Transport Stirrup Jars from the Southern Levant: New Light on Commodity Exchange in the Eastern Mediterranean

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Abstract

This article examines the issue of the distribution of transport stirrup jars found in the Late Bronze Age Levant. These vessels, representing long-range commodity exchange, are presumed to be largely of Cretan origin according to both their appearance and previous archaeometric analyses. However, determining whether non-Minoan sources of such vessels exist and identifying specific locales of production within Crete are ongoing foci of research. In this context, a group of transport stirrup jars from Late Bronze Age sites in Israel, predominantly from the harbor site of Tell Abu Hawam, was subjected to thin-section petrographic analysis. This group includes most of the examples known from this region. The results of the analysis indicate that a large proportion of the vessels, especially those found at Tell Abu Hawam, were produced in central or south-central Crete, although other Cretan and possibly non-Cretan sources also occur. A striking mirroring of this situation occurs on Crete at Kommos, a site exceptionally rich in ceramic imports of all kinds, including Canaanite amphoras produced in the vicinity of Tell Abu Hawam. Possible links between these two sites are discussed, shedding new and interesting light on the nature of bulk commodity exchange in the eastern Mediterranean during the Late Bronze Age.*

INTRODUCTION

International exchange, including trade in bulk commodities, has attracted considerable interest in archaeological research on the Late Bronze Age eastern Mediterranean over the past two or three decades.¹ Virtually all the regions ringing the eastern Mediterranean (Egypt, the Levant, coastal Anatolia, the Greek mainland), in addition to the large islands of Cyprus and Crete and many of the smaller islands in the central and eastern Aegean, appear to have been active participants in this trade. From a Levantine perspective, these intercultural exchanges are most abundantly represented by a wealth of ceramic imports from Cyprus and, to a lesser extent, from the Greek mainland. Reported imports to the Levant from Crete have been far more limited in number. The purpose of this study is to examine the evidence for specifically Late Bronze Age Cretan (i.e., Late Minoan) intercultural exchanges with the Levantine mainland provided by imported transport stirrup jars. This is a vessel form that appears to have been used principally for the transport of liquid produce in bulk from the Aegean to regions throughout the eastern and even central Mediterranean from as early as the 15th century B.C.E. until the 12th century B.C.E., but chiefly during the period from ca. 1400 to 1200.²

Late Minoan ceramic imports to the Levant identified prior to the early 1990s, including a total of 23 transport stirrup jars, were collected by Leonard.³ Subsequent discoveries of Late Minoan and even earlier Protopalatial Minoan pottery in Levantine contexts provided extensive bibliographical assistance at an early stage of the research. We wish to thank also Alexander Zukerman for first suggesting the idea for this study several years ago, and Nicolle Hirschfeld and two anonymous reviewers for the AJA for their remarks on an earlier version of the manuscript. A free, downloadable appendix can be found under this article’s abstract on the AJA website (http://www.ajaonline.org).

³ Leonard 1994, 193–200, map 38; most of the transport stirrup jars (Leonard 1994, 46–7, cat. nos. 515–33; 197–99, cat. nos. LM 25, LM 26, LM 33, LM 34) were represented by fragments only.

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have been relatively few in number and scattered in space. The number of imported Minoan vessels, especially transport stirrup jars, identified from this region has nevertheless roughly tripled (see online appx. on the AJA website) and merits more detailed attention. Moreover, thanks to an increasing number of petrographic and chemical analyses that have been focused on transport stirrup jars in particular during the past 15 years, it is now often possible to be much more specific about where such jars were produced within Crete and thus potentially to become more precise in reconstructing particular routes of exchange or trading networks.

This study is devoted exclusively to transport stirrup jars for several reasons. First, vessels of this particular type are by far the most common single Minoan vessel form to have been exported outside the island of Crete during the Late Minoan (LM) III period, as demonstrated by Leonard’s survey of Late Bronze Age Aegean pottery imported into Syria-Palestine and confirmed by continuing finds over the past two decades. Second, these vessels are typically produced on Crete in medium-coarse fabrics that lend themselves well to thin-section petrographic analysis for the purpose of determining their likely regions of manufacture within Crete. Third, as already noted, vessels of this type constituted the principal bulk transport container in use throughout the Aegean during the 250-year peak of intense cultural interchange that characterizes the Late Bronze Age eastern Mediterranean from ca. 1425 to 1175 B.C.E., so they serve as a particularly helpful marker for tracking high-volume trade in liquid commodities such as olive oil and wine.

Nevertheless, such vessels could easily be reused, if treated with some care after their initial emptying, by traders who may have had no connection at all with either their original places of production on Crete or their initial destinations when shipped outside that island. Moreover, with the exception of a single class of marks incised (after firing) into the backs of transport stirrup jar handles by Cypriot “middlemen,” these vessels provide no evidence themselves identifying their carriers. Their petrography, techniques of manufacture, and decoration constitute evidence only for where these containers were produced and cannot be used to document what might often have been quite complex histories of circulation prior to their eventual deposition in the archaeological record.

Only the roughly 60 transport stirrup jars found within the modern state of Israel have so far been accessible to us for the purposes of direct autopsy and fabric sampling, so the selection of Minoan transport stirrup jars discussed here is restricted to those recovered from the southern Levant (see online appx.; figs. 1–4). Other forms of bulk transport vessels in common use in the Late Bronze Age eastern Mediterranean, such as Canaanite jars, Egyptian amphoras, and Cypriot pithoi, provide interesting vehicles for comparison with Minoan transport stirrup jars in their distributions and frequencies in any reconstruction of the larger picture of bulk commodity exchanges during the 14th and 13th centuries B.C.E. in the eastern Mediterranean.

Each of these distinctive forms was evidently produced at numerous different locales within specific regions of the eastern Mediterranean. Their initial appearance in small numbers at sites well outside their regions of production as early as the 16th and 15th centuries B.C.E. (e.g., Canaanite jars at LM IA Akrotiri on Thera and in LM IB contexts at various sites on Crete, Egyptian amphoras at Kommos) provides evidence for new kinds of interregional maritime exchanges of commodities requiring bulk packaging, either liquids or pourable dry goods. The flow of containers carrying such commodities only appears to have become reciprocal, in the sense that the carriers began to move from west to east (i.e., the Aegean to the Near East) and vice versa, in the earlier 14th century B.C.E., at approximately the same time as the earliest Cypriot pithoi make their appearance in the Aegean. Of all the distinct regions that participated in such bulk commodity exchanges during the 14th and 13th centuries B.C.E., only Cyprus appears to have hosted production centers for more than one of these transport vessel forms: not only was it the center for the production of pithoi employed for this purpose, but it also appears to have sponsored the production

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7 Furumark 1941, Furumark Shape (FS) 164.

8 Supra n. 3.


10 Stockhammer 2008, 92–9; see also infra n. 128.

11 For Canaanite jars, see Sugerman 2000; Smith et al. 2004; Killebrew 2007; Day et al. (forthcoming); Rutter (forthcoming). For Egyptian amphoras, see Rose 2007, 127–29, 270–73, Shapes ME 3, ME 4; Martin 2009, 448–53 (with extensive additional references); Day et al. (forthcoming). For Cypriot pithoi, see Keswani 1989, 2009; Pilides 2000; Gilboa 2001.

12 E.g., Negbi and Negbi 1993.
of Canaanite jars in some quantity and even a few Aegeanizing transport stirrup jars (see below).

