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Incised Late Bronze Age lead ingots from the southern anchorage of Caesarea

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Highlights

- Lead ingots with Cypro-Minoan markings were found in the Caesarea anchorage.
- Lead Isotope Analysis indicated that the lead was mined in Iglesiente, Sardinia.
- Additional lead artefacts from the Levant, Cyprus and Egypt originate there.
- Results highlight the active role of Cypriots in Late Bronze Mediterranean Trade.

Abstract

Four lead ingots were found as part of a shipwreck cargo in the southern anchorage of Caesarea in Israel. Analysis of the lead and a study of the markings incised on three of them are presented here for the first time. Four Cypro-Minoan signs are identified and paralleled with signs found on Late Cypriot artefacts. Lead isotope analysis indicates that the lead originated in Sardinia. Such an origin was indicated by earlier analyses of lead ingots from other cargoes along the Carmel coast, as well as by additional lead objects from Cyprus and other regions around the eastern Mediterranean. The Caesarea ingots, together with the latter, highlight the role of the Cypriots in the Mediterranean Late Bronze Age metal trade, and date their involvement to the 13th–early 12th century BCE. Rather than a specific connection between Cyprus and Sardinia at this time, as previously reconstructed, a broader commercial network and heightened involvement of the Cypriots in regional and supra-regional exchange in the eastern Mediterranean are suggested.

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Keywords

Lead ingots; Levantine coast; Cypro-Minoan; Iglesiente; Sardinia; Mediterranean trade

1. Introduction

Twenty-two Bronze Age shipwreck assemblages, characterized by concentrations of single-holed stone anchors, are known along the Carmel coast in Israel (Galili et al., 2011). Several dating to the Late Bronze Age contain metal ingots (Fig. 1). These include the cargo from Hishuley Carmel, containing two complete oxhide copper ingots, 14 tin ingots and one lead ingot (Galili et al., 1986, Galili et al., 2013), a cargo from Hahotrim, which included fragments of oxhide copper ingots and lead ingots (Wachsmann and Raveh, 1981, Wachsmann, 2020), and two cargoes from Kfar Samir: Kfar Samir south containing lead and tin ingots (Raban and Galili, 1985, Galili et al., 2011), and Kfar Samir north, containing fragments of oxhide copper ingots and bronze spatter (Galili, 1985, Galili et al., 2011, Yahalom-Mack et al., 2014). A number of round lead ingots were apparently retrieved from the Kfar Samir north site by a fisherman, and were sold for scrap (Galili, et al., 2011: 67). An additional cargo was found near Neve Yam, containing 86 copper loaf-shaped ingots (Galili et al., forthcoming); based on chemical and lead isotope analyses, their origin was traced to the Arabah mines (Yahalom-Mack et al., 2014). A single loaf-shaped copper ingot, very similar to the ones from Neve Yam, was found in the Akko Harbor (Galili et al., 2011:69). An additional cargo, comprising four lead ingots, was found in the southern anchorage of Caesarea and is the subject of the current study (Fig. 2).

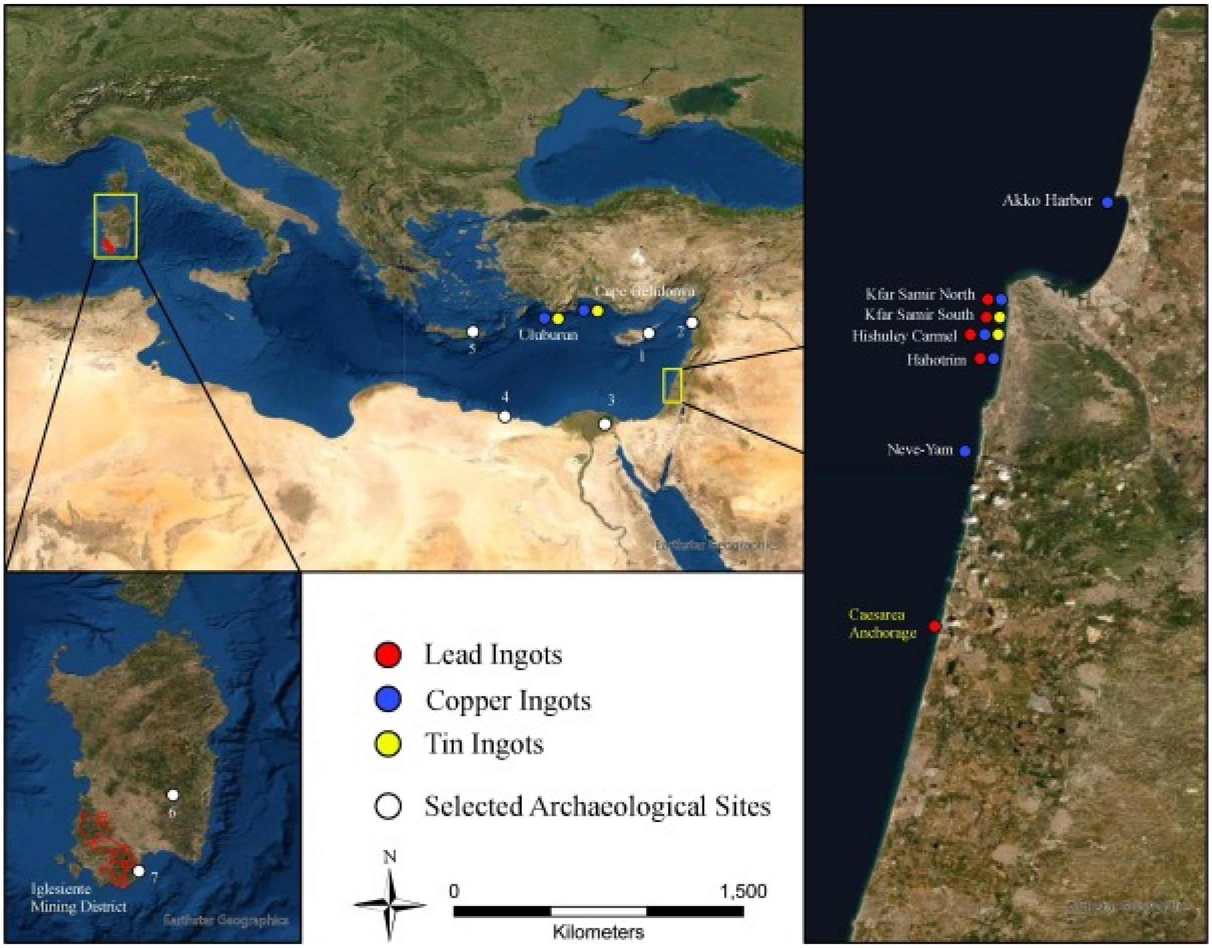

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Fig. 1. Map of the Mediterranean showing findspots of copper, lead and tin ingots, as well as main sites mentioned in the text: 1. Enkomi; 2. Ugarit; 3. Qantir Pi-Ramesses; 4. Zawiyet Umm el-Rakham; 5. Mochlos; 6. Nuraghe Arrubio; 7. Nuraghe Antigori.

