5$) and an oxygen depletion in the water column reveal unambiguously harbour deposits at 0.6–2.5 m b.s.l. depth in Tar11 core and 0.3–2.3 m b.s.l. depth in Drill2 core (Fig. 2) (Unit B). According to the radiocarbon dates (Table 1), harbour basins were in use from Late Bronze Age (1381–1056 cal BCE and 1122–927 cal BCE in Tar11 and Drill2 cores, respectively) to Late Antiquity (333–753 CE in Drill2 core). Five medium size pieces of brown coal (B-axe 2 to 5 cm; radiocarbon age > 45,000 Cal BP) were discovered at 0.9 m b.s.l. depth in Drill2 core. According to the C content, these materials are situated between lignite (C content of 66 wt%; $n = 6$ analyses) and bituminous coal (C content circa 81 wt%; $n = 2$) (Fig. 3).

As in many ancient Mediterranean ports, the post-harbour unit (0.6 to 0.1 m b.s.l. in Tar11 core and 0.2 to 0 m b.s.l. Drill2 core) is charac-

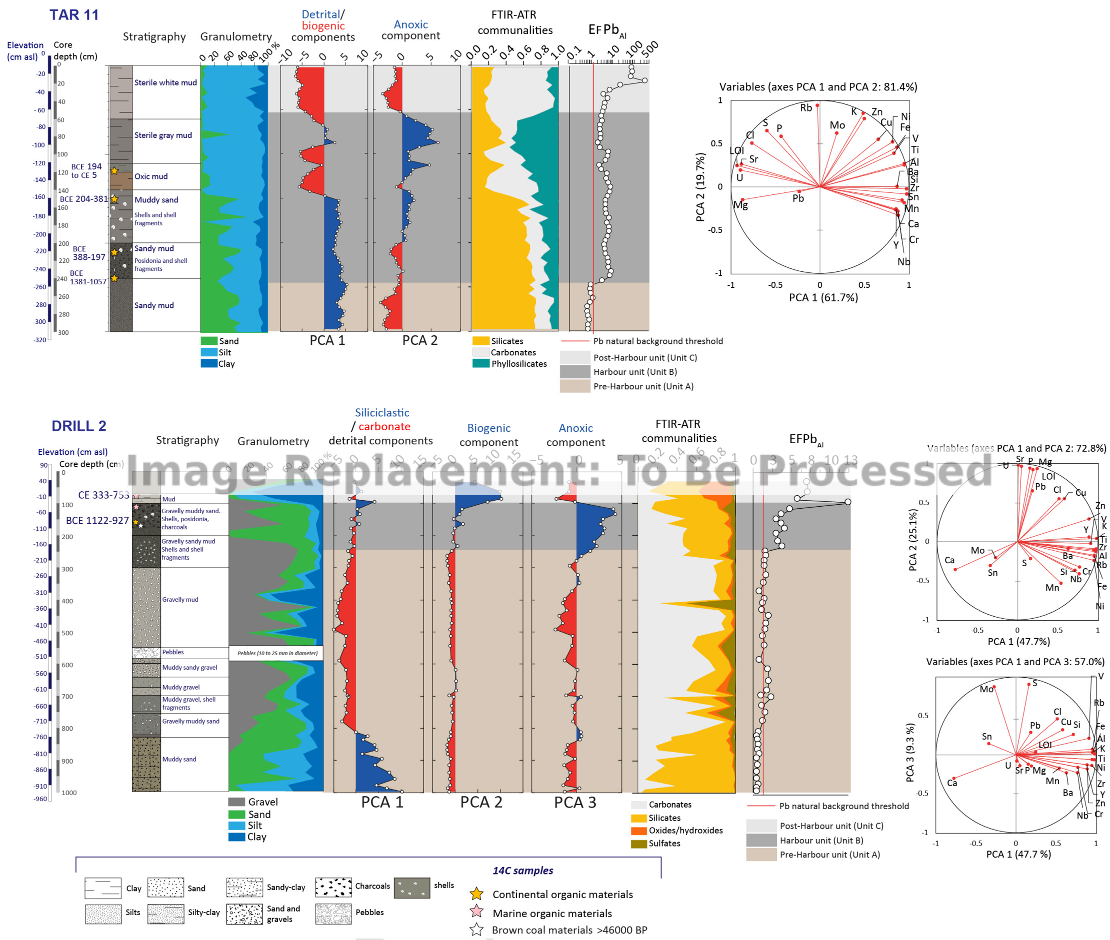

Fig. 2. Stratigraphic log of the Tar11 and Drill2 cores showing granulometry, Principal Component Analysis (PCA) of major and trace element concentrations, fractionation of Fourier transform infrared spectroscopy (FTIR-ATR) communalities, and Enrichment Factor of Pb (normalized to Al). Right panels show correlation circles of the PCA.

