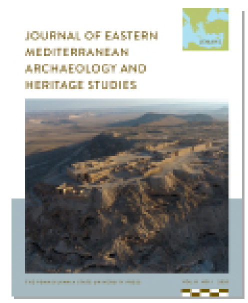
# The Origin of Tel Dor Hacksilver and the Westward Expansion of the Phoenicians in the Early Iron Age: The Cypriot Connection

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# THE ORIGIN OF TEL DOR HACKSILVER AND THE WESTWARD EXPANSION OF THE PHOENICIANS IN THE EARLY IRON AGE

## The Cypriot Connection

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**ABSTRACT**

A recent reanalysis of compositional and lead isotope legacy data from the early silver hoards of the southern Levant (ca. twelfth–ninth centuries BCE) identified that not only was most of this hacksilver mixed but that it probably derived from the Pyritic belt of southern Iberia, the Taurus mountains in Anatolia, and a third unknown source. We propose that the unknown component of Tel Dor's hacksilver was silver potentially derived from ores mined at Kalavasos on Cyprus. The presence of Cypriot silver in the southern Levant complements finds of Phoenician pottery on Cyprus, supporting that there was continuity of trade from the end of the Bronze Age to the beginning of the Iron Age between Cyprus and the Levant. Furthermore, our findings suggest that the technology required to smelt and cupellate argentiferous jarosite ores was first practiced on Cyprus prior to risky and costly ventures to Iberia.

**KEYWORDS:** Tel Dor, silver, jarosite, Phoenicians, mixing lines, lead isotopes

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The earliest period of the Iron Age marks the emergence of the Phoenicians as a distinct cultural entity with a considerable degree of continuity from their Late Bronze Age Canaanite antecedents (Bell 2016). Until recently, this earliest period (approximately 1200–900 BCE) has been thinly covered in the archaeological literature primarily because of the limited number of excavations conducted at many of the still-inhabited key sites (such as Tyre, Sidon, and Arwad), and, of course, due to modern-day geopolitics (Bell 2016).

Bell (2006: 5, 99–100), among others, has noted the remarkable continuity in settlement and material culture exhibited by the geographical region on the Levantine coast between Arwad in the north and Tel Dor in the south (Figs. 1 and 2)—the generally accepted boundaries of Phoenicia—across the Late Bronze/Iron Age transition. To the north, the important Late Bronze Age port of Ugarit was razed from the map permanently while coastal cities such as Ashdod and Ashkelon in southern modern-day Israel were rebuilt rapidly and exhibited new and distinctive architecture, lifeways, and ceramics (consistent with the settlement of the Philistines) compared with surrounding areas that were still, at least notionally, under Egyptian control (Bell 2006: 4–6).

This lack of destruction at the end of the Late Bronze Age in Phoenicia would have given resident merchants engaged in seaborne trade a distinct advantage in the earliest Iron Age. Bell (2006: 95–101) put forward the

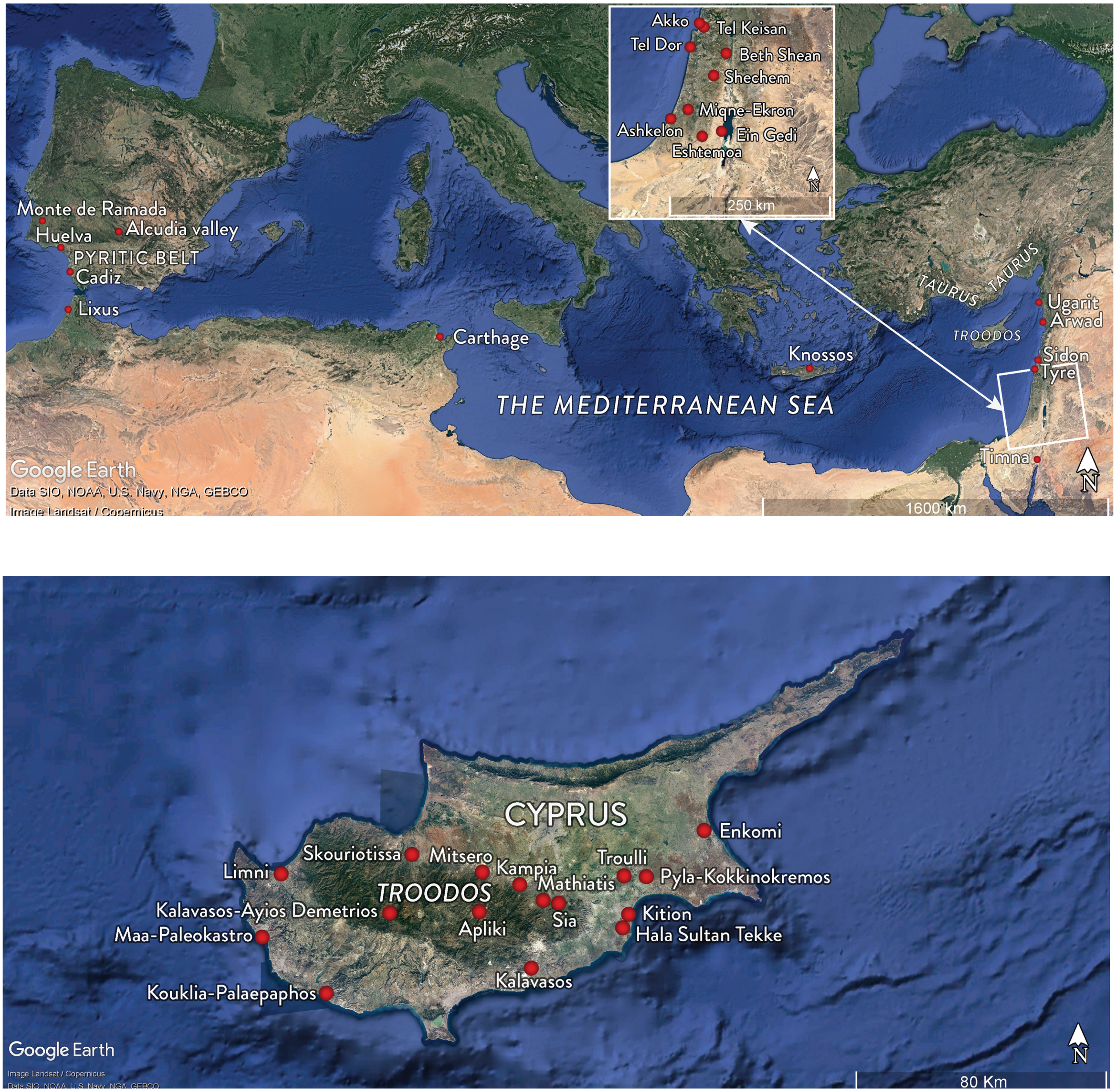


FIG. 1

**Maps showing the geographical area with sites mentioned in the text: (upper) Mediterranean Sea and (lower) Cyprus, including mining sites around the Troodos mountains.** (Photos: Google Earth. Map graphics by R. Stidsing.)

hypothesis that contact between Phoenicia and particularly western Cyprus (see Fig. 1 lower), continued across the Late Bronze/Iron Age transition. Tyre, Sidon, and the other Phoenician ports would have been able to continue to engage in maritime ventures to obtain necessary commodities, of which copper from Cyprus would have been one, in exchange for locally sourced products such as high-quality timber, wine, and purple dye.

It is now generally accepted, in light of recent excavations, that Tel Dor in northern Israel was part of the Phoenician cultural area in Iron I (ca. 1150–1000 BCE), rather than a Sea Peoples' settlement as was initially


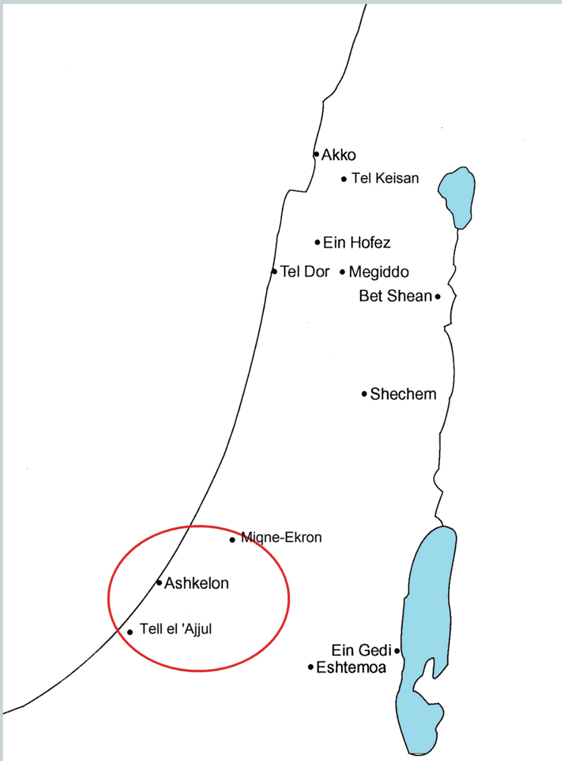


FIG. 2

**Maps of the southern Levant with the sites of hoards mentioned in the text. The upper map indicates areas of copper and silver ores in relation to the southern Levant: the Taurus mountains in Anatolia, the Troodos mountains in Cyprus, and Timna in southern Israel. The red ellipse in the lower map highlights the location of three hoards in Philistia. The photograph shows the Tel Dor hoard as displayed at the Out of the Blue exhibition in the Bible Lands Museum, Jerusalem, Israel.** (Top photo: Google Earth. Lower left: map by J. Wood. Lower right: detail of photo by Bukvoed, CC-BY-4.0 [https://creativecommons.org/licenses/by/4.0/deed.en]. Map graphics by R. Stidsing) thought based on textual evidence (Gilboa and Sharon 2017). Moreover, results from the Tel Dor excavations (directed since 2003 by A. Gilboa and I. Sharon) and the Palaepaphos Urban Landscape project (initiated in 2006 by M. Iacovou) have demonstrated that connections between Phoenicia and western Cyprus did, indeed, continue to be strong in the Early Iron Age.