TRANSPORT STIRRUP JARS: DEFINITION, TYPOLOGY, AND DISTRIBUTION

Definition and Typology

A stirrup jar is a closed vessel form with a relatively narrow, tapering or cylindrical neck rendered “false” by being capped with a solid clay disk, hence the shape’s alternative names of “false-necked jar” or pseudo-dostomos amphorae.13 Attached on the shoulder near the false neck is the true spout. Two vertical handles placed at 90° intervals to either side of the spout run from the lower shoulder to opposite sides of the disk sealing the false neck, defining in their courses a stirrup-shaped space on either side of the neck that has given this distinctive shape its most common name in English. Occasionally, especially on early examples of the form, a third handle is set on the shoulder directly opposite the spout with its upper attachment either at the disk or on the uppermost shoulder.14

Aegean stirrup jars have traditionally been divided into smaller and medium-sized versions produced in fine fabrics and much larger jars (the transport stirrup jars) manufactured in much coarser fabrics. This distinction is, to be sure, somewhat arbitrary, in that large jars were produced in comparatively fine fabrics during the earlier stages of development of the form on Crete in the Middle Minoan (MM) III and LM IA phases (17th–16th centuries B.C.E.), as well as during its later history on the Greek mainland in the Late Helladic (LH) IIIA2–B phases (14th–13th centuries B.C.E.). But from the 15th century B.C.E. onward, transport stirrup jars seem to have been produced on Crete invariably in medium-coarse to coarse fabrics. Several other technological features are characteristic of Minoan transport stirrup jars in particular. For example, many Minoan transport stirrup jars, although by no means all, consist of two wheel-thrown sections joined at a point roughly one-third of the way up from the base of the vessel. This piecing technique is readily discernible in photographs and drawings in the form of

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14 Furumark 1941, 610–11, FS 165, 169; Mountjoy 1986, 30–1, figs. 28.1, 28.2; Haskell 1985.
a shallow dent in the regular curve of the exterior body profile and a sudden increase in the wall thickness at the point where the joint was made, the latter resulting from the addition of a coil of clay at the interior junction of the two sections to strengthen the joint.15 Equally characteristic of Minoan transport stirrup jars is the use of coarser pastes for handles and occasionally for bases in comparison with the paste used for the body; this practice is reasonably common in various periods of Minoan ceramic production for portions of a vessel likely to be subjected to heavier wear but is alien to the Helladic ceramic tradition of the Greek mainland.16 Such variability in fabric composition within one and the same vessel may also be manifested in another way in the manufacture of transport stirrup jars in particular, in that the spouts of Minoan transport stirrup jars were quite often produced in medium-fine to fine pastes distinctly different from those used for the rest of the vessel body. However, Minoan transport stirrup jar handles never feature the single firing holes often

15 Haskell 1981a, 192–95; Rutter 2006a, 542–43, cat. no. 59/13; 545–46, cat. nos. 60/14, 60/17–18; pls. 3.68, 3.71; Stockhammer 2008, 92 n. 443.
16 Stockhammer 2008, 93 nn. 445–47.
found near the handle bases of Mycenaean amphoras, hydrias, and transport stirrup jars.\textsuperscript{17}

Most Minoan transport stirrup jars bear painted decoration executed in a dark-on-light style, most often consisting simply of banding.\textsuperscript{18} Completely plain Minoan transport stirrup jars are reasonably common also, as seven of the eight examples found on the Point Iria wreck show.\textsuperscript{19} The best-known and most easily recognizable versions of Minoan transport stirrup jars, however, are decorated with dark-on-light patterns, chiefly in the form of either one or two stylized octopus motifs distributed across a very broad body

\begin{figure}
\centering
\includegraphics[width=\textwidth]{transport_jars.png}
\caption{Transport stirrup jar fragments from Tell Abu Hawam: a, sample TAH2; b, sample TAH 8; c, sample TAH10; d, sample TAH9; e, sample TAH25; f, sample TAH18; g, sample TAH14; h, sample TAH3; i, sample TAH5; j, sample TAH7 (C. Amit).}
\end{figure}

\textsuperscript{17} Day and Haskell 1995, 96–7; Stockhammer 2008, 93 n. 449.
\textsuperscript{18} As in the cases of all eight of the wheelmade transport stirrup jars found on the Uluburun wreck (Day 1999, 68).
\textsuperscript{19} Day 1999, 65–7.
zone or an even more abstracted version of this pattern consisting of one or more horizontal wavy bands alone (see fig. 2a, b). Other patterns occasionally decorate the body, especially on earlier LM II–IIIA1 examples. Pattern-decorated transport stirrup jars may also bear additional motifs in a discrete shoulder zone squeezed in between the handles, spout, false neck, and some banding that separates the shoulder from the main body zone.

Transport stirrup jars produced on Crete exhibit a fair amount of variation in size but typically measure between 40 and 50 cm in height and between 27.5 and 35.0 cm in maximum diameter. Volumes range from roughly 12 to 18 liters. Unlike small and most medium-

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20 E.g., Kanta 2005, 226, figs. 2, 4, 5.
21 E.g., Kanta 2005, 227, figs. 6, 7; Maran 2005, fig. 1.2.
22 E.g., Blegen et al. 1953, 306–7, figs. 330, 408.4, 408.7, 408.10; Mountjoy 1997, 285, cat. nos. 14–18, fig. 6.
23 E.g., Kanta 2005, figs. 6, 7.
24 Pace Haskell (2005, 205), who cites a narrower 12–14 liter spread.

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Fig. 4. Transport stirrup jar fragments from Akko, Ashdod, and Ashkelon: a, sample Akko1 (drawing by S. Ad; courtesy E. Marcus); b, sample Akko2 (drawing by S. Ad; courtesy E. Marcus); c, sample Akko3 (drawing by S. Ad; courtesy E. Marcus); d, sample Ashdod1 (Dothan and Ben-Shlomo 2005, fig. 3.1.11); e, sample Ashdod Beach1 (Nahshoni forthcoming, fig. 13.3); f, sample from the Ashdod Beach site (Nahshoni forthcoming, fig. 13.1); g, sample Ashkelon1 (Cross and Stager 2006, fig. 22; courtesy Leon Levy Expedition to Ashkelon).
sized stirrup jars, which have narrow spouts that dispense their liquid contents very slowly and which were therefore well suited as containers for high-value perfumed oils, the much broader spouts of transport stirrup jars (which typically range between 5 and 7 cm in diameter) are capable of discharging the contents of these jars relatively quickly. Transport stirrup jars nevertheless make possible more controlled dispensing of their liquid contents than do most storage jars. Their initial contents are thus likely to have consisted for the most part of ordinary olive oil or wine, although in reuse they could, of course, have contained virtually any sort of liquid.\textsuperscript{25} No significant programs of residue analysis have yet been conducted on transport stirrup jars, not least, one imagines, because the capacity to reuse the jars would greatly complicate the interpretation of whatever residues might be recovered.

Minoan transport stirrup jars can also be readily distinguished from various Mycenaean and other Aegean regional variants of the shape and can be associated with specific regions in Crete by their decoration. For example, transport stirrup jars that bear light-on-dark painted ornament, whether purely linear or, much more rarely, patterned, have been determined to be west Cretan products from the region around Chania.\textsuperscript{26} Moreover, the vast majority of transport stirrup jars bearing painted labels in Linear B were manufactured in west Crete, although some were evidently also produced in both north-central and south-central Crete.\textsuperscript{27}

Thus, variability in the shape, clay fabric, and decoration of transport stirrup jars not only differentiates Minoan examples from Mycenaean products but also west Cretan from central Cretan versions.\textsuperscript{28} Such vessels were also produced at various points along the western Anatolian coast, as shown by fine, gray-burnished examples from Troy,\textsuperscript{29} dark-on-light painted examples in a highly micaceous fabric possibly produced at Miletus,\textsuperscript{30} and two handmade examples with burnished surfaces from the Uluburun wreck. Of the handmade examples from the Uluburun wreck, one has a dark mottled surface (inv. no. KW1977) and the other is painted with dark-on-light banding (inv. no. KW1429).

The sizable number of different production locales for such vases notwithstanding, it is clear from the large quantities of evidence published to date that most such large-volume transport stirrup jars were manufactured on Crete, including virtually all examples produced before the destruction of Knossos early in LM IIIA2, ca. 1375 B.C.E.\textsuperscript{31}

**Distribution**

Within the Aegean, the largest single deposits of Minoan transport stirrup jars come not from Crete but rather from palatially controlled storerooms at the sites of Mycenae, Tiryns, and Midea in the Argolid and Thebes in Boeotia.\textsuperscript{32} The decided rarity, albeit not total absence, of such imported Minoan transport stirrup jars from Mycenaean palatial establishments in Messenia at Pylos, in Laconia at the Menelaion,\textsuperscript{33} and in Attica at Athens\textsuperscript{34} indicates that the concentration of Minoan jars in the Argolid and Boeotia in particular is likely to reflect circumstances other than normal trade and exchange. Maran has suggested that these vessels may represent a form of tribute sent to selected Mycenaean palatial centers following the destruction of the palace at Knossos in early LM IIIA2 and the apparent collapse of Knossian hegemony over much of central and western Crete at that time.\textsuperscript{35} Interestingly, and in pronounced contrast to the functionally related Levantine bulk transport vessel known as the Canaanite jar,\textsuperscript{36} Minoan transport stirrup jars were rarely used by the Mycenaean mainlanders as grave goods.\textsuperscript{37}

Outside the Aegean (here understood to include the western Anatolian coast, the Dodecanese, and the shipwrecks at Gelidonya and Uluburun off the southern Lycian coast), transport stirrup jars have been found in highly variable numbers in four major regions: Italy (including the islands of Sardinia and Sicily), Egypt, Cyprus, and the coastal Levant from Syria in the north to the Gaza Strip in the south. A total of some 15 transport stirrup jar fragments have been reported from Antigori on Sardinia, Cannatello on Sicily, the sea off Filitudi in the Aeolian Islands, and the southern Italian mainland at Rocavecchia, Scoglio del Tonno, and Leporano.\textsuperscript{38} Three of the

