IMPORTED GLASS OBJECTS IN THE BRONZE AGE AEGEAN

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ABSTRACT

A great deal of evidence exists in support of Bronze Age intra-Aegean trade, but the dynamics and material goods that made up these exchanges are still being explored. Initially, foreign glass most likely originated in Western Asia and Egypt. Recent excavations at the Minoan sites of Chryssi, Papadiokambos, and Mochlos have provided evidence of such trade on Crete. All three sites yielded glass beads that, judging by their rarity in the region, must have come from elsewhere. While glass artifacts such as those found on Minoan Crete are often assumed to be Egyptian in genesis, a Western Asian source has not been sufficiently ruled out. Based on their findspots, appearance, and our present understanding of shipping and trade in the Bronze Age Aegean, it is most likely that the beads from Chryssi, Papadiokambos, and Mochlos were manufactured in the Levant and arrived in Crete from the East.

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TABLE OF CONTENTS

Page

LIST OF FIGURES

CHAPTER 1
INTRODUCTION

A great deal of evidence exists in support of Bronze Age intra-Aegean trade, but the dynamics and material goods that made up these exchanges are still being explored. For example, vitreous materials were imported into the Aegean, but potentially they could have been manufactured in more than one location. Initially, foreign glass most likely originated in Western Asia and Egypt. Recent excavations at the Minoan sites of Chryssi, Papadiokambos, and Mochlos have yielded evidence of such trade on Crete. All three sites contained glass beads from LM IB-Final that, judging by their rarity in the region, must have come from elsewhere. Having been asked by Thomas Brogan of the Chryssi and Papadiokambos excavations, as well as Jeffrey Soles of the Mochlos project in conjunction with their co-directors, Costis Davaras and Chryssa Sophianou, to publish these particular finds, I propose an exploration of their potential origins, as well as the significance of their presence on Crete. This will be approached through an examination of the technology used to create glass objects in the Bronze Age, as well as through a study of comparanda.

Glassmaking most likely originated in northern Mesopotamia ca. 2500 B.C. (Ingram 2005, 107; Davison 2003, 16). Probably because of its early role as a replicator of semi-precious gems, the technique of glassmaking was a closely guarded secret (Luckner 1994, 79; Davison 2003, 17). Around 1450 B.C., the Egyptian pharaoh Tuthmosis III launched a chain of successful military campaigns through the Levantine

region, conquering as far north as the Mesopotamian borders (Davison 2003, 18). During these 18th Dynasty expeditions, the Pharaoh was "in diplomatic contact with rulers of most of the Near Eastern powers of the time" (Cline 1994, 34). Significantly, glassmaking in Egypt appeared as a fully-developed industry within a century after this event (Luckner 1994, 80; Forbes 1966, 124). Craftsmen brought back as captives are possibly the cause of a blossoming glass industry in Tuthmosis's kingdom (Nicholson 1997, 380; Davison 2003, 18). Nicholson has also suggested that glass was introduced to Egypt in the form of gifts from conquered powers (Shortland 2001, 213). The reality probably lies in an amalgamation of these factors.

Approximately one thousand years after its birth in Western Asia, glass, now a well-developed industry, was introduced to the Aegean (Panagiotaki 2008, 45; Panagiotaki, Maniatis et al. 2004, 150). When it first appeared on Crete, these imported glass objects took the form of both beads and vessels (Panagiotaki, 2008, 45; Cline 2009, 196). While it is undeniable that Crete eventually developed its own glass industry, vitreous materials were originally developed abroad. As a result, it is unlikely that the earliest glass objects on Crete were locally made, rather than imported.

Many theories exist which try to explain how and when glass beads and vessels first arrived in the Minoan world, and there are just as many complications to cloud the potential for clear answers. As with any study of the remote past, there is the barrier of temporal distance. Most obviously, the deterioration of vitreous materials over time can be an obstacle preventing complete understanding of the appearance, creation, and genesis of a glass object. Vitreous materials are better preserved in dry climates than in

wet ones; the resulting imbalance in surviving artifacts does not necessarily reflect the use or production of such objects (Forbes 1966, 131).