Inevitably, ceramics, such as the diagnostic containers in which wine was shipped and other, decorated containers, have been critical in establishing the chronology of these relationships. The evidence from Tel Dor has been particularly valuable in establishing the timeline of Phoenician westward maritime expansion (Gilboa and Sharon 2001, 2003; Gilboa, Sharon, and Boaretto 2008). The direction and extent of these networks and their expansion through time is particularly relevant to the question being dealt with here, namely the origin of the silver in the Tel Dor hacksilver hoard. Given that there is no known source of silver in the immediate vicinity of Phoenicia, it is reasonable to assume that the silver in this hoard arrived at Tel Dor as a result of long-distance trade of some kind.

The Tel Dor silver hoard (8.5 kg hacksilver) was contained in a clay jug and was found in a space between two large buildings initially dated to the late eleventh-early tenth century BCE, close to the settlement's main harbor (Stern 2001) (see Fig. 2). The hoard is currently being dated to the second half of the tenth century BCE (Eshel et al. 2019). An assemblage of Phoenician bichrome ware was found in an associated building, as well as sherds from imported Cypriot wares and Greek wares from Euboea, which assisted the dating of the context and confirmed that long distance maritime trade was being conducted at this time (Stern 2001).

We recently reanalyzed the Tel Dor silver, together with examples from other hoards of similar date from the southern Levant (twelfth–ninth centuries BCE) (Table 1), using compositional and lead isotope legacy data (Wood,

TABLE 1 SITES, CHRONOLOGIES, WEIGHTS, AND NUMBER OF SAMPLES ANALYZED FOR EACH HOARD MENTIONED IN THE TEXT, ADAPTED FROM THOMPSON 2003.

| Location | Chronology | Number of samples (N=150) | Weight of silver (g) |
|---|---|---|---|
| Akko | Ninth–eighth century BCE<br>Note: Eshel et al. (2019) propose the tenth–ninth century BCE | 10 | 257.6 |
| Ashkelon | Late twelfth century BCE ?/1100BC | 7 | Bundle 1: 44.9<br>Bundle 2: 55.05 |
| Beth Shean | Twelfth century BCE | 5 | Beth Shean: A 2,423.8; B 2,434.65; C 1,332. |
| Ein Gedi | 630–586 BCE | 5 | 1,078 |
| Ein Hofez | Tenth–ninth century BCE?<br>Note: Eshel et al. (2019) propose the ninth century BCE | 15 | >1,200 |
| Eshtemoa | Eleventh–ninth (or tenth–eighth) century BCE<br>Note: Eshel et al. (2019) propose the eighth century BC | 15 | 26,000 |
| Miqne-Ekron | Seventh century BCE/circa 600 BCE | 50 | Miqne-Ekron A: 24.5; B 259.4; C 954; D 89.7; E 73; F 19 |
| Shechem | Late Bronze Age/Iron Age or 1000–200 BCE | 10 | >45.16 |
| Tel Dor | Eleventh–tenth century BCE<br>Note: Eshel et al. (2019) propose the second half of the tenth century BCE | 15 | 8,500 |
| Tell el 'Ajjul | Twelfth–eleventh century BCE | 10 | ? |
| Tel Keisan | Second half of the eleventh century BCE | 8 | 354 |

**Note:** The number of samples corresponds to the number of artifacts that were analyzed, that is, fragments from various types of ingots, hacksilver, silver sheet, wires, rods, tokens, jewelry, as well as indeterminate fragments. The total weight of silver is also shown. The proportion of silver pieces analyzed for each hoard varied. As a guide, 50 out of 305 pieces of silver from Miqne-Ekron were analyzed for LIA.

Montero-Ruiz, and Martinón-Torres 2019). The maps in Fig. 2 show the locations of these hoards. This analysis concluded that not only was most of this hacksilver mixed, but also that it probably derived from three main silver ore sources: the Pyritic belt of southern Iberia, the Taurus mountains in Anatolia, and a third unknown source (Wood, Montero-Ruiz, and Martinón-Torres 2019). The aim of the current article is to identify and situate this unknown source in the movement of silver and silver technology of the first-millennium Mediterranean.

## Sources of Silver

This section deals with two known sources of silver (Anatolia and Iberia) based on the hoards listed in Table 1, exploring the contact between these regions and the southern Levant. It further examines the rationale behind the identification of the third source.

*Anatolia*: The highland region of Anatolia's Taurus mountains was known as the "silver mountains" in antiquity and is considered to be one of the earliest environments in which metallurgy developed (Craddock 1985; Tylecote 1987). The Taurus mountains have often been cited as a likely source of raw materials such as metal, minerals, and wood, critical to the early urban populations of the Levant, Anatolia, and Iraq who lived in environments noted for their poor resources (Muhly 1973, 1976; Charles 1985; Moorey 1985).

The abundance of silver objects from tombs in Sidon, to the north of Tel Dor, has been used to support the idea that there was extensive and sustained trade with Anatolia during the Middle Bronze Age (Véron and Le Roux 2004; Doumet-Serhal 2004). Of the hoards of the southern Levant previously reanalyzed (Wood, Montero-Ruiz, and Martinón-Torres 2019), the silver recovered from the twelfth- to the eleventh-century BCE site of Tell el ʿAjjul was found to have compositional and lead isotopic signatures consistent with the Taurus mountains of Anatolia. This source attribution is therefore uncontroversial and may be viewed as a continuation of these earlier trade routes.

*Iberia*: The Anatolian signature detected in the tested samples was unsurprising. However, the discovery of hacksilver with a silver signature from Iberia in such an early context (ca. eleventh century BCE) is astounding and it runs counter to an assumption shared by many scholars that the westward movement of Phoenician maritime enterprises began no earlier than the ninth century BCE (e.g., Broodbank 2013: 489; Ruiz-Gálvez 2014: 196–214).

The possibility of an earlier Phoenician presence in Iberia has been raised, however, following rescue excavations in the city of Huelva in Spain in 1998 (a port through which metal derived from the Rio Tinto ore deposits would have passed; Gonzalez de Canales, Serrano, and Llompart 2004, 2006, 2008: 631–55). Finds included ceramic imports, ivory, silver, and other materials. Of the over 8,000 pottery sherds catalogued, half were Mediterranean imports, with Phoenician imports representing the largest group (over 3,000). Lesser quantities of other imports were present: Greek (33), Cypriot (8), Sardinian (30), and Italian (2). Furthermore, in addition to Middle Geometric II (ca. 800–750 BCE) material, there is increasing evidence, from the identification of the Late Helladic IIIC (1153–1070 BCE) and Late Minoan IIIC (1190–1070 BCE) pottery at Huelva (Palos de la Frontera Street), that trade goods were moving toward Huelva through the western Mediterranean from the eastern Mediterranean, Phoenicia, Cyprus, and Crete during the first half of the twelfth century BCE (Gómez Toscano and Mederos Martín 2018).

The excavators identified many similarities between the Phoenician ceramics of Huelva and those of, specifically, Tyre (Gonzalez de Canales, Serrano, and Llompart 2008: 634). Although the bulk of the Phoenician sherds has been attributed to later dates, the presence of 11 examples of the Tyre Type 12 storage jar, which has a reasonably well-defined chronological distribution and is virtually unknown at Tyre after Stratum IX, resulted in the excavators attributing some of the earliest Phoenician pottery of Huelva to the Kouklia Horizon (Tyre Strata XIII–X or 1050–900 BCE) (Gonzalez de Canales, Serrano, and Llompart 2006; Bikai 1978: 44, table 10A; Bell 2016: fig. 5.3) (Fig. 3, below).

Furthermore, the Huelva Type 12 storage jars are practically identical to those at Tel Dor (where they are abundant in Ir 1a [ca. 1150–1050 BCE], present in Ir 1b [ca. 1050–1000/980 BCE] and virtually absent thereafter, see Gilboa and Sharon 2003: table 17)—a picture that is chronologically consistent with that seen at Tyre.