\textsuperscript{25} Haskell 1981a, 212–13; 1981b, 236–37 n. 35.
\textsuperscript{26} Stockhammer 2008, 94 n. 450.
\textsuperscript{28} Haskell 2005, 208–12; Stockhammer 2008, 94–8.
\textsuperscript{29} E.g., Blegen et al. 1953, 240, figs. 388.3, 388.4, 395.15, 442.21.
\textsuperscript{30} Stockhammer 2008, 97–8.
\textsuperscript{31} Stockhammer 2008, 96 n. 450.
\textsuperscript{32} Rutter (forthcoming).
\textsuperscript{33} Catling 2009, 2690.
\textsuperscript{34} Stockhammer 2008, 274 n. 931.
\textsuperscript{36} Catling 2009, 2690.
\textsuperscript{37} Rutter (forthcoming).
\textsuperscript{38} See Stockhammer (2008, 276 n. 946) for an exception from Tiryns.
\textsuperscript{39} Taylor 1958, 139, cat. no. 1 (Leporano); Biancofiore 1967, pls. 10.30, 10.31 (Scoglio del Tonno); Jones and Day 1987 (Antigori); Vagnetti 1999, 273, fig. 4b; 279, pl. 9.7 (Filitudi); De Miro 1996; Vagnetti 1999, 191, fig. 6.1–3 (Cannatello); Guglielmino 2005, 640, pl. 166a.1–5 (Rocavecchia).
fragments from Cannatello are handles with marks incised in their backs after firing, an indication of their reuse by Cypriot handlers that is supported, in this particular case, by the imported Cypriot pithoi found at the same site.  

Almost exactly the same number of transport stirrup jars has been reported from Egypt. Of the four complete Aegean transport stirrup jars recovered in the chapels adjacent to the temple within the 13th-century B.C.E. Egyptian coastal fortress at Zawiyet Umm el-Rakham, three are clearly Minoan on the basis of their pieced manufacture, while the fourth, which features a perforated lower handle and vessel walls that taper in thickness gradually but consistently from the base to the upper shoulder, is hardly a typical Minoan transport body, this vessel, with its medium-fine fabric and burr-perforated lower handle and vessel walls that taper in thickness gradually but consistently from the base to the upper shoulder, is mainly a Greek import made in the Mycenaean tradition. A fifth complete stirrup jar, from Sidmant Tomb 59, is only medium-sized (ht. 23.3 cm, max. diam. 18.5 cm). Though decorated with a broadly looping horizontal wavy band on the upper shoulder, is a mainland Greek import made in the Mycenaean tradition.  

All four transport stirrup jar fragments published from Marsa Matruh probably belong to Mycenaean versions of the type, as the single ring base fragment certainly does and as one of the examples from Qantir does. But the other analyzed linear transport stirrup jar fragment from Qantir, a false neck and handle fragment from Deir el-Medina, and a patterned lower body sherd (plus a nonjoining handle bearing a post-firing incised mark from Amarna probably to be assigned to the same jar) are either certainly or very likely Minoan imports. What emerges as striking from the Egyptian evidence is how rare examples of Minoan transport stirrup jars are within the Nile Valley proper, only two of the six likely or confirmed examples coming from sites south of the north coast or the delta.

Of the more than 110 transport stirrup jars so far reported from Cyprus, about 20 are either complete or fully restorable, while there are 14 examples with both handles incised after firing and at least 20 more with at least one handle so marked. Among the complete examples, Minoan and Mycenaean imports are almost equally common (nine of the former vs. eight of the latter), while two specimens from tombs at Kazaphani and Kyrenia-Mylotaptes are suspected of being local imitations of Minoan models. More than half of the complete or fully restorable pieces were recovered from tomb contexts, a circumstance peculiar to Cyprus and some sites in the Levant. Indeed, they are rarely deposited in tombs within their primary region of manufacture in the Aegean, except on Crete and in the Dodecanese (Karpathos and Rhodes), and not at all in Egypt or Italy.

As of 2008, a total of 22 transport stirrup jars have been reported from six northern Levantine sites located in coastal Syria (Minet el-Beida, Ras Ibn Hani, and Ras Shamra/Ugarit) and Lebanon (Beirut, Sarepta, and Sidon). A little more than a third of these (eight of the 22) are complete or fully restorable, all but one of them because they were recovered from tombs. Of these eight, at least two from Ras Shamra, one from Minet el-Beida, and perhaps also a giant light-on-dark decorated example about 60 cm high likewise from Minet el-Beida are Minoan, while at least three are likely to be Mycenaean on the basis of their smaller sizes and details of their shape and decoration: one from Beirut, one from Minet el-Beida, and one from Ras Shamra. The origin of the last complete example, from Ras Ibn Hani, is uncertain. Three of these vessels have no incised marks on their handles, three have one handle so marked, and on
two, both handles bear incised marks. An additional five jars represented only by fragments have handles bearing marks incised after firing, so that practically half of the total of 22 jars from the northern Levant provide evidence for such marks, even though more than 25% of them do not preserve any portion of their handles. No fewer than 18 of the total of 22 come from the two sites of Ras Shamra and its harbor town Minet el-Beida. The overwhelming bulk of evidence for such Aegean transport stirrup jars from the northern Levant reported thus far can be connected with trade funneled through the kingdom of Ugarit in the 14th and 13th centuries B.C.E.

More than twice as many Aegean transport stirrup jars have been published from the southern Levant or have been made known to the authors by those responsible for their publication (see online appx.).\textsuperscript{57} Although the more than 50 specimens represented come from nine different sites (see fig. 1), the single site of Tell Abu Hawam has produced fully 75% of the total. It thus occupies a position roughly comparable with that of Ras Shamra/Ugarit in the north as the principal funnel through which such vessels evidently reached more southerly locales.\textsuperscript{58} A few southern Levantine sites at which Aegean transport stirrup jar fragments have been recovered are not coastal (e.g., Amman, Beth Shean, Gezer, Tell Sera). In addition, in a fashion comparable with that observed from finds at the northern Cypriot sites of Kazaphani and Kyrenia-Mylopotems, imported Aegean transport stirrup jars appear to have inspired occasional local imitations in Late Bronze IIB painted wares at sites such as Megiddo, Gezer, and perhaps also Tell Beit Mirmim.\textsuperscript{59} Aegean transport stirrup jars imported to the south were rarely employed as grave goods, with the result that only one atypical—nevertheless clearly imported—transport stirrup jar from a tomb at Deir el-Balah is complete or even fully restorable.\textsuperscript{60}

Despite the highly fragmentary nature of almost all transport stirrup jars thus far recovered from sites in the southern Levant, technological and decorative features, such as evidence for their construction from two large wheel-thrown pieces joined at the lower body level, the employment of different grades of paste for features such as the spout, handles, or base, the burnishing rather than polishing of vessel surfaces, and the use of medium-coarse to coarse pastes for the vessel body, allow many of these fragments to be attributed with a considerable degree of certainty to Minoan centers of production on these grounds alone (see online appx. for details). The overall picture of Aegean transport stirrup jar importation from this subregion of the Levant according to macroscopic observations indicates that roughly two-thirds of these vessels were produced on Crete, another 10–25% having been made at Mycenaean centers of production probably located on the Greek mainland. This leaves somewhere between 7% and 20% attributed to uncertain or unknown Aegean locales of production because of peculiarities of one kind or another. Of the more than 50 imported Aegean transport stirrup jars from the southern Levant, only nine bear on their handles marks incised after firing. A third of them (n=3) are Mycenaean examples of the type provided with broad and comparatively thin vertical strap handles produced in fine fabrics (from Ashdod Beach, Beth Shean, and Tell Abu Hawam), while two-thirds (n=6) feature the markedly thicker and somewhat narrower handles, elliptical in cross-section and manufactured in medium-coarse to coarse fabrics, that are characteristically Minoan (one each from Akko and Ashkelon and four from Tell Abu Hawam).

ARCHAEOMETRIC ANALYSIS OF TRANSPORT STIRRUP JARS

Previous Research

While outside the Aegean region only a few transport stirrup jars have so far been analyzed, a substantial number of studies have been devoted to vessels of this type found on Crete and the Greek mainland. Bronze to LM IIIA1–early LM IIIB in Minoan terms.