Table 1
Radiocarbon dating. AMS ^{14}C radiocarbon dates calibrated using OxCal (v4.4.4) with the IntCal20 and MarineCal20 calibration curves.

Sample code	Sample #	Elevation (cm bmsl)	Material	$\Delta^{13}C$	^{14}C Age (BP)	2σ Max and Min Cal. Age		Median prob. age
Poz#2–141,434	Tar11–1	−127.8	charcoal	−16	2085 ± 30	194 BCE	5 BCE	94, BCE
Poz-140,728	Tar11–2	−151.8	charcoal	−26	1785 ± 35	204 CE	381 CE	292,5 CE
Poz-140,677	Tar11–4	−223.8	charcoal	−26.1	2225 ± 35	388 BCE	197 BCE	292,5 BCE
Poz-140,741	Tar11–5	−246.8	plant remains	−17.8	2985 ± 35	1381 BCE	1056 BCE	1218,5 BCE
Poz#2–141,023	Drill2–2	−8.1	marine shell	3.4	2135 ± 30	333 CE	753 CE	543 CE
Poz-157,392	Drill2–2'	−63.1	charcoal	−30.2	2860 ± 30	1122 BCE	927 BCE	1024,5 BCE
Poz-140,727	Drill2–5	−88.1	lignite	−24.1	>46,000 ± 6180	46,990 BCE	45,685 BCE	46,337,5 BCE

terized by a major environmental change with an oxygen-deficient eutrophic regime evolving towards a submerged aquatic environment (Unit C) (Fig. 2). Post-harbour deposits record the highest EF_{Pb} values ranging from 3.9 to 335.2 (mean value of 58.1) in Tar11 core, and 5.9–12.4 in Drill2 core (mean value of 8.1). This sharp increasing trend of Pb contamination in the post-harbour unit has been recorded in numerous fillings of ancient harbour basins, especially during Medieval times (e.g. Rome, Delile et al., 2017; Neapolis, Delile et al., 2016; Ephesus, Delile et al., 2015), and may correspond to other inland local or regional industrial activities related to the reassignment of harbour activities.

5. Discussion

The dated stratigraphic connection of the brown coal materials with high Pb excess in Drill2 core seem to highlight, for the first time, a palaeo-metallurgical activity in a harbour area during the LBA/EIA transition and/or a regional trade of metals (as ingots shipping or local metallurgical transformation close to the harbour) and/or coal. Even if the use of brown coal in LBA/EIA Greek metallurgy has not yet been demonstrated by mining and metallurgical archaeology, its high C content (> 65 wt%) coupled with an alkaline mineral fraction with little sulfur content (Fig. 3) make it relevant for metallurgical use favoring slag formation directly from the lead-silver ores loaded in furnaces. The presence of these fragments of brown coal in a level dating from the end of the Bronze Age completes recent discoveries.: the exploitation and the use of brown coal as a combustion source during LBA has recently been indirectly identified in mycenaean Tiryns (Peloponnese) (Buckley et al., 2021) and there are lignite sources in the Peloponnese (Kavvadas et al., 2020) (Fig. 1B).

On a broader regional scale, this study raises questions about the potential connections that may have existed between local metallurgical