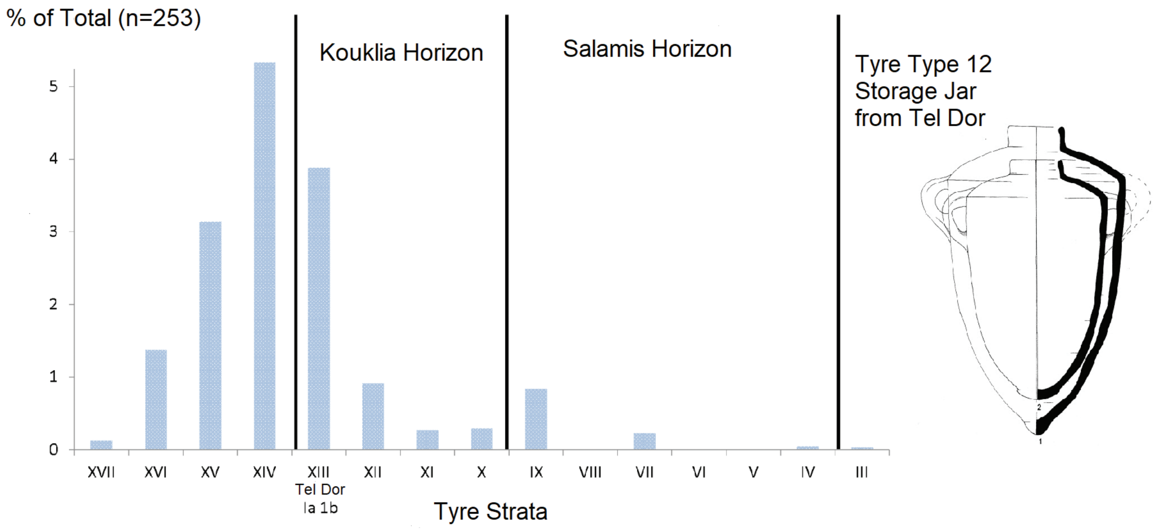


FIG. 3
**Chronological distribution of Tyre Type 12 storage jars at Tyre (sources: Bikai 1978: 44, table 10A; Gilboa and Sharon 2003: fig. 4:1 and 2; Bell 2016).** (Data from C. Bell.)

Three radiocarbon dates, obtained from cattle bones of the earliest horizon from which Phoenician pottery was recovered in Huelva, suggested a date range of 1000–820 BCE, with the weighted average of the three dates being 930–830 BCE (Gonzales de Canales, Serrano, and Llompart 2009; Bell 2016). These few dates, therefore, do not exclude the possibility of Phoenician contacts with Iberia in the tenth century BCE.

*The third source of silver*: Conventional wisdom has been that silver was not mined in Cyprus until modern times (e.g., Kassianidou 2012, 2013). This notion, however, has recently been challenged (J. R. Wood 2019). Before discussing the possibility of Cyprus being one of the sources of silver of the Tel Dor hoard more specifically, it is appropriate to refer to the broader context of east-west Mediterranean connections in the Early Iron Age, and the role of Cyprus. As Bell (2016) has pointed out, contacts between the geographical area of Phoenicia across the Late Bronze/Iron Age transition were maintained, particularly with the west of the island of Cyprus. There are also allusions to early connections between Cyprus and the Levant with Iberia. Both the Bronze Age Berzocana and Villena hoards in Iberia suggest technology with Cypriot or Canaanite/Levantine origins. The Berzocana hoard shows connections with the Cypriot-Levantine area, with a bronze bowl of the Cypriot-Canaanite type (Ruiz-Gálvez 2014: 196–214 citing Torres 2012; Zorea 2018) made using the lost-wax technique, bearing close resemblance to bowls from the Jatt hoard in Israel and bowls at Megiddo, both from around the end of the eleventh century BCE (Artzy 2006). These hoards support the view that Megiddo was a Canaanite city actively involved in maritime trade with both Phoenicians and Cypriots (Artzy 2006). Atlantic objects found in graves in Cyprus (Karageorghis and Lo Schiavo 1989) tend to support this position.

There is also archaeometric evidence that the Berzocana bowl has its origins in the eastern Mediterranean. Lead isotope analyses were conducted on the bronze bowl at the Curt-Engelhorn-Centre Archaeometry (CEZA) in Mannheim, Germany for lead isotope ratios with multicollector inductively coupled plasma mass spectrometry (MC-ICP-MS) using the established instruments and protocols of the CEZA laboratories. The results are presented in Table 2 and Fig. 4.

The following graphs (Fig. 4) show lead isotope analyses (LIA) of ores from Timna (southern Israel) and Feynan (Jordan) plotted alongside copper-based objects from the Jatt hoard in Israel and the bronze bowl from the Berzocana hoard (LIA in Table 2).

TABLE 2 LEAD ISOTOPE RATIOS FOR THE BRONZE BOWL FROM THE BERZOCANA HOARD.

| Berzocana ID | $^{208}Pb/^{206}Pb$ | $^{207}Pb/^{206}Pb$ | $^{206}Pb/^{204}Pb$ | $^{207}Pb/^{204}Pb$ | $^{208}Pb/^{204}Pb$ |
|---|---|---|---|---|---|
| 2226/MA-165664 | 2.1202 | 0.8701 | 17.962 | 15.629 | 38.082 |

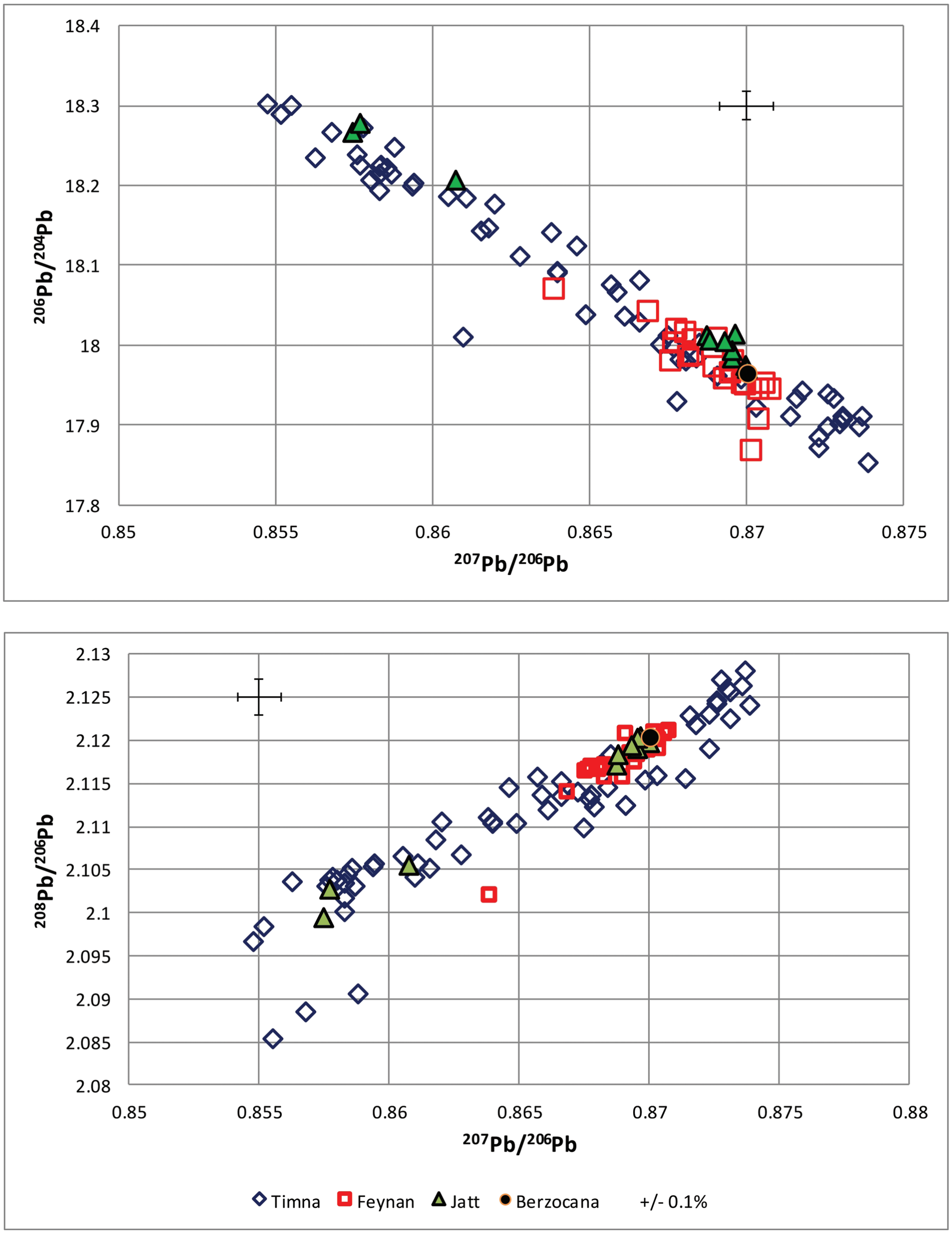


FIG. 4
LIA mirror plots showing the ores of Timna (southern Israel) and Feynan (Jordan) alongside copper-based objects from the Jatt hoard and the copper bowl from the Berzocana hoard.