\textsuperscript{58} The bulk of the imported Mycenaean and Minoan pottery from Tell Abu Hawam derives from the Late Bronze Age stratum V, spanning the period from the later 15th to the earlier 13th centuries B.C.E. (Hamilton 1955, 11–13, 35–66, pl. 11). It was more recently subdivided into five discrete horizons by Balensi (1980; 1985, 67–9), who considers it roughly contemporary with Megiddo strata IX–VIIb. A few of the Mycenaean sherds were recovered from the later stratum IV, ca. 1230–1110 B.C.E. (Hamilton 1935, 28–35), but these are likely to be largely, perhaps totally, residual. The Cretan ceramic imports, including most of the transport stirrup jars, thus date

\textsuperscript{59} For Megiddo, see Jerusalem, Rockefeller Museum, inv. no. PAM 34.1834; Guy and Engberg 1938, 72, 157, pls. 34.21, 124.18. Leonard and Cline 1998, 13, 31, no. 73. For Gezer, see Tel Aviv, Eretz Israel Museum, inv. no. MHP 666.60; Macalister 1912, 178–79. For Tell Beit Mirmim, see Albright 1932, 44, pl. 15.16.

\textsuperscript{60} Dothan 2008, 127. Very recently, three fragments of transport stirrup jars from the excavation at the settlement and cemetery of Deir el-Balah were brought to our attention (Dothan and Nahmas-Lotan 2010, 67–8, fig. 7.2) (see also the online appx. to this article). However, these sherds are currently not accessible for any further study.
Age ceramics from Crete, including transport stirrup jars, have been analyzed by archaeological methods, both chemical and petrographic, on several occasions in the past. The archaeological study of these vessels has benefited especially from the petrographic work of Day and his colleagues. Haskell’s recent summary of the forthcoming seminal analytical work on transport stirrup jars indicates that only west and central Cretan transport stirrup jars were exported to the mainland and elsewhere, while east Cretan products are considered not to have circulated outside the island. Most transport stirrup jars that have so far been subjected to petrographic and trace element analyses from contexts within the Aegean have proved to be Cretan products.

A large number of coarse ware stirrup jars from the so-called House of the Wine Merchant and House of the Oil Merchant at Mycenae were analyzed by petrography; four fabrics were defined, but because of the lack of reference material, it was not possible to determine the exact geographic provenance of the jars, although their fabrics were compatible with Cretan mineralogy. According to the analysis by optical emission spectroscopy (OES), most inscribed jars from Mycenae were found to originate from west Crete. In subsequent reexaminations of the examples from Mycenae, OES, atomic absorption spectrometry, instrumental neutron activation analysis (INAA), and petrography were all eventually employed. Chemical analysis indicated that most of the vessels came from west Crete; petrographic analysis substantiated these results but also suggested other sources for such jars on the island. Light-on-dark decorated transport stirrup jars were found to come from west Crete according to comparison with vessels from Chania. Another group, decorated in a dark-on-light style, was localized in central Crete, although with less specificity. Earlier chemical analysis had been conducted on a large sample (altogether numbering 108 specimens) of mostly inscribed stirrup jars from Thebes, from contexts considered to date to late LH IIIA. Most of the inscribed jars in this study (64 of 89) were eventually assigned to west Crete. A significant overlap between compositional patterns characteristic of various areas on Crete impeded any more precise localization of their production on the basis of chemical analysis alone. This realization highlights the importance of petrographic analysis in identifying the production locales of transport stirrup jars within Crete. Further petrographic analysis was conducted on 12 transport stirrup jars from Thebes. Seven of these were found to belong to a west Cretan fabric (characterized by a low-grade metamorphic fabric rich in phyllite and quartzite), similar to the ones found at Chania, Mycenae, and other sites; two other examples were attributed to central Crete, and a further three to the vicinity of Thebes. Three transport stirrup jars (LM IIIA) of probable east Cretan manufacture were exported to Karpathos. Most of the LM III transport stirrup jars so far analyzed from Malia indicate various sources within north-central Crete.

Recently, an assemblage of 18 transport stirrup jars from Kommos has been analyzed by petrography and INAA. As part of the same analytical program, 16 Minoan so-called short-necked amphoras, 32 Canaanite jars, and 22 Egyptian transport vessels (mostly amphoras) recovered at the same site were also analyzed. The main local fabric, located in south-central Crete, is characterized by volcanic and metamorphic rock fragments and siltstones (Fabric A), revealing similarities to some of the fabrics defined at other sites in the western Mesara plain as well as to products from the

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62 Day and Jones 1991; Day 1995, 1999; Day and Haskell 1995; Day and Joyner 2005; Day et al. (forthcoming). With regard to transport stirrup jars in particular, see also Haskell 2005, Haskell et al. (forthcoming). The earliest study was conducted by Bouchard 1968.
63 Haskell et al. (forthcoming).
64 Haskell 2005, 298 (but see infra n. 80).
65 Riley 1981.
66 Haskell et al. (forthcoming).
67 Haskell 2005, 369; Haskell et al. (forthcoming).
68 Riley 1981.
69 Haskell 1981b, 236; Riley 1981, 339.
70 Catling and Millett 1965; Catling et al. 1980.
71 Catling and Jones 1977; Catling 1995, Fabric I, pls. 37, 38a.
72 Day 1995, Fabric 3, pl. 38b–d.
73 Catling and Millett 1965; Catling and Jones 1977; Catling et al. 1980.
74 Catling et al. 1980, 95.
75 Catling et al. 1980.
76 Day and Haskell 1995.
77 Day and Haskell 1995, 90–1, pl. 1.
78 Day and Haskell 1995, pl. 2a, c, d.
79 Day and Haskell 1995, pl. 2b.
80 Melas 1985, 119–20, pls. 120–23; Rhodes, Archaeological Museum of Rhodes, inv. nos. BE 430, BE 288, BE 306. We are grateful to an anonymous reviewer for the suggestion that these three transport stirrup jars are likely to be of east Cretan manufacture.
81 Day and Jones 1991.
82 Day et al. (forthcoming).
much earlier LM IA kiln. About half of the transport stirrup jars from Kommos dated by context to between LM II and LM IIIB (15th–13th centuries B.C.E.), as well as all the short-necked amphoras, were produced in this fabric. Significantly, none of the vessels analyzed could be assigned to production locales on the northern coast, that is, in the vicinity of Knossos.

The Point Iria shipwreck, dated to the late 13th century B.C.E., contained a very homogenous group of eight transport stirrup jars attributed to a single source in central (perhaps south-central) Crete, none of them with marked handles. However, the 10 transport stirrup jars from the earlier Uluburun shipwreck show a combination of west Cretan and central (possibly south-central) Cretan products; four of these have marks that were incised in their handles after firing, indicating reuse and redistribution by Cypriot middlemen.

A transport stirrup jar with a painted Linear B inscription from Cyprus was analyzed and allocated a general Cretan origin. Archaeometric analysis of transport stirrup jars from the Levant includes INAA of a transport stirrup jar with painted signs (possibly Linear B) from Sidon attributed to Chania or western Crete, none of them with marked handles. However, the 10 transport stirrup jars from the earlier Uluburun shipwreck show a combination of west Cretan and central and possibly south-central) Cretan products; four of these have marks that were incised in their handles after firing, indicating reuse and redistribution by Cypriot middlemen.

Results of This Study

This petrographic analysis included 36 samples from Late Bronze Age sites in Israel (table 1; see figs. 2–4), of which at least 32 represent fragments of medium-coarse to coarse transport stirrup jars, three with marks incised in the backs of their handles after firing (TAH2, Ashkelon1, Akko2) (see online appx.). The fragments are usually body sherds, handles, or spouts. Transport stirrup jars produced exclusively in fine fabrics were not sampled, although the coarse sections of several fragments that combined fine with coarser pastes were (Ashkelon1, TAH6, TAH9, TAH21).

The pottery samples were sectioned and thinned to 0.030 mm in the standard method of petrographic thin-section preparation. The petrographic analysis was carried out at the INSTAP Study Center for East Crete on a Leica DMLP polarizing microscope.