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Fig. 2. Photograph of the four lead ingots recovered from the southern anchorage of Caesarea.

2. The cargo

Underwater surveys carried out in the southern anchorage of Caesarea by Haifa University and the Israel Antiquities Authority (IAA), headed by E. Galili, uncovered several assemblages dating from the Late Bronze Age (LB) onwards (Galili et al., 1993, Galili, 2017, Fig. 10). In one of them, alongside, five stone anchors, four lead ingots[1] were retrieved (Galili et al., 1993: Fig. 7; Galili, 2017: Fig. 10).

2.1. The lead ingots

The four lead ingots (see Table 1), all have a single hole, but differ in shape. One is drop-shaped (IAA No. 91-389), another is roughly rectangular (IAA No. 91-390)[2] and two are rounded (IAA Nos. 1637-63-1 and 91-392). No. 91-390 stands out having a rectangular cross-section (in addition to the general rectangular shape) and being relatively much heavier (20 kg). The remaining three are all plano-convex, weighing 8–9 kg. IAA No. 91-392 is the only unmarked ingot; the other three bear signs made by cold chiseling following the solidification of the metal (Fig. 2, Fig. 3).

Table 1. Summary of lead ingots from the Caesarea bay.

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IAA No.	Shape	Cross-section	Size (cm)	Weight (kg)	Markings*	Incised Lines	Sample No.	Figure
91-389	Drop-shaped	Plano-convex	30x16x3	8	CM 37 CM 69 CM 82	yes	LI 3	3:1
91-390	Roughly rectangular	Rectangular	32x20x4	20	CM 37 CM 82	yes	LI 4	3:2
1637-63-1	Rounded	Plano-convex	23x18x4	8	CM 87	-	LI 2	3:3
91-392	Rounded	Plano-convex	19x19x4	9	–	–	LI 1	3:4

CM = Cypro-Minoan.

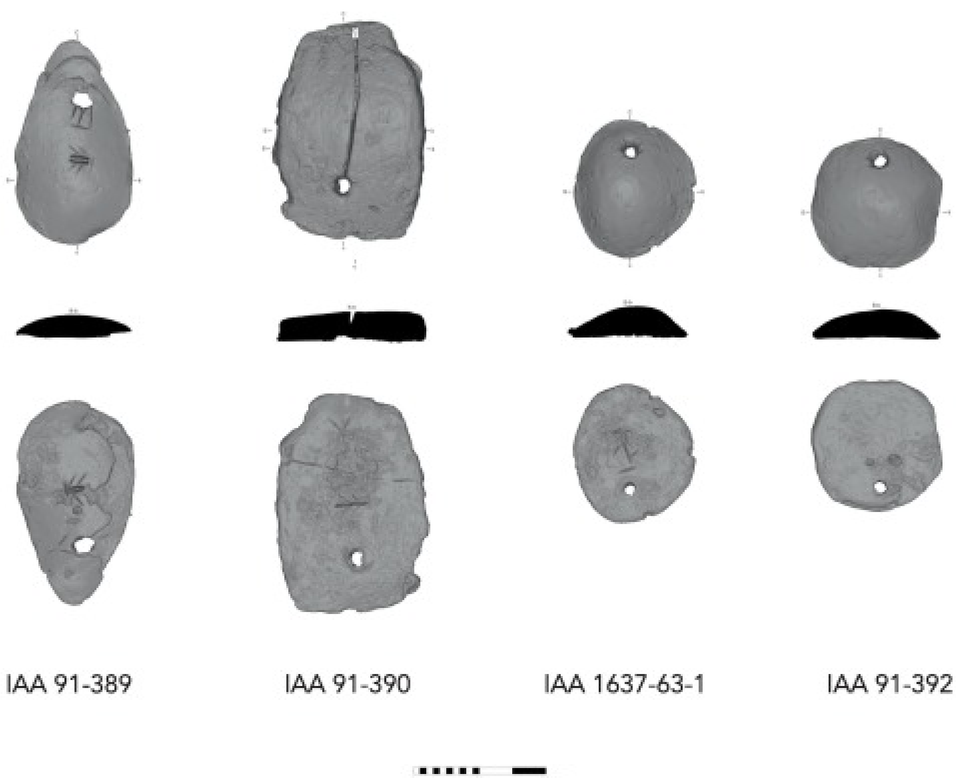

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Fig. 3. 3D scans of the lead ingots from Caesarea. Courtesy of Avshalom Karasik, Israel Antiquities Authority. 1. IAA 91-389; 2. IAA 91-390; 3. IAA 1637-63-1; 4. IAA 91-392.

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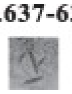
3. The incised marks

3.1. Ingot No. 91-389

Two signs that have been identified as Cypro-Minoan (CM) were engraved on the convex side of this ingot and two others on its flat side. Each pair is similarly oriented and mostly aligned. The signs on the convex side are identified as CM 37 (Valério, 2016: 120, Table 2: 32) and CM 69[3] (Valério, 2016: 185, Table 3:17). On the flat side, the signs are identified as CM 37 and CM 82 (Valério, 2016: 183, Table 3:13).

The CM 37 signs on both sides are similar, incised in a tree-like, six stroke style, suggesting that they were made by the same craftsperson. The vertical "stem" is broader than its "branches", suggesting the use of either two different tools, different parts of the same tool, or a different use of the same tool to achieve effects (i.e., stronger strike resulting in a deeper penetration, or tilting the chisel laterally after the strike resulted in wider penetration). The sign is identical in form to an incision on a vase from Enkomi (ENKO Avas 012, see Table 2; Valério, 2016: 120, Table 2.32), and, to a lesser degree, to a sign incised on a clay object from Enkomi (ENKO Apes 001, see Table 2; Valério, 2016: 65, 194, Fig. 3.2, sign on the right), as well as to an incised mark on the handle of a transport stirrup jar found at Zawiyet Umm el-Rakham in Egypt (Hirschfeld, 1999: Fig. 6.2).

Table 2. Summary of CM Markings found on Caesarea lead ingots suggested parallels.

Markings	Caesarea Ingots	Parallels	Reference in Valerio 2016	Date of parallel
CM 37	91-390 91-389 	ENKO Avas 012 	P. 120, Table 2.32	LCIIIA
CM 69	91-389 	ENKO Arou 001 	P. 185, Table 3.17	LCIIA-IIB
CM 82	91-390 91-389 	ENKO Apes 001 	P. 183, Table 3.13	LCI A-B
CM 87	1637-63-1 	KALA Arou 001.03 	P. 182, Table 3.11	LCIIC

The bottom of sign CM 69 is obscured by the hole in the ingot, yet four out of the five strokes that comprise it can be clearly detected. CM 82 on the flat side has three strokes and is similar to ENKO Apes 001 (see Table 2; Valério, 2016: 183, Table 3.13). It appears to be located on a slightly lower plane than CM 37. Thus, although the two marks have the same directionality, they are not perfectly aligned. This may be explained by looking at Ingot No. 91-390 where an incised line divides two similar marks, each possibly representing one portion of the ingot, as described below.