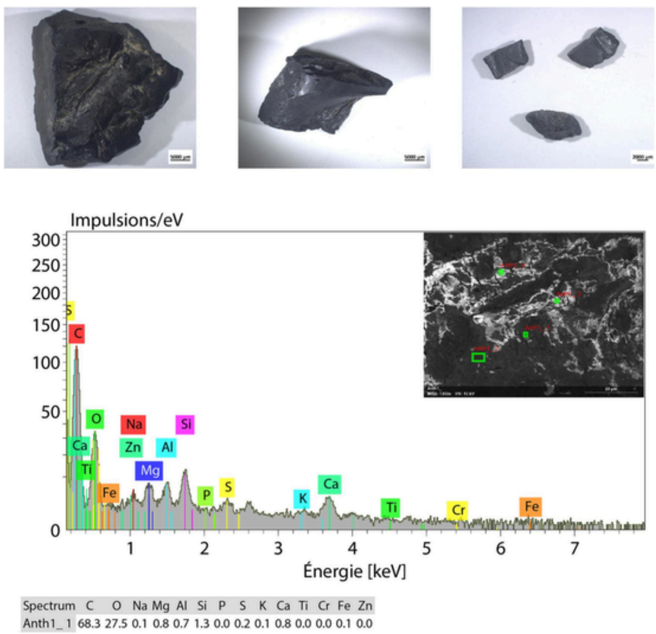

Fig. 3. The five brown coal materials recovered in Drill2 core and SEM-EDS analyses. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

activities (attested during the LBA by recent excavations around Lechaion, Xanthopoulou et al., 2020), regional mining operations, metal trade and the development of extensive maritime commercial exchanges. Indeed, there is evidence of silver-lead mining as early as the 3rd millennium BCE at Laurion (Attic peninsula) (Morin and Photiades, 2005), Sifnos, Syros, Milos (Cyclades) and South Euboea (Vaxevanopoulos et al., 2022) (Fig. 1B). Recent studies highlight the continuity of metal exploitation in the Eastern Mediterranean and their diffusion towards the west after the collapse of Bronze Age civilizations at the beginning of the Iron Age, primarily through maritime trade (Eshel et al., 2019; Eshel et al., 2023).

This ongoing harbour activity during the centuries of the LBA/EIA transition would have made Lechaion a central site in Eastern Mediterranean, whose economic significance led to its likely expansion and the construction of monumental port structures from the 7th century BCE onwards. Up to now, however, the only visible harbour remains at Lechaion date to historical periods and any protohistoric port structures, if they exist, are yet to be discovered.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability statement

Datasets related to this article (XRF and laser granulometry raw data) can be found at:

https://data.mendeley.com/datasets/rkd5vpbtv5/1

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.margeo.2023.107167.

References

Apostolopoulos, G., Minos-Minopoulos, D., Pavlopoulos, K., 2015. Geophysical investigation for the detection of liquefaction phenomena in an archaeological site, Lechaion, Greece. Geophysics 80, EN105-EN117. https://doi.org/10.1190/geo2014-0109.1.

Armijo, R., Meyer, B., King, G.C.P., Rigo, A., Papanastassiou, D., 1996. Quaternary evolution of the Corinth Rift and its implications for the late Cenozoic evolution of the Aegean. Geophys. J. Int. 126, 11–53. https://doi.org/10.1111/j.1365-246X.1996.tb05264.x.

Athanasopoulos, P., 2020. Inde i en middelhavshavn: Lechaions havneanlaeg i Korinth. In: *SFINX 32 årgang 2020,* Nr, 2, pp. 50–55. (in Danish).

Ben-Yosef, E., 2019. Archaeological science brightens Mediterranean dark age. Proc. Natl. Acad. Sci. 116, 5843–5845. https://doi.org/10.1073/pnas.1901885116.

Bintliff, J., 2012. The Greek early iron age and the concept of a dark age. In: The Complete Archaeology of Greece. John Wiley & Sons, Ltd, pp. 207–233. https://doi.org/10.1002/9781118255179.ch8.

Blegen, C.W., 1920. Corinth in Prehistoric Times. Am. J. Archaeol. 24, 1–13. https://doi.org/10.2307/497547.

Buckley, S., Power, R.C., Andreadaki-Vlazaki, M., Akar, M., Becher, J., Belser, M., Cafisso, S., Eisenmann, S., Fletcher, J., Francken, M., Hallager, B., Harvati, K., Ingman, T., Kataki, E., Maran, J., Martin, M.A.S., McGeorge, P.J.P., Milevski, I., Papadimitriou, A., Protopapadaki, E., Salazar-García, D.C., Schmidt-Schultz, T., Schuenemann, V.J., Shafiq, R., Stuijts, I., Yegorov, D., Yener, K.A., Schultz, M., Spiteri, C., Stockhammer, P.W., 2021. Archaeometric evidence for the earliest exploitation of lignite from the bronze age Eastern Mediterranean. Sci. Rep. 11, 24185. https://doi.org/10.1038/s41598-021-03544-w.