As noted above, petrographic analysis has been quite successful on numerous occasions in pinpointing the geographic provenance of ceramic pastes according to both geological considerations and comparison with reference materials, especially in allocating fabrics to broad regions within the island (e.g., western, north-central, and south-central Crete) (fig. 5). However, the geology of Crete is complex and repetitive because of the fault system, which is responsible for the discontinuous appearance of the same geological series across an extended geographic area. Central and south-central Crete are characterized by a geological environment of ophiolites and flysch mélange. These complexes extend in a discontinuous manner over a large area from Myrtos to the Mesara. They are composed of metamorphic (amphibolites, mica schists, gneisses), igneous (basalts, granites, serpentinites), and sedimentary (limestones, sandstones) rocks (see fig. 5). In ceramic fabrics, this composition is reflected either as clay paste with a single nonplastic component (e.g., only sandstones) or with a multitude of nonplastics (e.g., a few serpentinites, a few basalts, and a few metamorphics). Considering the repetitive character of the geology in this part of Crete, as well as the variability in the mineralogical composition of the geological formations, it becomes difficult if

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85 Buxeda i Garrigos et al. 2001 (infra n. 98); Day and Kilikoglou 2001.
89 Karageorghis 2008 (quoting results of H. Mommsen).
90 Hoffmann and Robinson 1993, samples 1–3 (infra nn. 107–9).
91 Other examples of certain or possible Cretan imports (not transport stirrup jars) to the Bronze Age southern Levant are comparatively rare and have in most cases been analyzed. Dated to the Middle and Late Bronze Age, these include one or two Kamares Ware fragments from Hazor (Dothan et al. 2000) and Ashkelon (Stager et al. 2008, 231, fig. 14.25 [two examples of cups from the gate area]), three so-called Cream Ware examples from Tell Abu Hawam (Hoffmann and Robinson 1993, samples 102, 103, 105, which were left unassigned to any particular Minoan provenance), and a Middle Bronze Age III pithos sherd with graffito from Tel Haror (Oren et al. 1996; Day et al. 1999). In no case has the precise source of these pieces within Crete been identified.
92 A fine transport stirrup jar from Tell Abu Hawam was analyzed by INAA by Perlman and Asaro and attributed to a Peloponnesian production center (Hoffmann and Robinson 1993, sample 85).
Table 1. Results of Petrographic Analysis of Transport Stirrup Jars and Related Samples from Israel.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Sherd Type</th>
<th>Fabric Group</th>
<th>Suggested Provenance</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>TAH2</td>
<td>incised handle</td>
<td>1a</td>
<td>south-central Crete</td>
<td>fig. 3a</td>
</tr>
<tr>
<td>TAH3</td>
<td>base</td>
<td>4</td>
<td>no evidence of Cretan provenance</td>
<td>fig. 3h</td>
</tr>
<tr>
<td>TAH4</td>
<td>body</td>
<td>1a</td>
<td>south-central Crete</td>
<td></td>
</tr>
<tr>
<td>TAH5</td>
<td>base</td>
<td>1b</td>
<td>south-central Crete</td>
<td>fig. 3i; high firing temperature; large fragments fine-grained, gray siltstone</td>
</tr>
<tr>
<td>TAH6</td>
<td>spout</td>
<td>5 related</td>
<td>no evidence of Cretan provenance</td>
<td>fig. 2c; very fine; hardly any inclusions</td>
</tr>
<tr>
<td>TAH7</td>
<td>body</td>
<td>1a</td>
<td>south-central Crete</td>
<td>fig. 3j</td>
</tr>
<tr>
<td>TAH8</td>
<td>body</td>
<td>1a</td>
<td>south-central Crete</td>
<td>fig. 3b</td>
</tr>
<tr>
<td>TAH9</td>
<td>neck, spout</td>
<td>5</td>
<td>no evidence of Cretan provenance</td>
<td>figs. 2b, 3d; relatively coarse</td>
</tr>
<tr>
<td>TAH10</td>
<td>body</td>
<td>1c</td>
<td>south-central Crete?</td>
<td>fig. 3c; rounded clay pellets</td>
</tr>
<tr>
<td>TAH11</td>
<td>body</td>
<td>1a</td>
<td>south-central Crete</td>
<td></td>
</tr>
<tr>
<td>TAH12</td>
<td>body</td>
<td>4</td>
<td>no evidence of Cretan provenance</td>
<td>fig. 3g</td>
</tr>
<tr>
<td>TAH13</td>
<td>body</td>
<td>1a</td>
<td>south-central Crete</td>
<td></td>
</tr>
<tr>
<td>TAH14</td>
<td>body</td>
<td>4</td>
<td>no evidence of Cretan provenance</td>
<td></td>
</tr>
<tr>
<td>TAH15</td>
<td>body</td>
<td>1a</td>
<td>south-central Crete</td>
<td></td>
</tr>
<tr>
<td>TAH16</td>
<td>body</td>
<td>1a</td>
<td>south-central Crete</td>
<td></td>
</tr>
<tr>
<td>TAH17</td>
<td>body</td>
<td>1a</td>
<td>south-central Crete</td>
<td>metamorphic component more prominent; phyllite, quartzite, quartzite-schist inclusions</td>
</tr>
<tr>
<td>TAH18</td>
<td>body</td>
<td>1a</td>
<td>south-central Crete</td>
<td>fig. 3f</td>
</tr>
<tr>
<td>TAH19</td>
<td>body</td>
<td>loner</td>
<td>uncertain</td>
<td>too fine</td>
</tr>
<tr>
<td>TAH21</td>
<td>spout, shoulder</td>
<td>1a</td>
<td>south-central Crete</td>
<td>fig. 2d</td>
</tr>
<tr>
<td>TAH22</td>
<td>body</td>
<td>1a</td>
<td>south-central Crete</td>
<td>probable amphoroid krater</td>
</tr>
<tr>
<td>TAH23</td>
<td>large body</td>
<td>1a</td>
<td>south-central Crete</td>
<td>fig. 3a, upper</td>
</tr>
<tr>
<td>TAH24</td>
<td>body</td>
<td>1a</td>
<td>south-central Crete</td>
<td>fig. 3a, lower</td>
</tr>
<tr>
<td>TAH25</td>
<td>false neck, handle stump</td>
<td>5</td>
<td>no evidence of Cretan provenance</td>
<td>fig. 3e; fine; few rock fragments</td>
</tr>
<tr>
<td>TAH26</td>
<td>body</td>
<td>1c</td>
<td>south-central Crete?</td>
<td>rounded clay pellets</td>
</tr>
<tr>
<td>Ashdod1</td>
<td>base</td>
<td>2</td>
<td>west Crete?</td>
<td>fig. 4d</td>
</tr>
<tr>
<td>Ashdod2</td>
<td>body</td>
<td>loner</td>
<td>no evidence of Cretan provenance</td>
<td>probably not a stirrup jar</td>
</tr>
<tr>
<td>Ashdod  Beach1</td>
<td>body</td>
<td>1a</td>
<td>south-central Crete</td>
<td>fig. 4e</td>
</tr>
<tr>
<td>Ashkelon1</td>
<td>spout, shoulder, incised handle</td>
<td>1 related?</td>
<td>south-central Crete?</td>
<td>fig. 4g; metamorphic rocks; no volcanic rocks</td>
</tr>
<tr>
<td>Ashkelon2</td>
<td>body</td>
<td>1 related?</td>
<td>south-central Crete?</td>
<td>amphoroid krater; metamorphic rocks; no volcanic rocks</td>
</tr>
<tr>
<td>Ashkelon3</td>
<td>handle, shoulder</td>
<td>loner</td>
<td>no evidence of Cretan provenance</td>
<td></td>
</tr>
<tr>
<td>Ashkelon4</td>
<td>body</td>
<td>loner</td>
<td>no evidence of Cretan provenance</td>
<td>probably not stirrup jar</td>
</tr>
<tr>
<td>Akko1</td>
<td>body</td>
<td>1a related?</td>
<td>south-central Crete?</td>
<td>fig. 4a; finer matrix, higher firing temperature</td>
</tr>
<tr>
<td>Akko2</td>
<td>incised handle, shoulder</td>
<td>1a related</td>
<td>south-central Crete?</td>
<td>fig. 4b; finer matrix, higher firing temperature</td>
</tr>
<tr>
<td>Akko3</td>
<td>base</td>
<td>1?</td>
<td>probably Crete</td>
<td>fig. 4c; similar to TAH17 (matrix color dissimilar); phyllite, quartzite, quartz; few chert and microfossils</td>
</tr>
<tr>
<td>Akko4</td>
<td>spout</td>
<td>3</td>
<td>central Crete</td>
<td></td>
</tr>
<tr>
<td>DB1</td>
<td>complete</td>
<td>loner</td>
<td>no evidence of Cretan provenance</td>
<td></td>
</tr>
</tbody>
</table>
not impossible to identify areas of production on the sole basis of the local geology. However, the growing body of evidence from the area of the Pediada shows that the fabrics encountered at numerous sites in this large area are very similar to those from the Mesara.\textsuperscript{95} For this reason, the provenance of the ceramic fabrics cannot be assigned with certainty to the Mesara or the Pediada, especially in dealing with vessels such as transport jars that move frequently across large areas. For the moment, it seems that central and south-central Crete best represents the origin of most of the fabrics examined by us. However, there are also some fabrics for which a Cretan provenance can be excluded with a high degree of probability, even though an alternative origin often cannot be provided because of the lack of comparative petrographic material.