3.2. Ingot No. 91-390

The ingot, in addition to the CM markings described below, is incised with longitudinal grooves on both sides: on the flat side a line was grooved horizontally, roughly demarcating a third and two-thirds of the ingot. Another line was carved vertically on the convex side, demarcating it approximately into two.

Two signs incised on the flat side of this ingot are identified as CM 37 and CM 82. As these signs are both separated by an incised line, and are oriented differently, they do not appear to form a cohesive pair. CM 82 also appears on a lead ingot recently reported from the Hahotrim cargo (Wachsmann, 2020: Fig. 4). Similar to Ingot 91-389 described above, CM 37 is depicted in the tree-like, six-stroke style. While the vertical "stem" of CM 37 is slightly broader than the branches here as well, it is narrower than the stem of Ingot 91-389. Notably, these two ingots differ in shape and size (see above).

3.3. Ingot No. 1637-63-1

Two signs were marked on the flat size. The lower one may be tentatively identified as a mirror image of CM 87. The second sign is a simple horizontal stroke above it (cf., Valério, 2016: 182, Table 3.11).

4. Chronology

Single-holed stone anchors were used throughout the Bronze and Iron Ages, and thus may not be used as a reliable chronological or cultural marker (Galili et al., forthcoming). However, based on the CM script, the date of the ingots can be established generally in the Late Cypriot (LC) period (c. 1600–1100 BCE; see Table 2). On the one hand, it is possible that the markings belong to an early phase of this script, perhaps as early as LC I, as the archaic, cursive, tree-like form of CM 37 found in ENKO Apes 001 is dated to this period, as is the CM 82 on ENKO Apes 001. On the other hand, a similar "tree-like" form of CM 37 was found incised on ENKO Avas 012, dated to LC IIIA (early 12th century BCE) (ibid.: 645) and the ENKO Apes 001 has a close parallel on the Zawiyet Umm el-Rakham stirrup jar, dated to the days of Ramses II, i.e., the 13th century BCE (Hirschfeld, 1999: 165).

5. Origin of the lead

5.1. Method

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The lead ingots from Caesarea were subjected to lead isotope analysis (LIA), a method particularly useful for provenancing ingots which are often directly related to the ore (for a recent discussion of the method, see Pernicka, 2014). Thirty mg of drillings were dissolved in nitric acid. Following dilution, Ag and Pb concentrations were determined using a quadrupole Inductively Coupled Plasma – Mass Spectrometer (ICP-MS, Agilent 7500cx). The ICP-MS was calibrated with a series of multi-element standard solutions (Merck; ME VI), standards of major elements and a blank. Drift was corrected by internal standards (750 µg/L Sc, 100 µg/L Re and 50 µg/L Rh). Standard reference samples (US Geological Survey standard reference samples T-201 and T-209) were examined after calibration for accuracy assessment. Estimated precision of the lead and silver concentrations was 3% and 5%, respectively, and accuracy was < 5% for both. For LIA, a solution containing 100 ng of Pb was analyzed without further purification using MC-ICP-MS (Neptune, Thermo). Thallium was used for mass-bias correction. An SRM-981 standard was run with the samples, yielding the following values: $^{206}Pb/^{204}Pb = 16.928 \pm 0.0002$, $^{207}Pb/^{204}Pb = 15.481 \pm 0.0002$, $^{208}Pb/^{204}Pb = 36.668 \pm 0.0005$ (n = 4).