Unfortunately, not all glass artifacts can even be associated with datable contexts, such as those identified by Panagiotaki from the material excavated by Sir Arthur Evans at Knossos (Panagiotaki, Maniatis et al. 2004, 162). Even if a glass object can be attributed to a secure context, that context is not necessarily the one in which the artifact was created. The "heirloom potential", or likelihood that an object was created much earlier than the context in which it was found, can complicate the interpretation of a glass import (Cline 1994, 1). This challenge is especially pertinent to Minoan Crete where many vitreous finds come from tombs which were in use for several generations (Panagiotaki, Maniatis et al. 2004, 162).

Textual evidence provides an additional challenge because it can occasionally prove to be a false friend. Davison wisely cautions against the use of contemporary economic records and letters as proof of glassmaking techniques. These documents, she asserts, were not meant to be educational; instead she reminds researchers that they were created for administrative purposes and had little to do with practical knowledge of technology. Davison further suggests that ancient texts regarding manufacturing techniques of vitreous materials might even have been intentionally cryptic in order to preserve trade secrets (2003, 109).

Acknowledgement of the challenges presented by ancient epigraphic sources is not to deny their use entirely. For example, it has been asserted that some early glass objects were created to imitate precious stones such as red jasper or lapis lazuli (Davison 2003, 18; Forbes 1966, 115, Panagiotaki 2000, 154). In fact, Forbes notes that the

Egyptian language distinguished between natural stone and “molten stone” or “molten precious stone” (1966, 123; For the publication of these records see Forbes 1966; Oppenheim 1973). It is also possible that textual sources, such as the Amarna letters, can illuminate diplomatic and trade relationships in the Bronze Age Aegean (Oppenheim 1973, 260–266).

The industry of glass can itself complicate an understanding of vitreous craft in the Bronze Age. For example, attempts to determine the origin of a glass object recovered in the Aegean can be thwarted by the blurring of lines between two different, but related industries: glassmaking and glassworking. Glassmaking, which includes the gathering and processing of raw material, results in unworked glass. This product could have been turned immediately into a vitreous object such as a bead, vessel, or other luxury item, but it could also have been traded or sent in unworked form to another workshop.

If a secondary workshop was part of the equation, it could have operated nearby, or after a significant lapse of time and distance between original production (Ingram 2005, 106). For example, Tell el-Amarna seems to have been host to a glass industry that included both glassmaking and glassworking areas (Petrie et al. 1894, 26-27). However, the discovery of glass ingots on the Ulu Burun shipwreck found off the coast of Turkey indicates that unworked glass was also being shipped overseas (Pulak 1985). Additionally, the Amarna letters confirm that glass was traded in unworked, or raw form (Ingram 2005, 11).

It is clear that vitreous materials, in both raw and finished forms, were being shipped by both sea and land to various locations throughout the Aegean. The consensus is that, in the Bronze Age, trade operated around the Aegean in a generally counter-

clockwise fashion (Cline 1994, xvii). Of course, merchants were not limited to any one beginning or end location. They could have commenced their cyclical journey at any point along the route, or have engaged in shorter journey between only two or three ports of call (Cline 1994, vxiii). An object on a trading vessel could have traveled through many combinations of sites before arriving at its final destination. As so many vitreous objects "imitated the shapes and styles" of other regions, determining a place of conception is a complicated process (Panagiotaki 2000, 155).

Additionally, it is unclear who initiated this trans-Aegean movement of goods, and why (Davis, 2008, 188–89). While the trade and exchange of some materials may have been centrally monitored or controlled, it is possible that other goods were moved by independent parties (Knapp, 1992, 113). For example, Cline asserts that relations between the Aegean and the Syro-Palestinian region consisted of "a combination of private merchants and official (royal?) missions" (1994, 49). Plenty of archaeological evidence exists for contact between Egypt and the Minoans, but it is also obvious that a relationship between Mesopotamia and the Aegean existed (Cline 1994, 24, 31). Unfortunately, there are many paths an artifact could have taken between these three locations, and just as many reasons for doing so.

In light of the aforementioned challenges, when faced with a vitreous artifact in the Aegean, how is a scholar to determine its place of origin? There are many visual similarities among glass objects found in the Aegean and those found in Egypt or the Levant. In addition, some scholars have taken a technological or chemical approach to comparison. For example, Panagiotaki and Nicholson have asserted that cobalt blue glass would have been imported from Egypt, while blue glass colored with copper is more

likely to have come from Western Asia (Panagiotaki 2004, 169; Nicholson 1997, 143). It is necessary to remember that distribution of vitreous objects could have happened in more than one stage. The vessels or other goods could have not only been exported, but then further distributed internally within the secondary region (Cline 1994, 86). Additionally, glass was sometimes re-melted in a location secondary to its place of origin, further complicating our ability to define an object's point of genesis (Nicholson, Jackson, and Trott 1997, 147).