The petrographic analysis resulted in the establishment of five fabric groups. Several samples not included in these groups nevertheless seem to relate to some of them, whereas six samples were not assigned to any group (“loners”). Fabric Groups 1–3 are suggested to represent Cretan production, while Fabric Groups 4 and 5 and most loners show no evidence of Cretan origin.

The main group, Fabric Group 1a (fig. 6a, b), constitutes almost 40% of the transport stirrup jars sampled

\textsuperscript{95} Nodarou and Rathossi 2008; work in progress by N. Panagiotakis, M. Panagiotaki, and E. Nodarou.
(14 specimens). All but one of the clear members of this group (Ashdod Beach1) come from Tell Abu Hawam. Another eight samples are related to this group, including Fabrics 1b and 1c (see table 1). The homogeneity in composition and texture is impressive, especially when one considers that the material consists of imported transport vessels. The fabric is characterized by a very fine, dark red-brown, optically inactive matrix. The coarse fraction includes mainly metamorphic rock fragments consisting of phyllites and quartzite/polycrystalline quartz (see fig. 6a, b) and smaller amounts of volcanic rock fragments of basic composition (basalt) (see fig. 6b), igneous rocks composed of lath-shaped plagioclase and pyroxene (dolerite?), and serpentine. The different components are present in varying amounts in the samples, but the general appearance is homogeneous. The attested variation seems to be due to the diversity of the raw material sources rather than to the selection of a specific rock temper by the ancient potters (see fig. 6b); other inclusions are monocrystalline quartz (also in the fine fraction) and, less commonly, siltstone, chert, and sandstone.

The samples of Fabric Group 1 display consistency and homogeneity in terms of texture and composition. The color of the matrix is the same in all the samples, while the absence of optical activity indicates high firing temperatures, as also inferred by Stockhammer on the basis of the pronounced wheel ridges on Minoan transport stirrup jar interiors.86 The base clay used is

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86 Stockhammer 2008, 93.
a micaceous and calcareous raw material in which the nonplastic inclusions were added as temper, as indicated by their size and bimodal distribution. In one sample (TAH2) (see fig. 6a), streaks of red clay have been noted, which are indicative of the presence of a second, noncalcareous clay in the clay mix.

The rock and mineral suite as represented in this fabric group is characterized by the coexistence of metamorphic, volcanic, and sedimentary rocks. This composition is connected with the ophiolite nappe and the flysch series and has been described as characteristic of the western Mesara, south-central Crete (see fig. 5), and, more specifically, the area around Kouses, as seen in the Early Minoan imports at Knossos97 and the LM IA pottery of the Kommos kiln.98 The analysis of the transport stirrup jars from the Point Iria shipwreck showed that their mineralogical composition is very similar to that of Fabric Group 1, and the western Mesara is considered to be their place of origin.99 Most of the samples from the Point Iria wreck are manufactured in a calcareous fabric containing microfossils, with one exception, sample A86/1, which differs from the main group because of the absence of microfossils in the clay matrix.100 The sample that deviates from the main group at Point Iria seems to be closer to the Tell Abu Hawam Fabric Group 1, which is characterized by the same mineralogy and a clay matrix without microfossils. Recent studies have shown that the geology of the ophiolite series characterizes a large area extending from Myrtos westward to the Mesara. The analysis of the Middle Minoan assemblage from Malia and the clay sampling carried out on the south coast,101 as well as the analysis of the Geometric figurine assemblage from Ano Viannos,102 have demonstrated that there cannot be any greater specificity in assigning provenance because of the homogeneity of the clay deposits over a large area. A more recent project (which is still in progress) involving material from the Pediada survey shows that the same mineralogy and homogeneity is seen also in the fabric of pottery and clay samples from this area (see fig. 6d).103 Note also that when the composition of products of the Hagia Triada and the Kommos LM I kilns were compared,104 petrographic analysis indicated similar fabrics, while chemical neutron activation analysis results show a certain distinction between the products of the two kilns, although they are near neighbors in the Mesara plain.

Therefore, in the case of the stirrup jars, which are transport vessels moving widely in the Aegean and the eastern Mediterranean, it is very difficult (if not impossible) to assign a more specific provenance than “central or south-central Crete.” Note, however, that this fabric is distinguished clearly from west, east, or north Cretan clays,105 especially as these latter clays lack volcanic rocks and usually are connected with the Phyllite-Quartzite series.

The sherds sampled as TAH25 and TAH26 (and possibly also other fragments) were perceived by Balensi to come from the same vessel as TAH23 and TAH24;106 yet, according to their petrographic fabrics, all these sherds probably represent different vessels. Previous INAA was carried out during the 1970s on two or three transport stirrup jars from Tell Abu Hawam (TAH2, TAH23) (see online appx.).107 These were not clearly grouped; TAH2 was denoted as “unassigned Mycenae environs,”108 while TAH23 and possibly another sherd from the same vessel109 were loners. Both vessels are attributed here to south-central Crete by petrography. Clearly, there was not sufficient reference material from Crete available for Perlman and Asaro during the 1970s, and thus sample TAH2 may have seemed relatively similar to Argive profiles.110

Fabric Group 1 is very consistent in mineralogy and texture, and therefore it was considered important to differentiate the samples that relate to this group but do not share the same degree of homogeneity (termed “Fabric 1 related” in table 1). More specifically, sample TAH17 has the same matrix and texture as Fabric Group 1, but the metamorphic component of its composition is more prominent, the nonplastic inclusions consisting exclusively of rounded phyllites, quartzites, and quartzite-schists. Sample TAH5 is characterized by a fine, greenish-brown matrix. The greenish tinge of

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100 Day 1999, 66.
101 Poursat and Knappett 2005, 21–4, pl. 68c, f.
102 Nodarou and Rathossi 2008.
103 Work in progress by N. Panagiotakis, M. Panagiotaki, and E. Nodarou.
104 Belfiore et al. 2007.
105 Thus, the area of north-central Crete, including Knossos and its environs, is clearly excluded.
106 Balensi 1980, pl. 33.7 (see fig. 2[a] in this article).
108 Hoffmann and Robinson 1993, Group I.
109 Hamilton 1935, pl. 19c.
110 Similarly, in the 1960s Catling and Millett (1965) erroneously attributed transport stirrup jars found in Thebes to east Cretan production centers; see also Day and Haskell (1995) for the difficulties of separating Cretan from mainland profiles by chemical analysis alone.
the matrix is indicative of high firing temperature. In composition, the nonplastic inclusions consist exclusively of large fragments of fine-grained, gray siltstone; this was defined here as Fabric Group 1b. This type of siltstone is commonly seen in central or south-central Cretan fabrics, either as a secondary component or as the sole component. In Fabric Group 1, it appears in several samples, but this is the only sample where it constitutes the only nonplastic inclusion (see fig. 6c); this sherd is described in the online appendix as unusually handmade, white-slipped, and lacking any specific surface treatment. Samples TAH10 and TAH26 have the same brown and optically inactive matrix as Fabric Group 1, but they are finer and contain very rare nonplastic inclusions that consist of fine-grained rounded siltstones with small quartz fragments and biotite mica laths. The main characteristic of this group is the presence of rounded clay pellets (esp. in sample TAH26); this differentiates it from the rest of Fabric Group 1 (fig. 7a), defined here as Fabric Group 1c.

All these samples are also thought to be of central or south-central Cretan origin, but they are manufactured with a different recipe than the vessels included in the main fabric group. Samples that could also come from central or south-central Crete, but are of a different fabric, are transport stirrup jars Ashkelon1 (see fig. 7b), Akko1 (see fig. 4a), and Akko2 (see fig. 4b), along with a probable amphoroid krater fragment, Ashkelon2 (fairly similar in fabric to Ashkelon1, as described in the online appx.). The two Ashkelon samples are very similar to each other. They are characterized by a dark brown and optically inactive matrix. The nonplastic inclusions consist of metamorphic rocks, mainly quartzite and quartzite-schist, along with some fine-grained biotite-phylite, quartz, and chert. The shape and distribution of the inclusions as well as the color and texture of the matrix seem to link this fabric to the central or south-central Cretan jars. However, the lack of volcanic rocks led us to separate these two from the main Fabric Group 1a.