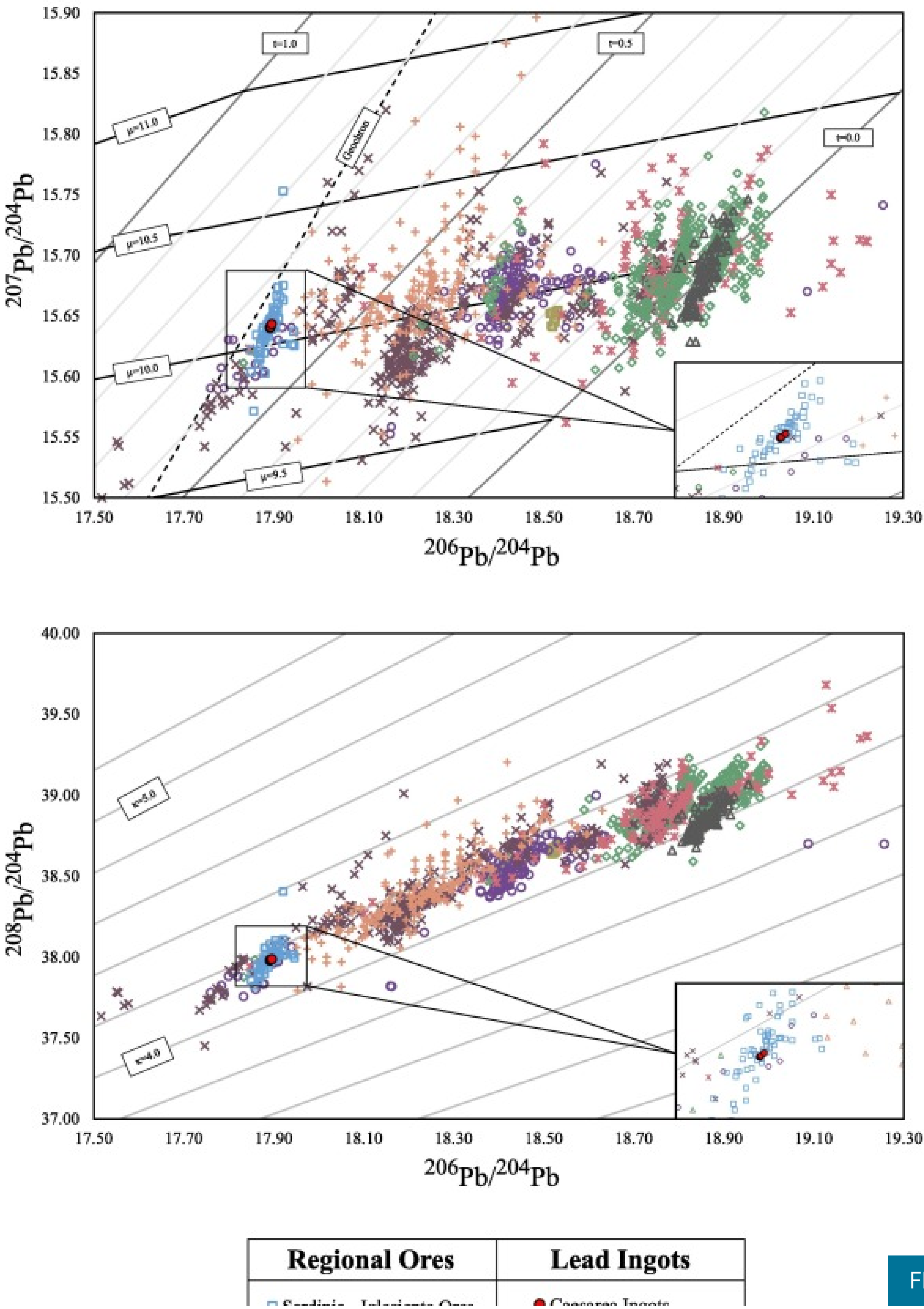
6. Results

The results of the analysis are presented in Table 3. All three Pb isotopic ratios measured for the four ingots, regardless of differences in shape and size, are very similar, suggesting that all were made of the same lead ore. When compared to isotopic data from the Mediterranean region (and Iran), the Caesarea samples are highly consistent with lead ores from the southwest of Sardinia at Iglesiente, and, to a lesser degree, with ores from southern France and Iberia (Fig. 4). Significantly, analysis of multiple lead objects from various Nuraghi (i.e., monumental stone building complexes) in Sardinia (Valera et al., 2005), show that lead from Cambrian galenas, specifically from southwestern sources on the island, was used for their production. Moreover, additional lead ingots from the Carmel coast (Fig. 5), as well as lead objects from LC Cyprus and other locations (Fig. 6), plot along the Iglesiente two-stage Pb-Pb model age isochrone (Fig. 4 inset), thus further supporting the use of the Iglesiente ore deposit during this time. Archaeological considerations also establish the use of Iglesiente ores rather than France and Iberia, as elaborated below.

Table 3. Lead isotopic ratios and silver content of the four lead ingots from the southern bay of Caesarea sampled for this study.

Sample No.	IAA No.	206Pb/204Pb	207Pb/204Pb	208Pb/204Pb	Ag (ppm)
LI 1	91-392	17.892	15.640	37.978	77
LI 2	1637-63-1	17.892	15.641	37.980	107

Sample No.	IAA No.	206Pb/204Pb	207Pb/204Pb	208Pb/204Pb	Ag (ppm)
LI 3	91-389	17.893	15.641	37.981	90
LI 4	91-390	17.896	15.643	37.986	63



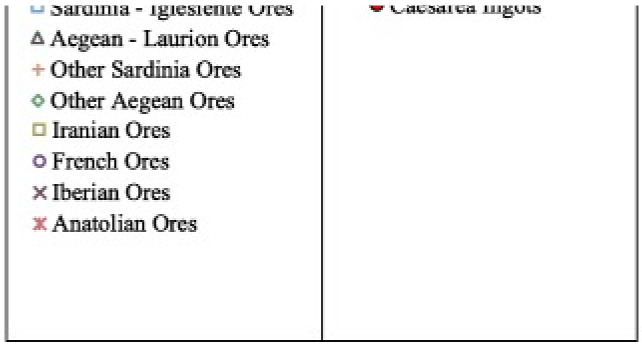


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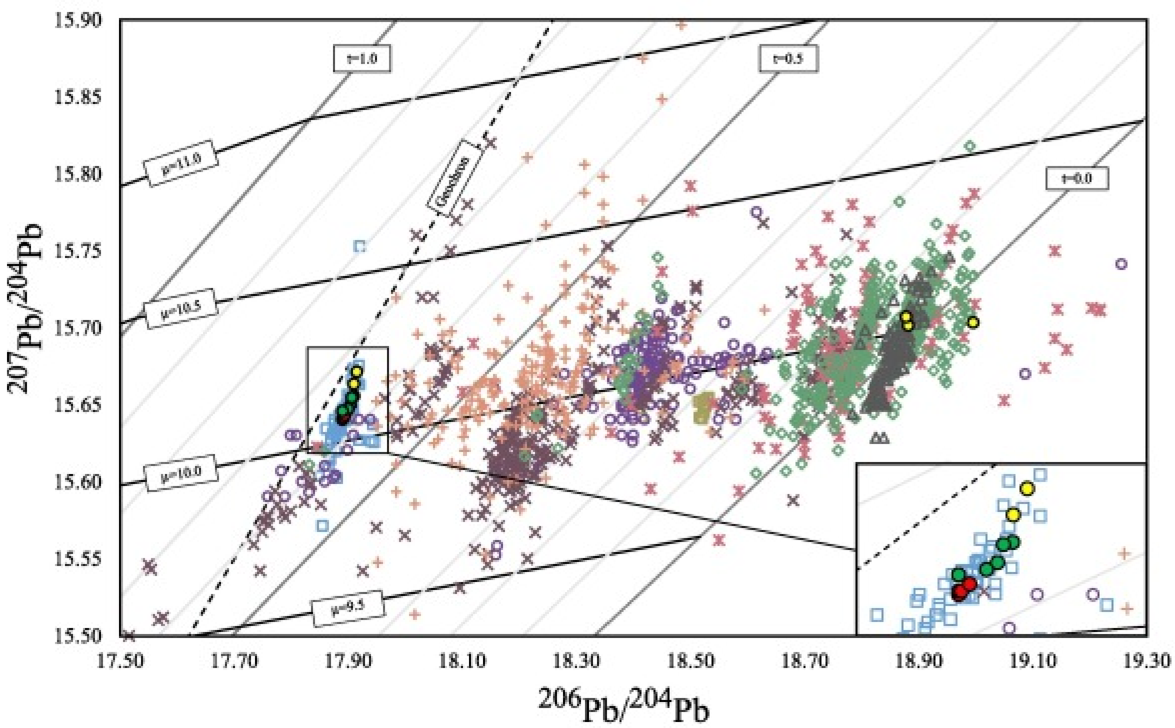
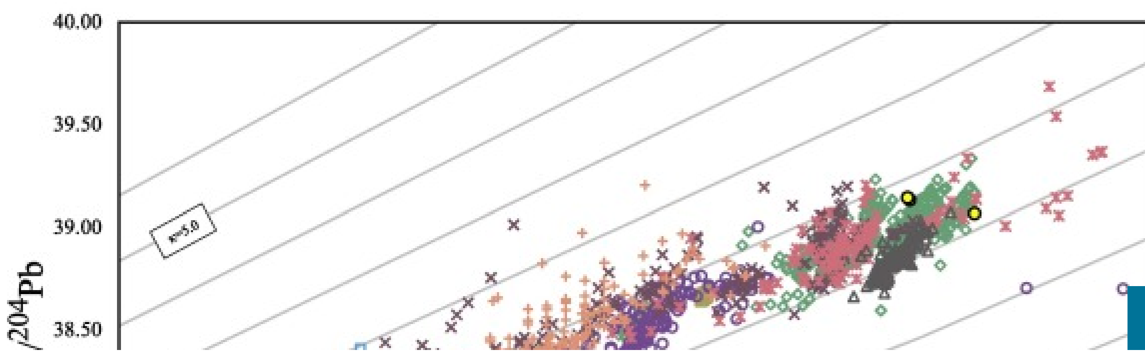
Fig. 4. Lead isotope ratios obtained from the Caesarea lead ingots plotted against a geologic age model (Stacey and Kramers 1975), as well as against lead ores from the Mediterranean region (see Supplementary 1 for references). The Iglesiente region of Sardinia is magnified in the bottom right corner.