The LIA plots clearly indicate that the Berzocana bowl and the copper-based objects from the Jatt hoard are consistent with Timna and Feynan ores. This movement of objects indicates that the westward trade in copper—which was recently demonstrated by the identification of Feynan copper used for tripod cauldrons at Olympia in southwest Greece (ca. 950–750 BCE; Kiderlen et al. 2016)—also extended to the movement of objects as far west as Iberia.

Further evidence for such long-distance contact is found with the Villena hoard, which contains exotic elements such as a nail (unknown in the Bronze Age, having been developed in Cyprus ca. 1200 BCE) and a gold-inlaid iron object (iron was rare in Iberia during the Late Bronze Age) (Ruiz-Gálvez 2014: 196–214). In terms of knowledge transmission and therefore sustained contact, the very presence of iron metallurgy more broadly has been highlighted as a technological innovation for this period, with the earliest artifacts, including tools, dating to the eleventh century BCE (Vilaça 2006, 2013). Further indications of sustained interaction between the eastern Mediterranean and Iberia is found at Monte de Ramada 1 (southern Portugal): here, a tenth-century BCE assemblage includes unusual bronze alloys as well as glass, faience, and ostrich shell beads, which have been interpreted as testifying to an archaic trade with the Mediterranean region before the establishment of the first Phoenician colonies on the southern Iberian coast (Valério et al. 2018).

Sustained contact between the east and Iberia is also apparent when it is considered that silver from Iberia found in the hoards of the southern Levant (from ca. the eleventh century BCE) was potentially of two types (Wood, Montero-Ruiz, and Martinón-Torres 2019): native silver (which was available to the indigenous Bronze Age Iberians) and silver deriving from the silver-bearing jarositic ores of southwest Iberia, which needed to be smelted (in some cases with exogenous lead) to produce argentiferous lead metal before cupellation to extract the silver. Taken together, this evidence could suggest that traders who traveled to Iberia and transmitted the lost-wax casting technique, iron metallurgy, and other technologies to the indigenous population in the eleventh century BCE, having witnessed firsthand the wealth around Huelva, decided to exploit the natural resources by introducing the smelting and cupellation technology.

Moreover, as will be discussed below, it is pertinent that jarosite was exploited instead of the argentiferous galena ores, which are abundant in other areas of southern Iberia. Irrespective of the specific cultural or political affiliation of these traders, if our proposal is correct, then there must be earlier evidence of cupellation in the archaeological record in Iberia that has yet to be discovered or identified.

The technological as well as the material evidence described above becomes even more significant when it is noted that the argentiferous jarosite ores of the pyritic belt of southwest Iberia are exceptionally rare around the Mediterranean and the Near East. One of the only places with similar mineralization is on Cyprus where silver is present in a jarositic mineral known as the "Devil's mud" at the base of the gossan. Until recently, the common belief was that the silver-bearing ores on Cyprus were not exploited in antiquity. This idea was challenged recently by J. R. Wood (2019). Similarly, on the basis of the information presented above, we suggest that the people who first extracted silver from jarosite ores in southwest Iberia may have acquired and practiced the necessary skills to recognize and exploit this type of ore, prior to any westward reconnaissance missions across the Mediterranean to Iberia. In other words, unless they learned these skills from the indigenous Iberians, the prospectors, miners, smelters, and refiners of Iberian silver in the Early Iron Age (ca. eleventh century BCE) potentially derived their expertise from mining and extracting the silver from the jarosite ores of Cyprus in the Late Bronze Age/Early Iron Age. This scenario would explain the fact that the earliest identified bellows nozzles associated with cupellated silver in Iberia are similar to those from the thirteenth-century BCE Apliki site on Cyprus (Hunt Ortiz 2003: 360–61, 392, fig. 146; Muhly 1991: 183). As Pappa (2013: 111) has highlighted, this cannot be mere coincidence.

The repercussions of a similar technology being applied in both Cyprus and Iberia is significant because it suggests that an early Phoenician presence on Cyprus cannot be viewed as purely demic diffusion where indigenous Cypriot culture is largely supplanted by that of the Levant (Gjerstad 1979), but that the Late Cypriot communities played a formative role in the process of becoming "Phoenician." In other words, the Phoenicians' identity, which to some extent is defined by their pursuit of acquiring metals, and which was potentially a composite of identities even in the Levant (Broodbank 2013: 485), became realized through their association with other groups, in particular the Cypriots who had been mining ores on Cyprus since the fourth millennium (Hemingway and Hemingway 2004).

## Silver in the Southern Levant

In terms of geographical and chronological distributions, the largest identified concentration of silver hoards in the ancient Near East is in the Iron Age of the southern Levant (Thompson 2003). Unlike the Bronze Age hoards of this region, as well as those of Cyprus and the Aegean, which tend to be more mixed in terms of metals and materials, silver appears to be the preferred metal in these Iron Age contexts. The increasing frequency of silver in hoards in the Iron Age (in some cases to the exclusion of other metals) becomes all the more remarkable when it is considered that the southern Levant has no geological silver sources of its own (Thompson 2003). This raises questions regarding the origins of the hoard silver as well as how and when it arrived in this region, with obvious implications for the understanding of the broader geopolitical context.

### *Mixing Lines*

From a technical point of view, the provenance of silver ingots or objects is more difficult to identify when the metal is a mixture of silver from different ore sources, rather than stemming from a single source. This is primarily because lead isotope analysis (LIA) cannot conclusively differentiate between silver with a mixed isotopic signature (i.e., coming from more than one ore source) and silver from either a single known ore source with similar values, or a source that has yet to be identified. This is further confounded when the LIA fields overlap. A potentially simple strategy to overcome this problem has been proposed (Wood et al. 2017; Wood, Montero-Ruiz, and Martinón-Torres 2019). The strategy involves two steps: (1) LIA values are used to calculate the crustal age (also known as the model age) of the ore from which the silver derived (using a two-stage evolution model and the parameters of Desaulty et al. 2012); this age is then (2) plotted against the levels of gold found in silver, given that gold is a useful geological indicator for a silver source as it is likely to survive the smelting and refining operations. This approach allows two types of data, isotopic and elemental, which are often geologically linked and can inform on provenance, to be plotted together. The following graph (Fig. 5) plots the Au/Ag ratio against the Pb crustal age of the ore (Ma: millions of years), illustrating that the silver from the Early Iron Age hoards of the southern Levant potentially lies on a series of mixing lines.

Details of how Fig. 5 (upper) was constructed and how each line can be interpreted have already been presented elsewhere (Wood, Montero-Ruiz, and Martinón-Torres 2019), but are summarized here. The data cluster at point 1 corresponds to the crustal ages and levels of gold within the silver, which are consistent with the Taurus mountains in Anatolia. The cluster at point 7 is not only consistent with ores from the Pyritic belt in southwest Iberia, but also with native silver found at Bronze Age sites in Iberia (as shown by the density plot). Point 5 and the cluster at point 6 are also consistent with Iberian silver-bearing ores, with low to high gold levels (up to 16%Au) being found in argentiferous jarosite ores (Gale, Gentner, and Wagner 1980).

Figure 5 (lower) shows the Tel Dor data from the upper plot and the associated mixing lines determined from all the hoards reanalyzed by Wood, Montero-Ruiz, and Martinón-Torres (2019). Furthermore, two silver ingot fragments recovered in Iberia are also plotted (Wood and Montero-Ruiz 2019): one is from La Rebanadilla near Malaga, which is potentially as early as the hoards of the southern Levant, that is, ca. late eleventh century BCE; the second is from Las Arenillas, near the mining site of Corta Lago at Rio Tinto, southwest Iberia. Although the Las Arenillas silver is probably from the Roman period (Craddock, Freestone, and Hunt Ortiz 1987), it provides a signature of silver derived from the same area mined by the Phoenicians. Essentially, these silver fragments highlight variation in gold levels in Iberian silver and crustal ages associated with the Hercynian orogeny of southwest Iberia.