Charalampakis, M., Lykousis, V., Sakellariou, D., Papatheodorou, G., Ferentinos, G., 2014. The tectono-sedimentary evolution of the Lechaion Gulf, the south eastern branch of the Corinth graben, Greece. Mar. Geol. 351, 58–75. https://doi.org/10.1016/j.margeo.2014.03.014.

Delile, H., Mazzini, I., Blichert-Toft, J., Goiran, J.P., Arnaud-Godet, F., Salomon, F., Albarède, F., 2014. Geochemical investigation of a sediment core from the Trajan basin at Portus, the harbor of ancient Rome. Quat. Sci. Rev. 87, 34–45. https://doi.org/10.1016/j.quascirev.2014.01.002.

Delile, H., Blichert-Toft, J., Goiran, J.-P., Stock, F., Arnaud-Godet, F., Bravard, J.-P., Brückner, H., Albarède, F., 2015. Demise of a harbor: a geochemical chronicle from Ephesus. J. Archaeol. Sci. 53, 202–213. https://doi.org/10.1016/j.jas.2014.10.002.

Delile, H., Keenan-Jones, D., Blichert-Toft, J., Goiran, J.-P., Arnaud-Godet, F., Romano, P., Albarède, F., 2016. A lead isotope perspective on urban development in ancient Naples. Proc. Natl. Acad. Sci. 113, 6148–6153. https://doi.org/10.1073/pnas.1600893113.

Delile, H., Keenan-Jones, D., Blichert-Toft, J., Goiran, J.-P., Arnaud-Godet, F., Albarède, F., 2017. Rome's urban history inferred from Pb-contaminated waters trapped in its ancient harbor basins. Proc. Natl. Acad. Sci. 114, 10059–10064. https://doi.org/10.1073/pnas.1706334114.

Delile, H., Goiran, J.P., Blichert-Toft, J., 2018. The contribution of geochemistry to ancient harbor geoarcheology: the example of Ostia Antica. Quat. Sci. Rev. 193, 170–187. https://doi.org/10.1016/j.quascirev.2018.06.019.

Eshel, T., Erel, Y., Yahalom-Mack, N., Tirosh, O., Gilboa, A., 2019. Lead isotopes in silver reveal earliest Phoenician quest for metals in the West Mediterranean. Proc. Natl.

Acad. Sci. 116, 6007–6012. https://doi.org/10.1073/pnas.1817951116.

Eshel, T., Gilboa, A., Tirosh, O., Erel, Y., Yahalom-Mack, N., 2023. The earliest silver currency hoards in the Southern Levant: Metal trade in the transition from the Middle to the late Bronze Age. J. Archaeol. Sci. 149, 105705. https://doi.org/10.1016/j.jas.2022.105705.

Hadler, H., Vött, A., Koster, B., Mathes-Schmidt, M., Mattern, T., Ntageretzis, A.K., Reicherter, K., Willershäuser, T., 2013. Multiple late-Holocene tsunami landfall i in the eastern Gulf of Corinth recorded in the palaeotsunami geo-archive at Lechaion, harbour of ancient Corinth (Peloponnese, Greece). Zeitschrift für Geomorphologie, Supplementary Issues 57, 139–180. https://doi.org/10.1127/0372-8854/2013/S-00138.

Kavvadas, M., Roumpos, C., Schilizzi, P., 2020. Stability of Deep Excavation Slopes in Continuous Surface Lignite Mining Systems. Geotech. Geol. Eng. 38, 791–812. https://doi.org/10.1007/s10706-019-01066-x.

Kolaiti, E., Papadopoulos, G.A., Morhange, C., Vacchi, M., Triantafyllou, I., Mourtzas, N.D., 2017. Palaeoenvironmental evolution of the ancient harbor of Lechaion (Corinth Gulf, Greece): were changes driven by human impacts and gradual coastal processes or catastrophic tsunamis? Mar. Geol. 392, 105–121. https://doi.org/10.1016/j.margeo.2017.08.004.

Lemos, I., 2006. The 'dark age' of Greece. In: Bispham, Edward, Thomas, Harrison, Sparkes, Brian (Eds.), The Edinburgh Companion to Ancient Greece and Rome. Edinburgh University Press, Edinburgh.