Fabric Group 2 includes only one sample (Ashdod1) (see fig. 7c). This fabric is characterized by a fine-grained, dark gray-brown matrix that is optically inactive (coarser than Fabric Group 1). The nonplastic inclusions consist exclusively of low-grade metamorphic rocks: fine-grained phyllite fragments, quartzite, and quartzite-schist fragments. Plastic inclusions consist of subrounded dark brown fragments surrounded by voids. The rock and mineral suite of this sample points toward an environment of low-grade metamorphic rocks, that is, the Phyllite-Quartzite series. This environment occurs in several regions of Crete, including the region of Chania in western Crete, well known as an important source of transport stirrup jars (see above).

Only one sample was defined as Fabric Group 3 (Akko4) (see fig. 7d). This is a fine calcareous fabric characterized by small fragments of micritic limestone and microfossils; the other nonplastics consist of monocrystalline and polycrystalline quartz and a few epidote and biotite fragments and laths. It seems that this sample is typologically as well as petrographically unique. In terms of provenance, the fabric greatly resembles the fine calcareous fabrics used for small and medium-sized vessels (e.g., jugs, cups) at Mochlos, east Crete, yet its geology is not distinctive in origin; it could be a product of any workshop on the north-central or northeastern coast of Crete, where there are extensive deposits of Miocene marls.

Fabric Group 4 includes three similar samples (TAH3, TAH12, TAH14) (see fig. 7e), all of which share the macroscopic description of being medium-coarse, unslipped, and unfinished on their pink to reddish-yellow (5–7.5YR 7/5) exteriors (see online appx.). Therefore, this group probably represents products of a single workshop. This fine sedimentary fabric is characterized by a calcareous matrix that is optically active. The nonplastic inclusions consist almost exclusively of fine-grained rock fragments composed of biotite, quartz, epidote, and white mica laths (shale). Secondary inclusions are rare fragments of quartz and micritic limestone, as well as a rock fragment with serpentine (seen in TAH14). There are red textural concentration features and clay striations indicating incomplete clay mixing. This does not seem to be a Cretan fabric.

Three samples were defined as Fabric Group 5 (TAH6, TAH9, TAH25) (see fig. 7f). This is a fine siltstone fabric characterized by an optically inactive matrix; the greenish color of the matrix is indicative of high firing temperature. The fine fraction is dominated by micritic limestone and biotite mica laths; there are also rare fragments of quartzite-schist and a fragment of serpentine. This fabric does not seem to be Cretan, either, but note that two of three samples (TAH6, TAH9) feature fine spout fragments joined to medium-coarse bodies, a characteristically Minoan combination of pastes of different grades in one and the same vessel; the spout on one of these pieces

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111 See also Hein et al. (2004) regarding such calcareous fabrics in Crete.

Fig. 7. Fabrics related to Fabric 1 and Fabrics 2–5: a, Fabric 1c, sample TAH26; b, sample Ashkelon1; c, Fabric 2, sample Ashdod1; d, Fabric 3, sample Akko4; e, Fabric 4, sample TAH3; f, Fabric 5, sample TAH9 (CP = clay pellets; Q = quartz; QT = quartzite; P = phyllite; PI = plastic inclusions; f = microfossils; S = shale).
(TAH6) was clearly handmade, however, and the body may have been as well (see online appx.).

Several samples were defined as “loners.” Sample TAH19 is too fine to be mineralogically distinctive and thus could or could not come from Crete. But the complete jar from Deir el-Balah (sample DB1), characterized by a high quantity of mudstone or grog inclusions, is unlikely to be Minoan. Likewise, sample Ashkelon3 is characterized by a brown and optically inactive matrix with micritic limestone, very little quartz and chert, and a considerable number of biotite mica laths and few white mica laths that may well not be Cretan fabric.

**Discussion**

The preceding typological and petrographic analyses have shown that the overwhelming majority of the coarse transport stirrup jars found at Tell Abu Hawam, along with a few specimens from Akko, Ashdod, and Ashkelon, appear to be of Cretan origin. As noted in the regional survey of its distribution outside the Aegean, this type of transport vessel is encountered in varying quantities in the Levant, Cyprus, Egypt, and Italy during the 14th and 13th centuries B.C.E., the heyday of eastern Mediterranean Late Bronze Age trade. Clearly used as a container for specific varieties of liquid traded in bulk quantities and featuring quite a wide range of different decorative as well as morphological characteristics, the transport stirrup jar was produced in a number of different fabrics. Most of those examples manufactured in medium-coarse to coarse fabrics can be attributed to Cretan centers of production. Specimens produced in fine fabrics, as well as handmade versions, were produced either on the Greek mainland or at a number of locales as well as handmade versions, were produced either on the Greek mainland or at a number of locales along the western Anatolian coast. Most of the transport stirrup jars found outside the Aegean, whether or not they are Minoan products, have been recovered at coastal sites or from shipwrecks. Moreover, in terms of sheer numbers, those discovered at coastal locales tend to be found in clusters at particular harbor sites: Hala Sultan Tekke, Enkomi, Episkopi-Bamboula, and Kition on Cyprus; Ras Shamra and its port of Minet el-Beida in Syria; Tell Abu Hawam in Israel; Marsa Matruh and Zawiyet Umm el-Rakham in Egypt; Canaltello in Sicily; Antigori in Sardinia; and Rocavecchia in Apulia. It seems reasonable to infer that the commodities carried in these vessels were decanted at these harbor sites and redistributed to locales farther inland in other types of vessels.

Assessing the importance of the traffic in commodities carried in transport stirrup jars relative to those transported in bulk containers characteristic of other regions within the eastern Mediterranean (e.g., Canaanite jars, Egyptian amphoras, Cypriot pithoi, and Plain White jugs) is made difficult by the highly uneven state of publication of these kinds of vessels. Transport stirrup jars are easily recognized in Levantine, Egyptian, and Cypriot Late Bronze Age contexts even when represented by nothing more than single sherds, thanks to their decoration and distinctive fabrics. The same cannot be said for the plain and often altogether unremarkable fragments of Canaanite jars, Egyptian amphoras, and Plain White Cypriot transport vessels. While these may be routinely singled out as nonlocal in Aegean or central Mediterranean contexts, they all too often elude more precise identification by ceramic specialists understandably unfamiliar with rarely encountered fabrics from what are, to them, very distant sources. At present, a little more than 25% of the roughly 240 transport stirrup jars recovered from sites outside the Aegean (including those from the shipwrecks at Gelidonya and Uluburun) come from the southern Levant, and almost 50% come from Cyprus. Of approximately 120 Cypriot pithoi that have been reported from findspots outside Cyprus, about

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113 Several additional samples do not appear to belong to transport stirrup jars, whether produced on Crete or not. These do not appear in the online appendix but are listed in table 1. Samples Ashkelon2 and TAH22 are both south Creto in terms of their fabric but are more likely to be fragments of amphoroid kraters than of transport stirrup jars. Sample Ashdod2 is characterized by many microfossils, indicating a marly sediment as the possible source of the raw material. The voids are elongate and orientated parallel to the vessel margins, which is characteristic of tempering with organic material. Ashkelon4 is characterized by a fine, greenish-brown matrix that is optically inactive. This sample contains igneous rocks, some serpentine, pyroxene, biotite, quartz, and rare fragments of muscovite. In the fine fraction there are many fragments of biotite and biotite mica laths as well as some epidote.


115 The distribution of the transport stirrup jars almost exclusively at eastern Mediterranean coastal sites and the occasional signs of reuse farther away indicate that we are dealing mainly with commodity trade rather than object trade. By contrast, standard Aegean and Cypriote tablewares traded for their own sake rather than for their contents are frequently found at noncoastal sites (see, e.g., Zuckerman et al. 2010 [and references therein] for the southern Levant, Mühlenbruch 2009 for the northern Levant).

116 To this list of transport vessel types could perhaps be added western Anatolian reddish-brown burnished jugs (Rutter 2006b, 658–63; 2006c) and Sardinian dark-burnished jars (Rutter 2006b, 674–78).
10% were found at three sites on Crete (Kommos), Sicily (Cannatello), and Sardinia (Antigori); another 15% from the three shipwrecks of Iria, Gelidonya, and Uluburun; and approximately 15% from 11 different sites in Israel (Akko, Ashdod, Ashdod South Beach, Ashkelon, Beth Shemesh, Hazor, Megiddo, Tell Abu Hawam, Tell Barash, Tell Qashish, Tell Sera). More than 60% come from the three Syrian sites of Minet el-Beida, Ras Shamra, and Tell Kazel. Canaanite jars were produced over a vastly wider region than were Cypriot pithoi, including Cyprus itself, and were extensively exchanged for a significantly longer period of time than the two centuries during which interregional trade in Aegean transport stirrup jars and Cypriot pithoi flourished. It is therefore hardly surprising that the number of Canaanite jars published to date from sites on the Greek mainland and Crete is roughly twice that of the transport stirrup jars so far identified in the southern Levant, however plain and indistinctive the former may be. To put all these numbers into perspective, however, one should remember that the single shipwreck of ca. 1310 B.C.E. at Uluburun carried a cargo that included more Canaanite jars than the total number of such jars previously reported from all excavated sites in the Aegean. This limited survey of the evidence, albeit brief and incomplete, provides a rough idea of the scale of the traffic in bulk commodities, at least in relative terms, during the peak period of interregional exchanges within the Late Bronze Age eastern Mediterranean.