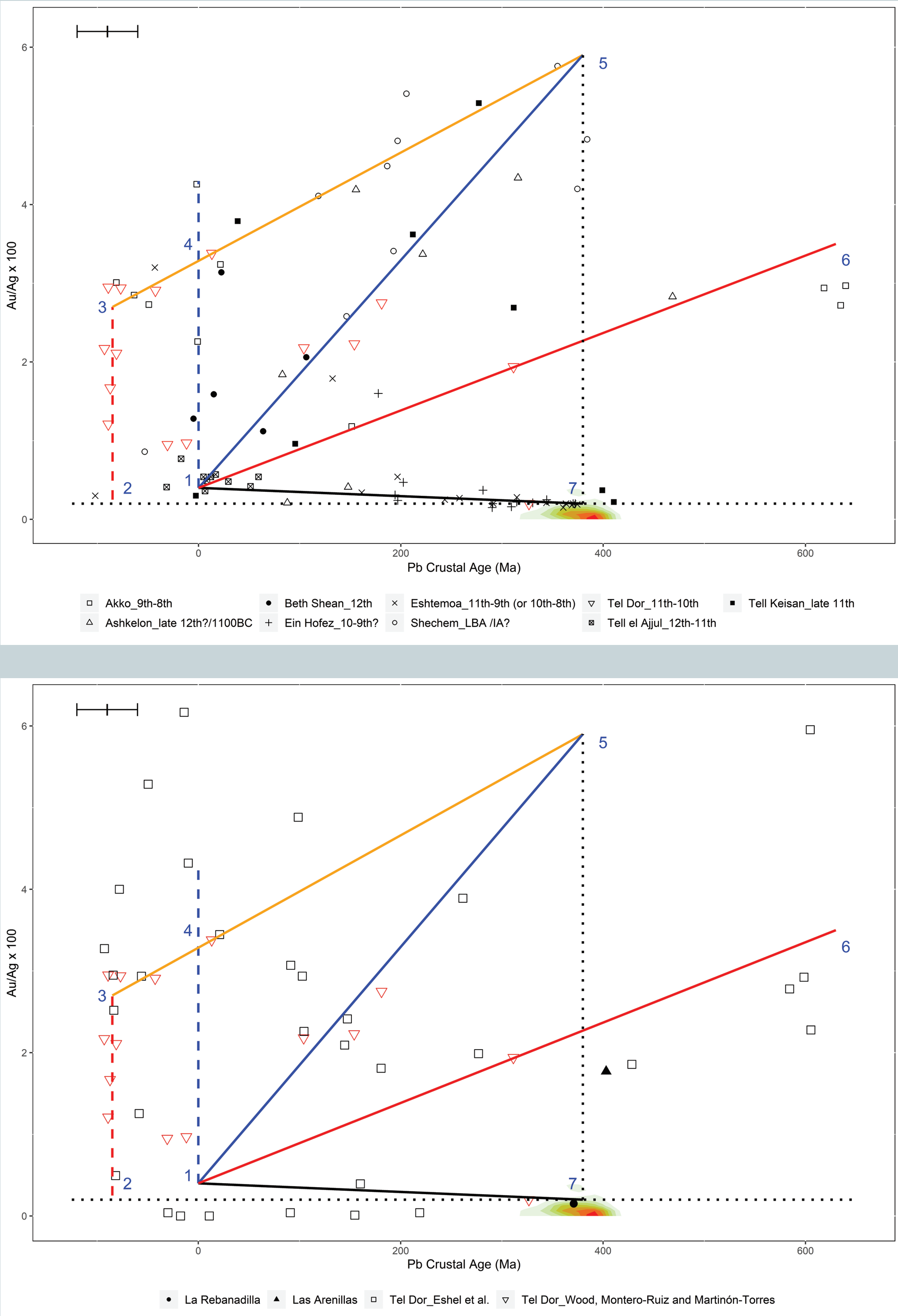


FIG. 5

The upper plot shows Au/Ag x 100 versus Pb crustal age (Ma) for the Late Bronze Age/Early Iron Age hoards (see Wood, Montero-Ruiz, and Martinón-Torres 2019). The density map (high density: red; low density: green) is derived from compositional data (measured by ED-XRF) and lead isotope data for Bronze Age silver found in Iberia (Comendador Rey et al. 2014; Bartelheim et al. 2012; Murillo-Barroso et al. 2014; Murillo-Barroso 2013). The black dotted line shows the detection limits from the ED-XRF technique used to measure the composition of the hoard data. The silver from the Tel Dor hoard is highlighted in red in the upper plot. The lower plot replots this data (i.e., inverted red triangles) and the mixing lines from the upper plot, alongside recent data for Tel Dor from Eshel et al. 2019 (blue squares) and two silver ingot fragments recovered in Iberia (Wood and Montero-Ruiz 2019). Other lines and numbered points are described in the text. The error bar was determined from propagating the error on lead isotope ratios (±0.1%) to the Pb crustal age.

The lead isotope data from Eshel et al. (2019) has been reanalyzed using the same procedure and is also presented (see Fig. 5 lower). It must first be noted that as with the initial reanalysis (Wood, Montero-Ruiz, and Martinón-Torres 2019), silver samples with very high levels of gold have not been included on this plot (in this case, two samples from Eshel et al.'s data), as these samples may have been a consequence of deliberate alloying rather than unintentional mixing, perhaps to alter the color. Furthermore, the methods of measurement of the two datasets are different: Wood, Montero-Ruiz, and Martinón-Torres (2019) reanalyzed data from ED-XRF measurements (elemental) and from thermal ionization mass spectrometry (TIMS) (lead isotopes) on the 15 samples measured by the Oxford group (OXALID);[1] Eshel et al. (2019) remeasured 34 samples from Tel Dor using inductively coupled plasma mass spectrometry (ICPMS) (elemental and lead isotopes). Nevertheless, Fig. 5 (lower) shows that the two datasets are similar. First, both datasets support the presence of a vertical mixing line at around -80Ma, that is, increasing Au/Ag levels with similar crustal ages (discussed below). Second, both exhibit mixing of low and high crustal age silvers, with increases in Au/Ag levels commensurate with the orange line (points 3–5) and the blue line (points 1–5) determined from all hoards (see Fig. 5 upper). Furthermore, Eshel et al. (2019) present data that traverses the horizontal axis from low to high crustal ages at very low Au/Ag levels, strongly suggesting that silvers with low gold concentrations but vastly different crustal ages were mixed together. These samples may be commensurate with the black line between points 1 and 7 in Fig. 5 (upper). Alternatively, samples on the black line may be part of a mixing line that extends from point 2 to point 7. This is difficult to differentiate, as the detection limits are higher for the EDXRF compositional data. Nonetheless, it appears that silver from Tel Dor was a mixture of silver with low and high crustal ages, while the vertical mixing line supports that silver from the same source (i.e., similar crustal ages) was inadvertently mixed with gold, perhaps when remelting gilded silver objects, to produce silver with an unusual composition (Au/Ag x100 ~ 3–4) that subsequently became part of another mixing line (orange mixing line between points 3 and 5).

Silver at point 6 might at first seem consistent with a Sardinian source, reflecting genesis during the Caledonian orogeny, that is, high crustal ages. This view has recently gained traction as Eshel et al. (2019) suggest that Sardinian silver was exploited by the Phoenicians prior to the ores in Iberia. Like Thompson and Skaggs (2013) and Martín Hernández (2018), Eshel et al. base their conclusions predominantly on lead isotope data, rather than combining compositional data directly into the analysis. However, there are other reasons that make Sardinia less likely a candidate than Iberia. First, Sardinian silver ores are lead-zinc-silver galenas, which are problematic to smelt. Wertime (1968, 1973), for example, highlights how sphalerite (ZnS) in galena deposits was actively avoided by ancient miners in Iran. Furthermore, while there is more conclusive evidence for the exploitation of argentiferous galena in Sardinia in later periods (De Caro et al. 2013), the resulting silver would be expected to have Au levels $<0.1\%$ (Meyers 2003), much lower than the Au/Ag values at high crustal ages in Fig. 5. Although it could be argued that the high gold in the samples results from accidental mixing during silver recycling, there is no evidence of a gold-poor end-member of such a hypothetical mixing line at around 600 Ma. This would suggest that Au/Ag levels for this high crustal age silver is geological, which makes these silver finds more compatible with silver extracted from jarosite, such as the argentiferous jarosite ores at the ancient mining sites of southwest Iberia (Gale, Gentner, and Wagner 1980). It is also worth noting that there appear to be no silver objects that can be dated with any certainty to the Nuragic age discovered in Sardinia (Atzeni, Massida, and Sanna 2005). Moreover, Sardinian lead objects appear to have low silver levels, which, although having been interpreted as evidence for de-silvered lead, could also reflect the low concentrations of silver generally found in these galena ores (Valera and Valera 2006). There are also issues regarding the absence of evidence for silver mining on Sardinia at this time by the Nuragic culture, as well as in a Phoenician presence before the ninth century BCE. For example, van Dommelen (1997) highlights that the Phoenicians had little influence on the Nuragic culture even as late at the eighth century BCE. A key question would be: If the

Phoenicians had mined silver in Sardinia, supplying Tel Dor and other sites in the southern Levant in the tenth century or earlier, why would they have set out to exploit the jarosite ores of Iberian Huelva with the concomitant additional shipping distance? This question becomes even more pertinent when we bear in mind that the types of ore exploited in the Huelva region are of a different type (i.e., jarosite) and would have required a different extraction technology compared to the galena ores on Sardinia.