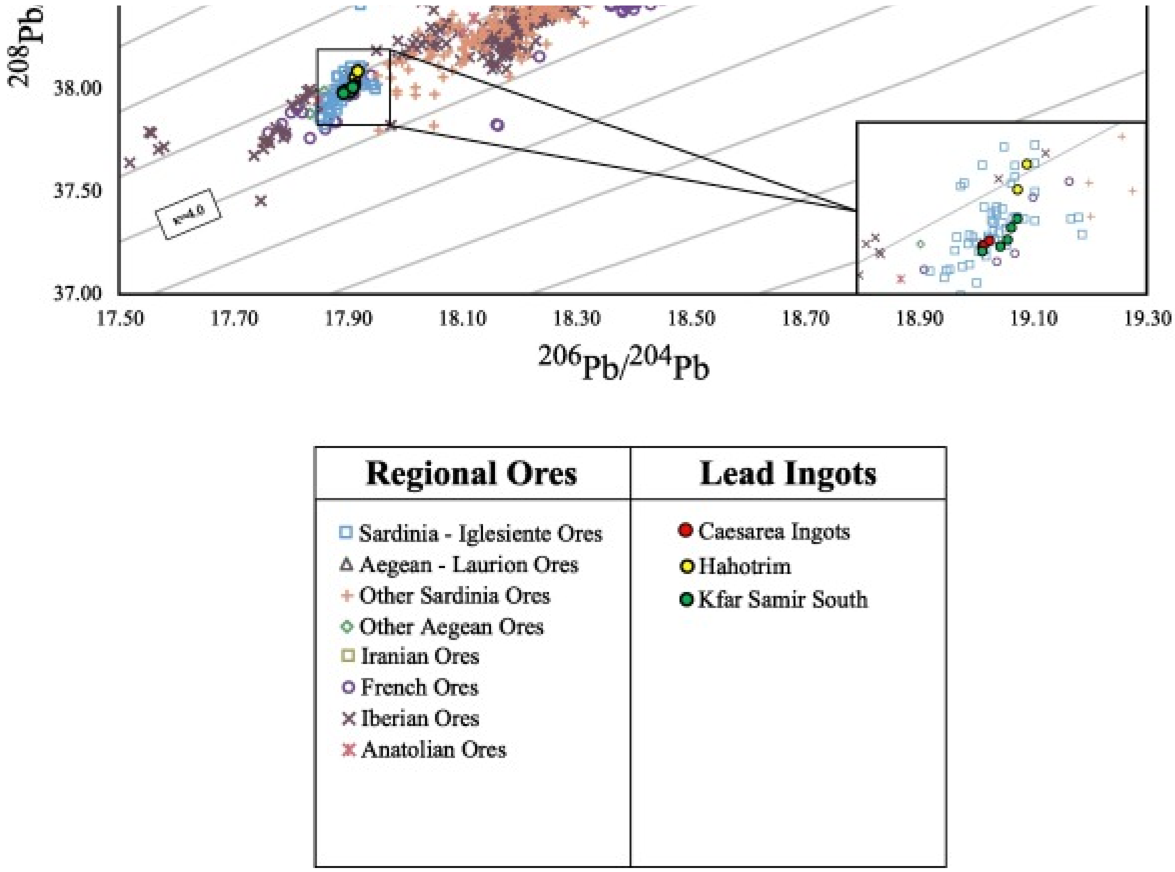


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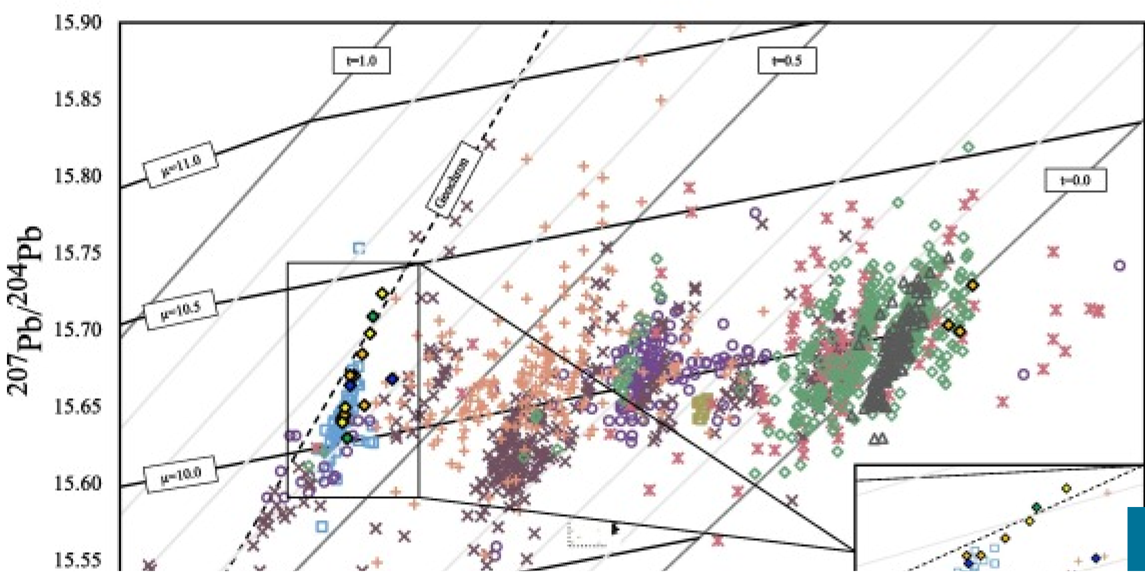
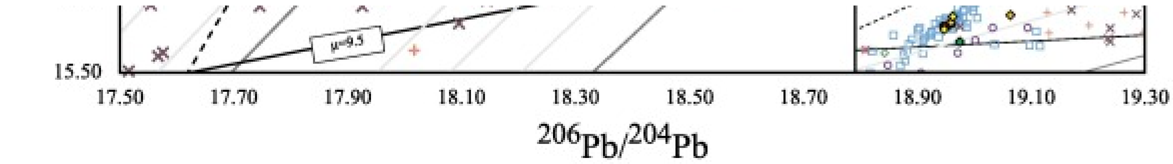
Fig. 5. Lead isotope ratios obtained from the Caesarea lead ingots plotted against a geologic age model (Stacey and Kramers 1975), lead ores from the Mediterranean region (see Supplementary 1 for references), as well as against other lead ingots recovered from Hahotrim and Kfar Samir South cargos (http://oxalid.arch.ox.ac.uk/). The Iglesiente region of Sardinia is magnified in the bottom left corner.