Loven, B., Kourkoumelis, D., Micha, P., Athanasopoulos, P., 2018. Lechaion Harbour Project 2013-2014. In: Simosi, A. (Ed.), Βουτιά στα Περασμένα. Η υποβρύχια αρχαιολογική έρευνα 1974–2014. ΤΑΠΑ, Αθήνα, pp. 85–90. (in Modern Greek).

Martínez Cortizas, A., Sjöström, J.K., Ryberg, E.E., Kylander, M.E., Kaal, J., López-Costas, O., Álvarez Fernández, N., Bindler, R., 2021. 9000 years of changes in peat organic matter composition in Store Mosse (Sweden) traced using FTIR-ATR. Boreas 50, 1161–1178. https://doi.org/10.1111/bor.12527.

Mazarakis-Ainian, A.I., Coulson, W.D.E., 2011. The "Dark Ages" Revisited : Acts of an International Symposium in Memory of William D.E. Coulson, University of Thessaly, Volos, 14-17 June 2007. University of Thessaly Press.

Moretti, I., Sakellariou, D., Lykousis, V., Micarelli, L., 2003. The Gulf of Corinth: an active half graben? J. Geodynam. Faults: Analysis, Proces. Monitor. 36, 323–340. https://doi.org/10.1016/S0264-3707(03)00053-X.

Morhange, C., Pirazzoli, P.A., Evelpidou, N., Marriner, N., 2012. Late Holocene Tectonic Uplift and the Silting up of Lechaion, the Western Harbor of Ancient Corinth, Greece. Geoarchaeology 27, 278–283. https://doi.org/10.1002/gea.21388.

Morin, D., Photiades, A., 2005. Nouvelles recherches sur les mines antiques du Laurion (Grèce). Pallas 327–358.

Mourtzas, N.D., Kissas, C., Kolaiti, E., 2014. Archaeological and geomorphological indicators of the historical sea level changes and the related palaeogeographical reconstruction of the ancient foreharbour of Lechaion, East Corinth Gulf (Greece). Quatern. Int. Relat. Sea Level Chan 332, 151–171. https://doi.org/10.1016/j.quaint.2012.12.037.

Rothaus, R., 1995. Lechaion, Western Port of Corinth: a preliminary Archaeology and history. Oxf. J. Archaeol. 14, 293–306. https://doi.org/10.1111/j.1468-0092.1995.tb00065.x.

Stiros, S., Pirazzoli, P., Rothaus, R., Papageorgiou, S., Laborel, J., Arnold, M., 1996. On the date of construction of Lechaion, western harbor of ancient Corinth, Greece. Geoarchaeology 11, 251–263. https://doi.org/10.1002/(SICI)1520-6548(199605)11:3<251::AID-GEA4>3.0.CO;2-2.

Tzonou, I., Morgan, C., 2019. The Corinthia, in: A Companion to the Archaeology of Early Greece and the Mediterranean. John Wiley & Sons, Ltd, pp. 719–741. https://doi.org/10.1002/9781118769966.ch29.

Vaxevanopoulos, M., Blichert-Toft, J., Davis, G., Albarède, F., 2022. New findings of ancient Greek silver sources. J. Archaeol. Sci. 137, 105474. https://doi.org/10.1016/j.jas.2021.105474.

Vött, A., Hadler, H., Koster, B., Matthes-Schmidt, M., Röbke, B.R., Willershäuser, T., Reicherter, K., 2018. Returning to the facts: Response to the refusal of tsunami traces in the ancient harbour of Lechaion (Gulf of Corinth, Greece) by 'non-catastrophists' – Reaffirmed evidence of harbour destruction by historical earthquakes and tsunamis in AD 69–79 and the 6th cent. AD and a preceding pre-historical event in the early 8th cent. BC. Z. Geomorphol. 28.

Xanthopoulou, M., Banou, A., Zymi, E., Giannouli, E., Karapanagiotou, A., Koumousi, A., 2020. Το αρχαιολογικό έργο στην Πελοπόννησο 2. *Πρακτικά της Β΄ Επιστημονικής Συνάντησης Καλαμάτα, 1–4 Νοεμβρίου 2017*. pp. 105–114.