Taking these factors into consideration, it seems more probable that the cluster at point 6 reflects silver-bearing jarositic ores in Iberia with Pb crustal model ages of over 600 Ma that were mined in the Early Iron Age. For example, there are lead ores from Ossa Morena, close to the Pyritic belt of southern Iberia, with high crustal age values (600–750 Ma; calculated from the LIA data of Marcoux, Pascual, and Onézime 2002, and Tornos and Chiaradia 2004). Furthermore, there are ores in the Alcudia valley in central Spain, an active mining area in the Late Bronze Age, which have equivalent crustal ages (calculated from the LIA data of Santos Zalduegui et al. 2004). The Alcudia valley data are shown on traditional LIA plots in Fig. 6 (below). The data could suggest that lead from the Alcudia valley was required to extract silver from jarosite at Huelva, resulting in silver with lead isotopic signatures that reflect where the lead, rather than where the silver was mined. In fact, it is probable that lead was acquired from various locations in Iberia to conduct this operation (Murillo-Barroso et al. 2016).

Essentially, Fig. 5 suggests that the silver in the hoards with high crustal ages and high gold levels derives from argentiferous jarosite, which was exploited from the eleventh century BCE on (or, considering solely the Tel Dor data, at least the tenth century BCE). These are earlier than the dates usually proposed for a Phoenician presence in Iberia. These ores require cupellation to extract silver from the lead used as a silver collector to smelt the jarosite ores, and thereby this technique must have been available in Iberia at this time. In other words, although silver could have been acquired through trade (as evidenced from the Iberian native silver signature in the hoards at point 7, i.e., silver with low gold, low lead, and high crustal age), additional technology was required to extract silver from jarosite. These methods were probably not available to the indigenous inhabitants of Iberia until the know-how and technology to extract silver from jarosite arrived from the eastern Mediterranean.

Tel Dor silver lies on several mixing lines (see Fig. 5), exhibiting not only differences in gold concentrations but also in crustal ages. As mentioned above, at least six of the 15 samples from Tel Dor appear to lie on a vertical mixing line on the Au/Ag vs. Pb crustal age plot (the red dashed line from points 2–3 in Fig. 5), with data from Eshel et al. (2019) supporting this interaction (see Fig. 5). Interestingly, a similar vertical mixing line to this was observed for the later hoard of Tel Miqne-Ekron, a hoard potentially deposited just prior to the Babylonian attack of 604 BCE (Wood, Montero-Ruiz, and Martinón-Torres 2019: fig. 4). This observation lead to the proposal that the vertical alignment was the result of the melting down of silver objects with gilt or gold parts. Possibly, such melting had to be done rapidly in times of unrest, thereby *unintentionally* increasing the gold levels in the silver while retaining the LIA signature of the silver ore.

Table 3 shows the LIA values of six silver pieces from Tel Dor that lie on the vertical mixing line in Fig. 5 (upper). Without making any assumptions regarding how the data are distributed, it is interesting to note that $^{208}Pb/^{206}Pb$ and $^{207}Pb/^{206}Pb$ have a lower coefficient of variation compared to $^{206}Pb/^{204}Pb$, potentially a consequence of the difficulty in measuring the low abundance $^{204}Pb$ accurately (J. R. Wood 2019). This will become relevant below when we consider the LIA plots presented in Fig. 6, as the offset between ores and objects on these LIA plots is potentially a systematic error deriving from signal-to-noise issues when measuring the $^{204}Pb$ isotope.

### *Silver on Cyprus*

As alluded to above, due to a recent reexamination of historical and modern mining sources as well as a reevaluation of geological and archaeometallurgical evidence

TABLE 3 LIA RATIOS FOR THE SIX SILVER SAMPLES FROM TEL DOR (OXALID) THAT LIE ON THE VERTICAL MIXING LINE (RED DASHED) IN FIG. 5 AND ORES FROM KALAVASOS, CYPRUS (OXALID).

| Location | $^{208}Pb/^{206}Pb$ | $^{207}Pb/^{206}Pb$ | $^{206}Pb/^{204}Pb$ |
|---|---|---|---|
| Tel Dor | 2.05502 | 0.82736 | 18.944 |
| Tel Dor | 2.05645 | 0.82681 | 19.009 |
| Tel Dor | 2.05709 | 0.82717 | 18.997 |
| Tel Dor | 2.05511 | 0.82676 | 18.985 |
| Tel Dor | 2.05576 | 0.82689 | 18.977 |
| Tel Dor | 2.05465 | 0.82651 | 18.992 |
| mean | 2.05568 | 0.82692 | 18.9839 |
| st. deviation | 0.00094 | 0.00031 | 0.02241 |
| CV | 0.0457% | 0.0375% | 0.1180% |
| Kalavasos ores | | | |
| mean | 2.0507 | 0.8236 | 18.9401 |
| st. deviation | 0.0032 | 0.0017 | 0.0371 |
| CV | 0.1560% | 0.2064% | 0.1959% |

(Wood 2019), the debate has been reopened as to whether silver in Cyprus, which is still present in mineable amounts, was exploited in antiquity. For example, there are indications that cupellation may have been conducted on Cyprus in the Early Iron Age at the site of Maa-Palaeokastro on the west coast, as indicated by finds of argentiferous lead (Karageorghis and Demas 1988) and evidence that could suggest silver processing at Kition (Wood 2019). Furthermore, silver ingots hidden together with fragments of a silver bowl discovered during excavations at Pyla-Kokkinokremos, a site with evidence of substantial metallurgical activity, have been interpreted as part of a thirteenth-century BCE silversmith's hoard (Karageorghis and Demas 1984; Karageorghis 1983) or as possibly the immediate forerunner of the hacksilver hoards deposited in the Levant (Sherratt 2016: 297) and elsewhere in the eastern Mediterranean from the twelfth century onwards (Thompson 2003). This, coupled with the well-attested associations of Maa-Palaeokastro with the central Levant, including Tel Dor, as evidenced by pottery (Bell 2006; Jones and Vaughn 1988: 386–95), gives rise to the possibility that silver mined, smelted, and cupellated on Cyprus could have ended up in the Tel Dor hoard.

Against this background it is interesting to consider the possibility that point 2 in Fig. 5, with its low crustal age and low gold concentration, may be consistent with a Cypriot silver-ore source and whether it is also the signature of unmixed silver from this source. First, Anatolian ores from the Taurus mountains have already been discounted as a possible source for Tel Dor silver through a point-by-point comparison of LIA data on two samples carried out by Thompson and Skaggs (2013). Although this small sample cannot represent the entirety of the Tel Dor silver, it is consistent with Fig. 5, which shows that the cluster associated with the Anatolian source that supplied silver for the Tell el ʿAjjul hoard (i.e., cluster 1) is from an older source than the Tel Dor silver falling on the red dashed vertical line between points 2 and 3. Furthermore, Laurion on the Attic peninsula in Greece has a relatively narrow range of crustal ages that are also higher than those of point 2 (OXALID; Wood, Montero-Ruiz, and Martinón-Torres 2019). However, this does not automatically rule in Cyprus as the ore source from which the Tel Dor silver derives (see Fig. 5). This requires examining both the mixing plot (see Fig. 5) and traditional LIA plots (Fig. 6).