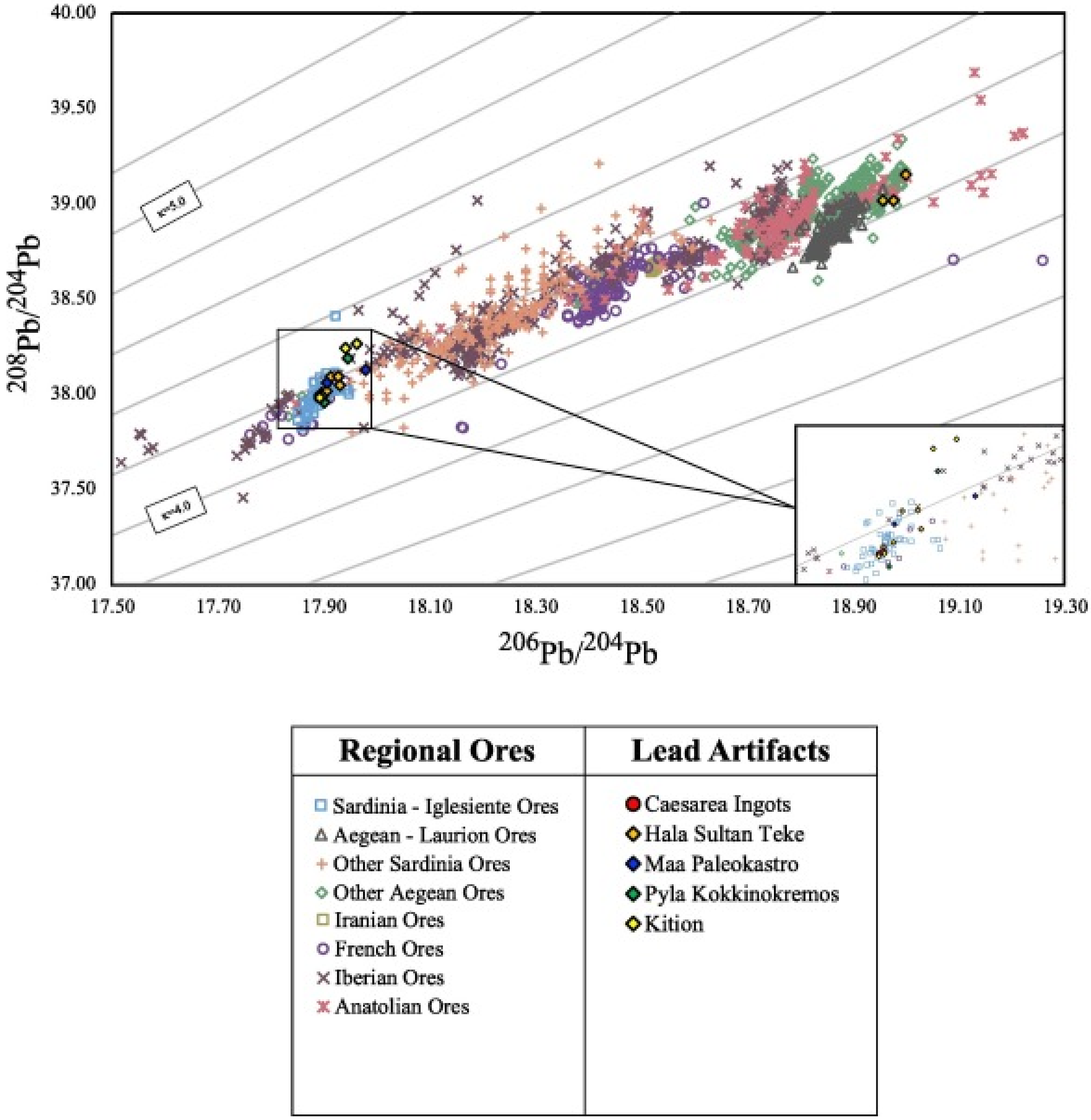


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Fig. 6. Lead isotope ratios obtained from the Caesarea lead ingots plotted against a geologic age model (Stacey and Kramers 1975), lead ores from the Mediterranean region (see Supplementary 1 for references), as well as against lead artefacts from Cypriot sites (Stos-Gale and Gale 2010; http://oxalid.arch.ox.ac.uk/). The Iglesiente region of Sardinia is magnified in the bottom left corner.

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Silver content of the ingots ranged between 63 and 107 ppm Ag, fitting well within the range measured in Nuragic lead artefacts by Valera et al. (2005:51-59), between 13 and 432 ppm Ag. It remains to be determined whether the lead was a by-product of silver production or quarried for its own sake (ibid.: 60–63 and see Discussion below).

7. Discussion

7.1. Sardinian lead in the eastern Mediterranean: trade and chronology

As indicated by the analytical results, the lead in the ingots from Caesarea originated from the Iglesiente area in southwest Sardinia. An Iglesiente provenance is consistent with multiple lead objects recovered from various Nuragic contexts (Valera et al., 2005: 60), and provides direct evidence of exploitation of Sardinian lead earlier than previously thought (contra Terpstra, 2021:180). Additional occurrences of Sardinian lead in the eastern part of the Mediterranean basin include other lead ingots found along the Carmel coast (see below), as well as lead artefacts from Cyprus and Egypt.

Lead ingots were found in several cargoes along the Carmel coast. In the Hishulei Carmel cargo, a single plano-convex lead ingot was found in a very corroded state (Galili et al., 2013). The Kfar Samir south cargo contained at least five lead ingots (Raban and Galili, 1985, Galili et al., 2011) and the Hahotrim cargo contained several lead ingot fragments (Wachsmann, 2020). LIA performed on a selection of these (from Kefar Samir south and Hahotrim, in addition to the present samples from Caeserea), showed that their lead is consistent with the Iglesiente source (Fig. 5; Wachsmann, 2020, following Stos-Gale forthcoming; http://oxalid.arch.ox.ac.uk/).

The presence of Sardinian lead, specifically from Iglesiente, was demonstrated by Stos-Gale and Gale, 1994, Gale and Stos-Gale, 2010 following their lead isotope analysis of lead objects from Cypriot sites such as Hala Sultan Tekke, Maa Paleokastro, Pyla Kokkinokremos and Kition, dated between the LC IIC and the LC IIIA (13th and early 12th centuries BCE). The large quantities of lead found at Hala Sultan Tekke by the Cyprus Swedish Expedition (Fischer and Bürge, 2016) are of particular significance. Lead objects, as well as melted lead and a lead ingot, were found in the industrial quarter CQ1, leading the excavators to suggest that there had been production of lead objects at the site. The location of a lead ingot fragment at the base of a wall was interpreted as a foundation deposit, indicating the importance of lead to the inhabitants of the site (Recht, 2016). The Sardinian origin of the lead is joined by a limited amount of imported Sardinian Black Burnished tableware and domestic ceramics, which were found in one of the offering pits in proximity to burials there, dating to LC IIC (Fischer and Bürge, 2019, Gradoli et al., 2020). At Pyla-Kokkinokremos, a Sardinian-type *olla a colletto* was found in a terminal LC IIC context dating to ca. 1200 BCE. The vessel was mended in antiquity using metal clamps made of Sardinian lead (Gale, appendix IV in Karageorghis, (2011)); petrographic analysis of this imported olla suggested an origin in northwestern Sardinia (Fragnoli and Levi, 2011). It seems therefore th existed mostly in the 13th century BCE, while Sardinian lead found in LC IIIA contexts may be either residual or indicative of a continuity of such contacts into the early 12th century BCE.