The petrographic analyses reported here indicate that close to 60% of the 23 transport stirrup jars sampled from Tell Abu Hawam derive from central or south-central Crete, constituting a fabric group that is noteworthy for its homogeneity and coherence (see table 1, Fabric Group 1a). These analyses also make clear that a number of other production centers are represented among the additional 10 samples from Tell Abu Hawam and the further nine collected from Akko, Ashdod, Ashkelon, Ashdod South Beach, and Deir el-Balah, whether on Crete (see table 1, Fabric Groups 2, 3) or in locales potentially outside that island (see table 1, Fabric Groups 4, 5, plus several “loners”). The important role played by central and south-central Crete in the production of transport stirrup jars has been revealed by earlier analyses of exported transport stirrup jars found on Cyprus as well as on the Uluburun and Point Iria shipwrecks.

It is therefore not surprising that the lion’s share of the transport stirrup jars identified at the premier south Cretan port of Kommos are likewise products of this region. By contrast, the west Cretan production centers that produced so many of the imported Minoan transport stirrup jars reported from mainland Greek sites are only sparsely represented among the southern Levantine specimens so far sampled (see table 1, Fabric Group 2, Ashdod1). In view of how often transport stirrup jars appear to have been reused and how many different production centers are represented among the transport stirrup jars recovered at a single Cretan port such as Kommos, the vessel represented by Ashdod1 is as likely to have reached Ashdod by way of Kommos or Tell Abu Hawam as to have come directly from western Crete. Unlike those from shipwrecks, the collection of transport stirrup jars amassed from Hamilton’s excavations at Tell Abu Hawam (see online appx.) represents exchanges conducted over at least a century and perhaps closer to two. So the dominance of the central and south-central Cretan component within this collection is presumably a long-term phenomenon that is also reflected in the important position occupied in eastern Mediterranean trade from the late 15th through at least the mid 13th centuries B.C.E. by the south Cretan port of Kommos. This trade may well have involved such Egyptian coastal sites as Marsa Matruh and Zawiya Umm el-Rakham and ports along the Levantine coast south of Tell Abu Hawam, such as Ashdod and Ashkelon, as well as sites farther north along the Lebanese and north Syrian coasts and the large centers along the south coast of Cyprus.

The pattern of a heterogeneous mix of a number of production locales represented among the Aegean bulk transport vessels imported into Tell Abu Hawam—but one clearly dominated by transport stirrup jars manufactured in central or south-central Crete—is intriguingly mirrored at Kommos by a closely comparable pattern. Of a total of some 75 imported Canaanite jars so far reported from Monopatia and final Palatial contexts on Crete, almost 90% come from the site of Kommos, with just two known from Chania in the far west, one from Palaiakastro in the far east, and a half-dozen fragments recently identified from House A at Mochlos plus two from Pseira in and around the Bay of Mirabello on the north coast. From contexts on the Greek mainland during the same period, roughly

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119 Day et al. (forthcoming).
120 Haskell 2005; Stockhammer 2008, 94, 276.
121 Day et al. (forthcoming).
123 Rutter (forthcoming).
35 additional examples of such jars are known, most of them more fully preserved than the bits and pieces found on Crete because they tend to be found in Helladic funerary contexts as grave goods.\textsuperscript{127} Thus, at present, the premier Levantine bulk transport vessel of the 15th–12th centuries B.C.E., the so-called Canaanite jar,\textsuperscript{126} is found as overwhelmingly at a single harbor site in the Aegean—Kommos in southern Crete—as the Aegean analogue, the transport stirrup jar, is found concentrated at Tell Abu Hawam.

Petrographic analyses of a substantial number of the Canaanite jars recovered at Kommos,\textsuperscript{126} along with macroscopic inspection of virtually all examples by Margaret Serpico of the Canaanite Amphora Project,\textsuperscript{127} have identified roughly one-third of the jars imported to Kommos as products of the coastal plain south of Haifa and of the northwestern Jezreel Valley. The jars were used to ship pistacia resin to the Egyptian centers of Amarna and Memphis and, by extension, quite probably the same substance to contemporary Minoan consumers. In view of their places of production, as determined by the petrological makeup of their fabrics, these Canaanite jars are likely to have been shipped from Levantine ports either in the Bay of Haifa (above all, Tell Abu Hawam, although perhaps also Akko) or from coastal emporia just to the south (such as Tell Nami). Thus, the predominance of central and south-central Cretan products among the Aegean bulk transport vessels imported to Tell Abu Hawam is to a large degree matched by a corresponding frequency of Levantine imports from the Bay of Haifa region to Kommos during the period ca. 1425–1250 B.C.E.

Does this symmetry between the corpora of imported bulk transport vessels from Kommos and Tell Abu Hawam suggest that direct trade in the form of basic commodity exchanges was conducted between the two sites? Such direct trade links across the Mediterranean, though possible, have so far very rarely been persuasively documented in the archaeological record.\textsuperscript{128} The function of these two sites as major access gateways and outlets for their respective regions may have been a natural consequence of their locations, with Kommos as an outlet for the agricultural wealth of the Cretan Mesara plain and Tell Abu Hawam as an outlet for the Carmel coast and valleys of northern Israel.\textsuperscript{129} In such a reconstruction, these two sites would thus have served as “end terminals” for an extensive eastern Mediterranean system of trade in bulk commodities. The Minoan and Canaanite transport vessels were consequently deposited at these sites in larger numbers as they were eventually broken and discarded. The evidence presently available does not permit any more substantive conclusions on the nature of the eastern Mediterranean trade system, in the opinion of the authors, but future research designs, especially those involving the analysis of shipwreck cargoes yet to be discovered, should explore this possibility in greater detail.

CONCLUSIONS

The study of Late Bronze Age Minoan transport stirrup jars in the Levant indicates that one of the most significant concentrations of these distinctive vessels in the entire Levant occurs at the site of Tell Abu Hawam. The site is already acknowledged as a major gateway for the importation of Cypriot and Mycenaean tablewares into this region. Petrographic analysis of the transport stirrup jars from Abu Hawam as well as other sites in Israel indicates that the large majority of them were made in central or south-central Crete. This result draws additional attention to the site of Kommos, which has produced by far the largest concentration of Levantine, Egyptian, and Cypriote ceramic imports, including Canaanite jars, not only on Crete but in the entire Aegean. The symmetrical importation of bulk transport vessels at the two sites might indicate direct trade and commodity exchange links between them, but it could also result from the two being termini of a large eastern Mediterranean trading system serving not only the Levant and Crete but also Egypt, Cyprus, and the Greek mainland. The nature of the commodity exchange between these regions during the Late Bronze Age is an intriguing topic that will only become better understood after more comprehensive provenance analysis of bulk transport containers throughout

\textsuperscript{121} Rutter (forthcoming).
\textsuperscript{122} Killebrew 2007.
\textsuperscript{123} Day et al. (forthcoming).
\textsuperscript{124} Rutter 2006b, 649–53, 712 n. 218.
\textsuperscript{125} It is difficult to prove the existence of directional trade. In our case, some of the storage vessels (either transport stirrup jars or Canaanite jars) that ended up being deposited at both Tell Abu Hawam and Kommos could easily have reached their final destinations after multiple emptyings and refillings at any number of intermediate eastern Mediterranean ports, and they would thus not qualify as persuasive evidence for purposeful direct exchanges between south-central Crete and the Bay of Haifa. For definitions of directional trade, see Renfrew 1977; Renfrew and Bahn 1996, 350–62. For the Aegean, see Cline 1994, 86–7. Yannai (1983, 103–4) argued for seafaring merchants operating within a system of “directional commercial” trade, asserting that profit-motivated entrepreneurs acted as middlemen in trade between the Mycenaean Aegean and the greater Levant.
\textsuperscript{126} Arzy 2005, 2006.
the eastern Mediterranean, and especially with more attention paid to residue analysis of the organic commodities carried in them.

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