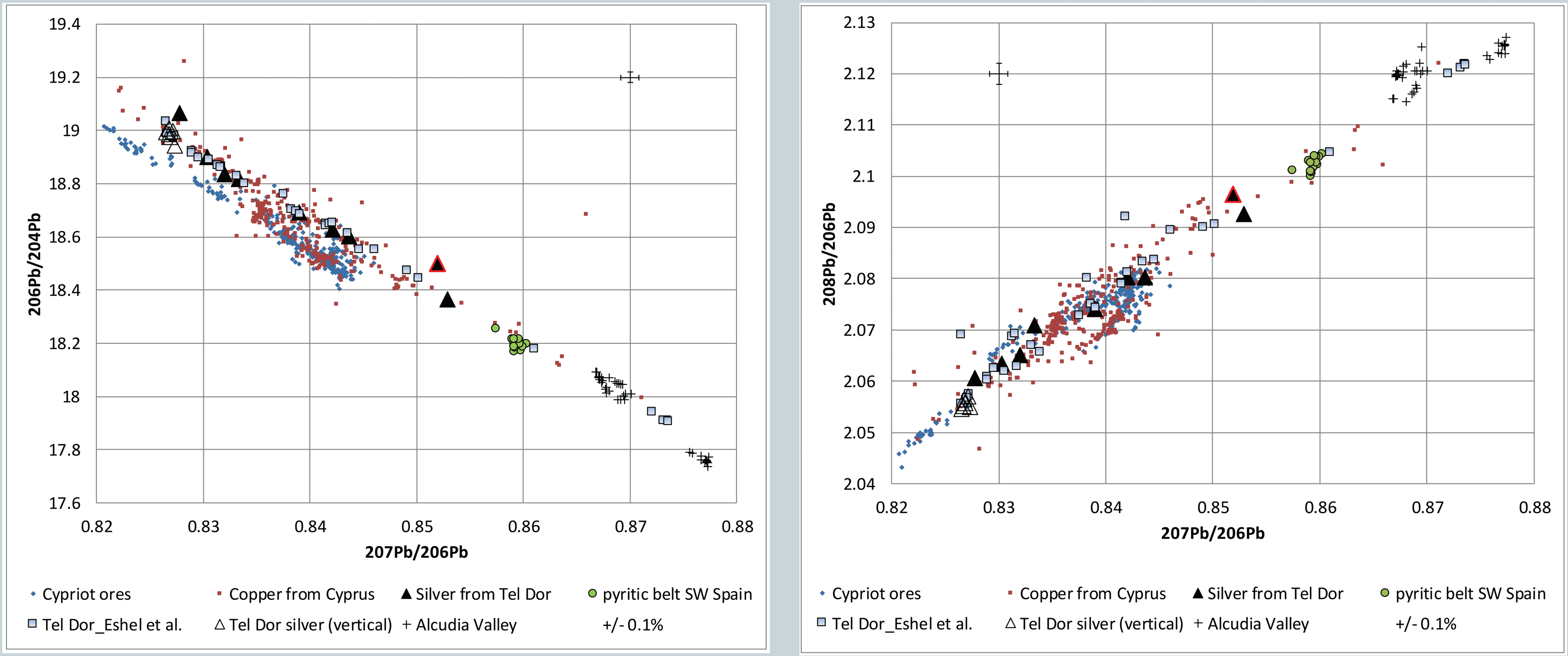


FIG. 6

Lead isotope mirror plots showing Cypriot ores, copper objects found on Cyprus, silver from Tel Dor (which falls on a vertical mixing line in Fig. 5), the remaining silver from Tel Dor, and ores from the Pyritic belt in southwest Iberia. The silver from Tel Dor, which falls on the vertical mixing line in Fig. 5, appears to cluster with ores from the Kalavasos mining area on Cyprus, and with artifacts found on Cyprus (see Table 4). The remaining silver from Tel Dor appears to fall on a trajectory with ores from the Pyritic belt of southwest Iberia. The one piece of silver from Tel Dor (OXALID code: DOR004/97.3320/1) with a signature consistent with Iberian native silver (▲) lies slightly above the line of trajectory, suggesting that this silver did not derive from the Pyritic belt in Iberia. It should be noted that despite differences in measurement method, the majority of Eshel et al.'s (2019) data follows the same trajectory, with four samples consistent with the LIA data from the Alcudia valley in Iberia. Lead from this region was potentially used as a silver collector to extract silver from jarosite for some of the Tel Dor and Akko silver (see Fig. 5), which was subsequently mixed with silver from Cyprus. This scenario is further supported as, according to Eshel et al. (2019), the hoards at Akko and Tel Dor have similar chronologies (see Table 1).

Figure 6 shows LIA mirror plots of the Tel Dor silver that lie on the vertical mixing line in Fig. 5 and Table 3 (unfilled triangles) alongside the remaining silver from Tel Dor (filled triangles) and the Tel Dor silver data from Eshel et al. (2019). Copper objects recovered from Cyprus, Cypriot ores, ores from the Pyritic belt in southwest Iberia and the Iberian Alcudia valley are plotted (OXALID; Stos-Gale et al. 1995; Pomiès et al. 1998; Santos Zalduegui et al. 2004). It should first be noted that the $^{206}Pb/^{204}Pb$ vs. $^{207}Pb/^{206}Pb$ plot exhibits differences between copper objects found on Cyprus and Cypriot ores, which has led to the speculation that about 30% of Bronze Age copper objects found on Cyprus derived from other locations (Stos-Gale 2015). However, as discussed in Wood (2019), the difference is perhaps better explained as an offset resulting from signal-to-noise issues when measuring the $^{204}Pb$ for objects with low amounts of lead (e.g., small samples from copper artifacts). The upshot of this reassessment is two-fold: (1) a much lower percentage of Bronze Age copper objects recovered on Cyprus requires an explanation involving a recourse to exogenous ore sources; (2) if it is accepted that the Middle Bronze and Late Bronze Age copper objects found on Cyprus are consistent with Cypriot ores, then, by the same rationale, the silver from Tel Dor is also consistent with these ores (see Fig. 6).

Figure 6 shows that the silver from the vertical mixing line is clustered, suggesting a single ore source, while the remaining silver from Tel Dor appears to lie on a trajectory towards ores from the Pyritic belt of southwest Spain. By using a point-by-point comparison against the Cypriot ores recorded in the OXALID database, the only region on Cyprus with LIA ratios that correspond closely to the LIA ratios from the Tel Dor silver in Table 3 is the mining district of Kalavasos on the southern edge of the Troodos mountain range. Again, without making assumptions on how the LIA data is distributed, the 27 ore measurements from the Kalavasos region (OXALID) have the following mean values: $^{208}Pb/^{206}Pb = 2.0507$ (st.dev = 0.0032) and $^{207}Pb/^{206}Pb = 0.8236$ (st.dev = 0.0017) and $^{206}Pb/^{204}Pb = 18.9401$ (st.dev= 0.0371). This makes it plausible that the Tel Dor silver (see Table 3) was mined at Kalavasos and/or that lead from this region was used to extract the silver. The former scenario is supported by Pantazis (1967: 144) who noted that the ancient ore deposit, under the gossan, had been originally mined for gold and silver at the Platies Mine in Kalavasos.

A further line of evidence to support the Cypriot origins of the Tel Dor silver is presented in Table 4, which shows objects found on Cyprus with similar LIA (and thereby Pb crustal ages) to the Tel Dor silver. Although none of these artifacts is silver (silver objects are rare on Cyprus), it is of particular note that nearly all were recovered to the east of the Troodos mountains, areas with potential access to the Kalavasos ore district located at the southern edge of this mountain range. Furthermore, a lump of lead from the harbor town of Hala Sultan Tekke dating to LC IIIA (ca. 1200–1100 BCE) has very similar LIA values to the Tel Dor silver (ca. eleventh–early tenth century BCE), which could indicate that lead from the same deposit was used to extract this silver. Two possible scenarios emerge: either the silver-bearing ores had sufficient lead to act as a carrier for silver extraction or lead with a similar signature to ores at Kalavasos was added as an exogenous carrier. Either way, it is notable that the silver at Tel Dor in Table 3 and Fig. 5 (red dashed line between points 2 and 3) appears to be consistent with both objects and ores found in Cyprus.

The remaining silver samples from the Tel Dor hoard (i.e., nine of the 15 samples) seem to lie on mixing lines that result in both varying levels of gold and increasing crustal ages (see Fig. 5 upper). The orange mixing line suggests that Tel Dor silver with elevated levels of gold (i.e., the top of the vertical mixing line at point 3) was present in sufficient amounts to mix with silver from Iberia (point 5). Eshel et al.'s (2019) data shows a similar interaction, albeit in some cases at higher Au/Ag levels. This would suggest that silver with a Cypriot ore signature was remelted with silver objects from the same source (thereby unintentionally increasing the gold concentration, see above) *before* being mixed with silver from the Iberian source. This silver mixture was subsequently deposited in several hoards in the southern Levant: Tel Keisan, Ashkelon, Beth Shean, Shechem, Akko, Eshtemoa, and Tel Dor itself.

TABLE 4 LIA RATIOS AND INFORMATION ON ARTIFACTS RECOVERED FROM CYPRUS WITH SIMILAR LIA VALUES TO THE SILVER FROM TEL DOR THAT FALL ON A VERTICAL MIXING LINE (RED DASHED IN FIG. 5) (SEE ALSO TABLE 3). THE SHADED DATA SHOWS THE LIA VALUES FOR A LUMP OF LEAD FROM HALA SULTAN TEKKE. THOSE ARE HIGHLY CONSISTENT WITH THE SILVER SAMPLES FROM TEL DOR THAT FALL ON THE VERTICAL MIXING LINE (SEE TABLE 3).

| Metal artifacts recovered on Cyprus (OXALID) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Museum or excavation no. | Region | Site | Find spot | Type | Principal metal | Description | Chronology | $^{208}Pb/^{206}Pb$ | $^{207}Pb/^{206}Pb$ | $^{206}Pb/^{204}Pb$ | Pb crustal age (Ma) |
| Statue G, Enkomi 1960, No. 126 | Mesaoria, East | Enkomi | unknown | Statue | Cu | Statue | LBA (Mycenean) | 2.05504 | 0.82656 | 18.995 | -91 |
| F1552 (1980)b | Southeast | Hala Sultan Tekke | Well, 2nd metre, layer 5 | Fragments | Cu | Lump of metal | LC IIIA | 2.05526 | 0.82640 | 19.004 | -92 |
| N1424 | Southeast | Hala Sultan Tekke | Site | Fragments | Pb | Lump of lead | LC IIIA | 2.05808 | 0.82841 | 18.955 | -60 |
| N1432 | Southeast | Hala Sultan Tekke | Site | Fragments | Pb | Lump of lead | LC IIIA | 2.05587 | 0.82732 | 18.975 | -79 |
| KAD15 (80-T.5-3.1) | South | Kalavasos, Agios Dhimitrios | Site | Fragments | Cu | Metal fragments | LC IIC? | 2.05659 | 0.82743 | 18.981 | -75 |
| 702;131 | Kyrenia, North | Lapithos | Tomb 702 | Weapon/ tool | Cu | Axe | MC III | 2.05742 | 0.82624 | 18.951 | -111 |
| PH9 | Mesaoria | Pera Hoard | Tombs | Tool | Cu | Awl | MC III/LC I? | 2.05451 | 0.82621 | 18.982 | -103 |

One piece of silver (OXALID code: DOR004/97.3320/1) falls on the black mixing line, within the cluster at point 7. This silver, with its low gold and lead concentrations (<0.2%Au, <0.2%Pb) and crustal age comparable with Hercynian orogenies (327Ma) suggests that it may have been "pure" Iberian native silver. It is also one of the only pieces of the analyzed Tel Dor silver whose form is recognizable (a finger (?) ring fragment), not needing a classification as "indeterminate" silver. Regarding the early chronology of the Tel Dor hoard, it is feasible to interpret the presence of native silver as being reflective of trade with the indigenous Iberians.