In addition to the Iglesiente lead known in Cyprus, such lead was identified in 13th century BCE contexts in Qantir Pi-Ramesses in the Nile Delta (although these results remain unpublished; http://oxalid.arch.ox.ac.uk/).

Based on the evidence at hand, it thus appears that Sardinian lead was systematically traded to the eastern Mediterranean by way of a network encompassing a broad geographic distribution that included Egypt and the Southern Levantine coast.

7.2. The significance of Cypro-Minoan markings on ingots

As demonstrated above, the markings on the Caesarea ingots have clear parallels in the Cypro Minoan (CM) script (signs CM37, CM69, CM82 and CM87). It has been suggested that the markings on ingots could be indicative of branding, ownership, quality assurance, or quantity values (Galili et al., 2011, Galili et al., 2013, Ferrara and Bell, 2016, Valério and Davis, 2017, Galili et al., 2019).

CM markings were also identified on tin ingots from the Hishuley Carmel and Kfar Samir south sites along the Carmel coast (Galili et al., 1986, Galili et al., 2011, Galili et al., 2013, Galili et al., 2011, Galili et al., 2013: Figs. 14–16; Valério and Davis, 2017: Fig. 6).[4] CM 82 appears on both the Hishuley Carmel tin ingots and on one of the Caesarea lead ingots presented here (No. 91-390).[5]

While it would be expected to find CM markings on copper oxhide ingots that typically were produced on Cyprus, their presence on lead and tin ingots is counterintuitive, since Cyprus, while geologically rich in copper, lacks tin and lead sources (Kassianidou, 2006, Berger et al., 2019: Fig. 1). A possible explanation for this phenomenon is that Cypriot agents were directly involved in the trade of these metals and were the ones who chiseled the signs on the ready-made items. While Cypriot involvement in the widespread trade of tin and copper around the eastern Mediterranean during the Late Bronze Age has been suggested (i.e., Muhly, 1973, Maddin et al., 1977, Stech-Wheeler et al., 1979, Kassianidou, 2003), recent evidence, including the present analyses, suggests that lead also played a significant role in the Cypriot metal trade (Fischer and Bürge, 2016, Recht, 2016).

7.3. Cypriot trade in Sardinian lead and other metals

Contacts between Cyprus and Sardinia were first suggested based on the discovery of Cypriot oxhide ingots, as well as metal-production tools and some Cypriot pottery, in Sardinia (Gale, 1991, Gale and Stos-Gale, 1987, Gale and Stos-Gale, 1992, Lo Schiavo, 2001, Lo Schiavo, 2008). The nature and extent of these contacts have been fiercely debated, ranging from a maximalist viewpoint envisioning an actual Cypriot presence on Sardinia (Lo Schiavo, 2001, Sabatini and Schiavo, 2020) to a minimalist approach suggesting that the oxhide ingots could b

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from a single cargo (Webster, 2016: 127), finding it difficult to explain the occurrence of foreign copper on a copper-producing island (Budd et al., 1995, Knapp, 2000). However, this latter suggestion was dismissed based on the fact that out of the seven complete oxhide ingots found in Sardinia, no two were alike (Russell and Knapp, 2017, following Lo Schiavo, 2008: 244–245). Ultimately, following chemical and lead isotope analyses demonstrating that oxhide ingots from Sardinia were made of Cypriot copper, contact between the islands became an established fact (e.g., Begemann et al., 2001, Kassianidou, 2001, Kassianidou, 2005, Gale, 2006, Russell and Knapp, 2017).

The direction and initiators of such contacts are still debated. Russell and Knapp (2017) highlighted the possibility that Sardinians may have been responsible for the trade, as Sardinia was not without seafaring capabilities (Lo Schiavo and Campus, 2013, Russell and Knapp, 2017, but see Lai, 2013: 99–100, who suggested that substantial Sardinian seafaring began only in the early Iron Age). However, the large amount of Cypriot copper found on Sardinia in the form of ingots, alongside the lead ingots presented here with their CM signs, provide the most straightforward explanation of this trade, which appears to be related to the proactive involvement of Cypriot agents. This is in contrast to the claim by Russell and Knapp (2017) who asserted that… *"the archaeological record does not substantiate the notion that Cypriote or any other eastern Mediterranean merchants or prospectors actively sought access to Sardinian ores"*, even though Stos-Gale and Gale, 1994, Stos-Gale and Gale, 2010 have repeatedly shown that Sardinian lead was present on Cyprus. We now know, based on the accumulating evidence of lead objects on Cyprus, and CM-marked ingots in the Eastern Mediterranean made of Sardinian lead, that Cypriots actively sought Sardinian lead, both for distribution in Mediterranean markets and for their own use (see Kassianidou and Knapp, 2005, Recht, 2016 for a similar view), in light of the lead-poor nature of Cypriot copper (e.g., Gale, 2006, Kassianidou, 2006). In addition to the use of lead for mundane purposes in Cyprus (e.g., net sinkers and weights), it also had a possible military use for sling bullets (Recht, 2016). In addition, lead, with its particularly low melting point, was required for the production of elaborate bronze castings, such as stands and figurines, which were commonly produced during the 13th and 12th century BCE in Cyprus (e.g. Papasavvas, 2001, Charalambous et al., 2014).[6]

The date of the Sardinian-Cypriot trade interaction may be set based on Cypriot copper oxhide ingots found in Sardinia that are dated between the 13th and 11th centuries BCE, although many of them derive from unclear contexts. Within this chronological range, the well-dated examples of copper oxhide ingots were found in 13th century BCE contexts, for example, the Funtana Coberta-Ballao hoard comprised of 31 ingot fragments and dated based on LHIIIB pottery forms (Sabatini and Lo Schiavo 2020). This date is compatible with the occurrences of Sardinian lead in well-dated contexts in Cyprus (as noted above), as well as in Qantir-Pi Ramesses. Significantly, the diverse shape and size of the ingots from Caesarea anchorage indicates that they were produced either in different workshops and/or over a prolonged period of time.