Through an attempt to understand the route taken by glass objects into, and through, the Aegean, we can hopefully gain a better understanding of vitreous items in the Bronze Age. Luxurious in their own right, glass vessels could have contained precious liquids such as perfumed oils. Glass beads could have been worn as jewelry, such as the necklaces depicted in wall paintings at Thera (Karetsou, Andreadaki-Vlazaki and N. Papadakis 2001, 95). Beads that accompanied the deceased into their tombs, as well as those that adorned the living may have been sewn onto garments or headdresses (Karetsou, Andreadaki-Vlazaki and N. Papadakis 2001, 94–95).

It is my intention to combine a variety of strategies to investigate the possible origin of glass beads from Chryssi, Papadiokambos, and Mochlos, and glass vessels from Amnissos, Kalyvia, and other sites. My research examines the general dynamics of Bronze Age trade, in an effort to determine the most likely path that glass artifacts would have taken across the Aegean. I have also cataloged and drawn several glass beads found in recent excavations in Minoan contexts on Crete. In 2009, some of these pieces were examined using pXRF technology available at the INSTAP Study Center for East Crete. None of them were ground up for analysis or otherwise destroyed. In addition to study of

the aforementioned ancient beads, I undertook a replication study in collaboration with the Glass Area at Temple University's Tyler School of Art. This included working with Amber Cowan, a senior graduate student, to create glass beads of similar appearance and in a comparable technique to those cataloged for this thesis. The aforementioned methods were undertaken to compare the craftsmanship, materials, decoration, and style of this study group to glass objects from Bronze Age Egypt and the Levant.

This study includes a catalog of eighteen vitreous beads and vessels, twenty of which are unpublished and currently housed by the INSTAP Study Center for East Crete. A permit for this work is pending. Many of these objects possess a similar pattern of trailed lines creating a feathered decoration. Such items will be compared to objects found in both the Levant and Egypt.

While glass artifacts such as those found on Minoan Crete are often assumed to be Egyptian in genesis, a Western Asian source has not been sufficiently ruled out. Far more evidence than what is available is needed to write definitively on the origin and provenance of specific glass objects in the Aegean. In Panagiotaki's words, "the analytical work is still in its infancy" (2008, 48). However, a combination of visual, technological, and textual approaches can shed much needed light on the dynamics of the trade of vitreous materials in the Bronze Age.

CHAPTER 2

CHRONOLOGY AND BACKGROUND

Found in LM IB-Final contexts, glass beads were excavated at Mochlos, Papadiokambos, and Chryssi in the summers of 2005 and 2009. These items correspond in date to glass objects from both Egypt and Western Asia. On Crete, this era is part of the Neopalatial period, extending from MM II–LM IB. At this time, Crete was the most urbanized and densely populated "civilization yet to arise in the Aegean" (Davis 2008, 205; Younger and Rehak 2008, 141). In addition to achieving local prosperity, Minoans expanded their network and influence beyond Crete (Younger and Rehak 2008, 140). Regularized trade was taking place across the Late Bronze Age Aegean at this time, as demonstrated by the existence of sailing ships, "standardized weights and measures" as well as products (Knapp 1998, 115).

At roughly 1700 B.C., Crete suffered a great earthquake, or a series of earthquakes (Knapp 1998, 112). "During the Neo-Palatial period that followed," the Minoan palaces on the island were "elaborately reconstructed" (Knapp 1998, 112). This era of stability was supported by an economy in which palaces "could take advantage of land for farming and herding" (Betancourt 2007, 69). Late Minoan, however, was interrupted by the eruption of Thera. While it was previously thought that Thera's explosion was responsible for the end of Minoan Crete, this is now understood not to be the case (Davis 2008, 205). The volcano, accompanied by tsunamis and earthquakes, does not appear to have ended Minoan civilization but instead "marked a pause that can be documented in the archaeological record" (Betancourt 2007, 67). After the Theran

disaster, it appears that “contact between Crete and the Aegean continued” (Davis 2008, 205).

Absolute chronological dates for these events are still being debated. According to current scholarship, Thera erupted at the end of LM IA; the “absolute calendar date for the eruption, and thus the range of time included in the LM IA period”, however, is still up for consideration (Knapp 1998, 114). Evidence from Mochlos, for example, has caused scholars to suggest the possibility of a longer LM IB period at this, and other, sites (Soles and Davares 2003).