Another piece of silver (OXALID code: DOR0013/97.3325/10) found at Tel Dor may be a mixture of Anatolian and Iberian (or Sardinian) silver (red line). As mentioned above, it is more probable that this piece of silver is a mixture of Anatolian and Iberian silver, rather than silver extracted from Sardinian ores. However, more significantly, this appears to be the only piece of silver from Tel Dor that could potentially lie on a mixing line with an Anatolian source. This is because the remaining five pieces of silver from Tel Dor are more difficult to attribute to a specific mixing line: The blue line (see Fig. 5, upper plot) could suggest that these five pieces of Tel Dor silver were a mixture of Anatolian (low gold, low crustal age) and Iberian silver (high gold and high crustal age). However, it is also possible that silver from Cyprus was mixed directly with silver from Iberia (see Fig. 5, lower plot), some of it ending up in the commercial center of Shechem in the middle of vital trade routes through the region (B. G. Wood 1997). This means that these five pieces of silver from Tel Dor may not lie on the blue line between points 1 and 5 but were a mixture of Cypriot silver (point 2: low gold, low crustal age) with Iberian silver (point 5: high gold, high crustal age). In fact, Eshel et al.'s (2019) data, which lie along the horizontal axis at low Au/Ag levels, could support the idea that there was direct mixing between

Iberian and Cypriot silver, that is, between points 2 and 7 in Fig. 5 (lower). As mentioned above, Thompson and Skaggs (2013) discounted the Taurus region of Anatolia for the Tel Dor silver based on LIA alone (in contrast to Eshel et al.'s [2019] interpretation). However, Eshel et al.'s (2019) data, here reanalyzed on a mixing plot with the crustal age, is perhaps more indicative of direct mixing between Cypriot and Iberian silver for the Tel Dor silver. The fact that one of the Pyla silver ingots found on Cyprus was found to have a gold concentration of 0.1wt%Au (Gale and Stos-Gale 1984), suggests that the intersection of a line between points 2 and 5 and between points 2 and 6 (Fig. 5 lower) could be the end-member of the mixing line, that is, the signature of unmixed Cypriot silver at point 2. The ingots and the associated hemispherical silver bowl recovered at Pyla may or may not have derived from the same ore deposits as the Tel Dor silver (their Pb crustal model ages range between 10Ma and -50Ma, which is not entirely inconsistent with the possibility that they come from the same source). However, this evidence demonstrates that silver with low crustal ages and low gold concentrations has been recovered in archaeological contexts in Cyprus. Furthermore, there appears to be a cluster at point 6 for both Tel Dor silver and silver recovered at Akko (see Fig. 5 upper and lower). These clusters are consistent with lead deriving from the Iberian Alcudia valley (see Fig. 6), which could suggest that lead from this region was used as silver collector for the jarosite ores of Huelva from around the tenth century BCE.

In summary, the traditional LIA plots (see Fig. 6) show that the Tel Dor silver is consistent with ores from Cyprus, while the Au/Ag vs. Pb crustal age plot (see Fig. 5) suggests that unmixed silver from Cyprus has levels of gold commensurate with silver recovered on Cyprus. Furthermore, the trajectory of the Tel Dor silver on traditional LIA plots (see Fig. 6) suggests that silver deriving from Cypriot ores was mixed with silver deriving from Iberian ores, while the mixing lines (see Fig. 5 lower) show that in some cases Cypriot silver could have been mixed directly with Iberian silver, and in other cases it was first mixed with silver from the same source (increasing the gold levels) before being remelted with silver from an Iberian source (red dashed vertical mixing line and orange mixing line). The one piece of silver found at Tel Dor with an Iberian native silver signature (within the cluster at point 7 in Fig. 5) potentially lies above the trajectory on the $^{206}Pb/^{204}Pb$ vs. $^{207}Pb/^{206}Pb$ plot (see Fig. 6), supporting that it does not derive from the Pyritic belt. Furthermore, only one piece of silver from Tel Dor appears to lie on a mixing line with an Anatolian source (red solid line in Fig. 5). However, a direct mixing line between point 2 (i.e., unmixed Cypriot silver) to the Akko cluster at point 6 (see Fig. 5 upper) and the Tel Dor cluster (see Fig. 5 lower), would suggest that none of the Tel Dor silver derived from Anatolian sources, an assertion which clearly has repercussions regarding the connections that Tel Dor had in the eleventh and early tenth centuries BCE or, according to Eshel et al. (2019), the late tenth century BCE.

## Discussion

The reanalysis presented above suggests that the unknown silver source identified in the mixing graphs as the main component of the silver from Tel Dor is the Kalavasos mining district of south Cyprus. Some of this hacksilver would have been mixed directly with Iberian silver, while in other cases this silver would have been remelted with silver originating from the same ore source, before being mixed with silver derived from Iberian ores. In the case of the vertical mixing line, the increase in gold concentration is potentially due to the failure to remove gold rims, handles or gilt prior to melting down silver from the same source, while the other lines reflect the gold levels of the constituent components. The mixing lines and the LIA mirror plots suggest that the coastal town of Tel Dor predominantly received silver that came from Cyprus and Iberia, thereby lending support to the view that the conveyers of the silver to Tel Dor were the Phoenicians. This has important repercussions. In terms of technological transfer, the fact that similar technologies are required to extract silver from jarosite ores suggests that the smelting technology (which probably required the addition of exogenous lead for the ores from Cyprus and Iberia) as well as the cupellation technique were transmitted over the same maritime trade routes. The established connection of both Cyprus and Iberia with Phoenician maritime trade suggests that these routes may have been used to convey silver in the Tel Dor hoard to its point of deposition.

Furthermore, the chronology of the Tel Dor hoard (now believed to date to the second half of the tenth century BCE) is consistent with the earliest possible ceramic evidence and radiocarbon dates recovered from Huelva, suggesting those who had the know-how to exploit jarositic ores may have traveled there. Whether western Cyprus was a way station for western expansion and/or part of a settled Phoenician presence on Cyprus at the beginning of the Iron Age is difficult to ascertain. However, individuals with knowledge of how to prospect, mine, and smelt jarositic ores and with the know-how to cupellate silver from argentiferous lead would be a necessary component of such technology transfer from Cyprus to Iberia. This implies knowledge transfer between the mines of Cyprus and Iberia, and close collaboration with those controlling the trade routes. Furthermore, a Cypriot origin for the Tel Dor silver provides direct evidence of a reciprocal movement of materials between Cyprus and Phoenicia, with timber, wine, and purple dye going one way from the Levant to Cyprus and silver and copper going the other way. Moreover, as Bell has put forward elsewhere (Bell 2016), the Phoenicians may have used Palaepaphos, and western Cyprus generally, to start their westward expansion in the earliest years of the Iron Age. In essence, such a location for ventures westward would provide an explanation not only for the large amounts of Phoenician pottery found in western Cyprus from the earliest Iron Age but also to how the technology to exploit jarositic ores was transmitted from the east to southwest Iberia.

## Conclusions

We propose that the people with the know-how to exploit jarosite for silver were also the people with an archaeological footprint in both Cyprus and Iberia in the Early Iron Age. We further suggest that these people were Phoenicians, tempered by sustained presence on Cyprus where they developed (or acquired) this know-how. However, regardless of whether the knowledge was conveyed by Phoenicians, Cypro-Phoenicians, or Cypriots, the silver that was brought back east to the Phoenician homeland, a homeland that included Tel Dor, was essentially procured through smelting and cupellation technology moving across the Mediterranean from east to west. In effect, the people who ventured west to exploit silver in Iberia, who had been alerted by native silver arriving through trade with the indigenous Iberians to the Levant in the eleventh century BCE, already knew exactly where they were sailing to, what they were looking for, and how they were going to get it.

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## Note

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