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Tin, the other component needed for the production of bronze, was unlikely to have been mined in Sardinia (Valera et al., 2005). A study of tin ingots from Mochlos, Crete and from Late Bronze Age shipwrecks found along the eastern Mediterranean coast, indicated that the source was located at Cornwall or Devon in England and, possibly, in the French Massif Central or Iberia (Berger et al., 2019). Sardinia could have played a key role in the acquisition of tin from such western sources to distribution throughout the eastern Mediterranean, thereby benefiting from the Atlantic trade (Kassianidou and Knapp, 2005, Pappa, 2019). In addition to lead, it is likely that Cypriot agents tapped into the tin that was available on the island (Sherratt, 2016b). It is thus no coincidence that tin, lead and copper ingots were found in various combinations in cargoes along the Carmel coast, although Hishulei Carmel is the only cargo that carried all three (Galili et al., 2013).[7]

7.4. Further related issues

In light of the results of the present study, showing the intense and robust trade interaction between Cyprus and Sardinia, especially during, the late Late Bronze Age, a number of pertinent issues arise.

1. Copper trade between Sardinia and the eastern Mediterranean may have included other copper sources, in addition to the Cypriot one that is indicated by the analysis of oxhide ingots from Sardinia. Several fragments of loaf-shaped copper ingots at Nuraghe Arrubio, from the second half of the 14th century to the 12th century BCE, physically and isotopically resemble the copper ingots from Neve Yam on the Carmel coast (Montero Ruiz, 2018). The latter were provenanced to Faynan in the Arabah and dated to around the 12th century BCE (Yahalom-Mack et al., 2014; Galili et al. in press). While copper deposits in Sardinia and the Arabah are generally of the same geological age (500–600 million years), making it difficult to distinguish between the two, Faynan is a more likely source for the Neve Yam ingots, mainly due to the relatively high lead contents; future analyses will resolve this question. Whether Sardinian copper made it to the Carmel coast at the end of the Late Bronze Age or Faynan copper arrived at Sardinia, the connections between the regions are well evident, and clearly focused on the trade in raw metals.

2. Having established the Cypriot involvement in the trade of Sardinian lead, the question may be asked as to the Sardinian versus Cypriot involvement in the mining and smelting of this product. Nuraghe Antigori, one of the largest Nuraghi in Sardinia, and one which contains evidence for foreign contacts, mainly in the form of Aegean pottery (see Russell and Knapp, 2017: 20), is located near the Iglesiente ore source. Lead isotope analysis of several lead objects from this site points to this source (Gale and Stos-Gale, 1987, Gale, 2006). This raises the possibility that the local elites who are thought to have inhabited the Nuraghe were the active agents in the mines, possibly under commission by the Cypriot merchants.

3. Whether lead was mined and smelted on Sardinia for its own sake during the Nuragic period and the 13th and early 12th centuries BCE in particular, or whether as a by-pr

production, is currently unknown (Valera et al., 2005, Terpstra, 2021). In a recent analysis of silver from Iron Age Phoenician hoards, it was shown that the silver in the Levant was obtained from Sardinia only from the 10th century BCE and onwards, notably, originating from the very same Iglesiente lead ores (Eshel et al., 2019). The use of Sardinian lead in the Levant during the late 2nd millennium cannot be established based on lead isotope analysis of local silver hoards, due to extensive mixing of silver with Pb-rich copper at this time. Such mixing introduced extraneous lead which obscures the interpretation of the lead isotopic analytical results (Eshel et al., 2021, contra Wood et al., 2020, Thompson and Skaggs, 2013). One argument against the use of Iglesiente lead ores for silver may be that, according to Stos-Gale and Gale (2010), the silver from LC IIC contexts on Cyprus did not originate in Sardinia and mostly came from Laurion in the Aegean (see note 6). If silver was sought by Cypriots on Sardinia, then we would expect a Sardinian origin of the silver being used on Cyprus.

7.5. Conclusions

This study joins previous research to suggest that Cypriot agents were actively involved in a broad Mediterranean trade network that was characterized by non-palatial, multi-scalar and non-formal endeavors (Artzy, 1997, Russell and Knapp, 2017: 20–21; Sherratt, 2016a), with an emphasis on the two-way trade in raw metals. The Cypriot initiative was directed both to distributing the raw metals, along with other commodities such as Aegean pottery, to Mediterranean trade nodes, and to fulfilling their own needs in the manufacture of added-value end products that required lead and tin, in addition to the local copper or scrap metal, a process that culminated during the 13th and 12th centuries BCE on Cyprus (Sherratt et al., 1991, Sherratt, 2016a, Pickles and Peltenburg, 1998, Karageorghis and Kassianidou, 1999, Sherratt, 2012.

It is not argued that voyages such as that of the Uluburun ship were initiated by Cypriots (Bass, 1991, Pulak, 1998; though see Kassianidou, 2003: 115). It may be cautiously presumed, however, that if metals were the main commodity traded during the 13th and 12th centuries BCE, a large portion of their movement can now be traced to Cypriot hands. In this case, rather than the Uluburun ship sailing off route to make a stop at Cyprus to collect oxhide ingots, it may be hypothesized that Cypriot agents transported the metals to its port of departure, somewhere along the eastern Mediterranean coast. In such a scenario, the Cypriots assume a more active role in the actual movement of the ingots that they produced and also procured as middlemen from as far as the western Mediterranean.

CRediT authorship contribution statement

N. Yahalom-Mack: Conceptualization, Writing – original draft, Methodology, Validation, Supervision. **D.M. Finn:** Visualization, Writing – original draft. **Y. Erel:** Methodology, Resources, Validation, Writing – original draft. **O. Tirosh:** Investigation. **E. Galili:** Conceptualization, Writing – original draft. **A. Yasur-Landau:** Conceptualization, Writing – original draft.

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Appendix A. Supplementary data

The following are the Supplementary data to this article:

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Supplementary data 1.

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2 Rectangular lead ingots are portrayed in New Kingdom Egyptian wall paintings (Wachsmann, 2020: 222–224 and references therein).

3 Valério (2016: 185) highlights the relationship between CM 08 and CM 69, which appears to have developed from the former.

4 Additional unprovenanced tin ingots with CM marks are described in Berger et al. 2019.

5 Copper oxhide ingots with markings attributed to the CM script were found mostly in the Uluburun and Cape Gelidonya shipwrecks, but also in Sardinia (Kaiser, 2013), although it is not certain whether all indeed belong to this script (Valério and Davis, 2017). Notably, CM marks have been found on miniature copper oxhide ingots (Ferrara and Bell, 2016).

6 The source of lead prior to this period may have been the Aegean (Gale and Stos-Gale, 1981b: 19

7 The official, palace-controlled trade between Ugarit and the Aegean included lead sourced mainly to Laurion (unpublished results http://oxalid.arch.ox.ac.uk/), explaining the lack of Sardinian lead ingots in both the Uluburun and Cape Gelidonya shipwrecks (Gale and Stos-Gale 1981a; Gale and Stos-Gale 1981b; Stos-Gale 2000).

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