While the palaces of Phaistos and Knossos both thrived in earlier periods, Phaistos appears to have lost some of its influence in LM IB (Knapp 1998, 116). Potentially, the administration of the whole island was left to the larger center (Younger and Rehak 2008, 150–151). It has been suggested that Knossos “probably ruled all of Crete” (Betancourt 2007, 29). This Neopalatial period “flourished from just after the destructions of MM IB until the destructions of LM IB” (Betancourt 2008, 216). The end of LM IB is marked by widespread destruction by fire “which destroyed almost all administrative sites” on the island (Younger and Rehak 2008, 140; Knapp 1998, 116). Neopalatial Crete had seen “considerable expansion in settlement” (Davis 2008, 201). On the other hand, in the subsequent LM II period, “settlement all over Crete contracted” (Knapp 1998, 116).

Mochlos is located in east Crete and was settled as early as EM IIA (Wilson 2008, 93). The island includes house tombs and exhibits burial practices “similar to those of the Mesara tholoi” (Wilson 2008, 93). The Neopalatial architecture on what is now an island “follows a long period of occupation;” settlement began as early as the EM II

period, and appears to have lasted until the end of LM IB (Soles and Davares 2003, 2). Furthermore, it has been suggested that Mochlos "experienced several different construction phases" after the explosion of Thera (Soles and Davaras 2003, 46). Both Mochlos and Chryssi do not show destruction at the end of LM IB and continued to be inhabited into the LM IB-Final period, which contains stylistically later pottery. Glass beads found at these sites come from LM IB-Final, not pre-destruction LM IB. LM II, with Mycenaean influence, begins after LM IB-Final in East Crete.

CHAPTER 3

LM IB BEAD-MAKING TECHNOLOGY

Although glass vessels come from later in Bronze Age Crete, the only glass objects known from LM IB are beads.

Mochlos	4 beads
Papadiokambos	2 beads
Chryssi	7 beads

Figure 1. LM IB-Final glass beads

Mochlos, Chryssi, and Papadiokambos, all of which are located in eastern Crete, contained glass beads in LM IB-Final contexts. Four of these glass beads were excavated at Mochlos, two of which exhibit a zigzag decoration created by trailing and manipulating threads of colored glass. Two of the glass beads were found at Papadiokambos, both of which are blue and globular in shape. Seven glass beads were excavated at Chryssi in LM IB-Final contexts. At least two of the beads from this site also exhibit the same type of zigzag decoration.

With one exception, the solid glass beads from all three sites were rounded or fully spherical. Only one of the solid glass beads, CHR 808, is flower-like in shape. All of those found at Chryssi are white, while the two from Mochlos are blue. Only one of

these solid blue beads from Mochlos remains intact, while the other has been crushed. The beads from Papadiokambos are smaller than the others, and are bright blue. All of the solid glass beads appear to have been pierced through the center.

Both Mochlos and Chryssi also yielded decorated glass beads. Numbering four in total, these objects are all white. On the surface, the opalized trails of glass decoration are also white, although they were originally a color contrasting with the body of the bead. Testing done during the summer of 2009 at the INSTAP Study Center for East Crete has suggested that iron content found in CHR 654 and CHR 651 might represent the body of the bead and manganese the decoration, although this is inconclusive. Iron yields a brown color and manganese yields a black color. If the manganese present in the beads was intentional, the beads were potentially brown with black zigzag trails of glass. All four of the decorated glass beads are cylindrical in shape and pierced lengthwise.

Some of the beads from Mochlos and Chryssi exhibit zigzag designs. These beads are similar in appearance and most likely identical in means of production. An examination of exact formulae will not take place in this chapter because, as Phillips states, "the ancient artisans did not have exact, definitive formulae" (Phillips 2005, 93). Rather, this chapter focuses on ingredients for vitreous products in general, as well as specific techniques for glassmaking and beadmaking. Experiments conducted in the fall of 2009 help to clarify how wire-wound beads were made.

Glass consists of soda, lime, and silica. Bronze Age craftsmen could have found these ingredients in plant ash, sea shells or coral, and quartz sand respectively (Ingram 2005, 111; Forbes 1966, 117). Plant ash, also known as *Salsola kali*, would have been available "all over the Mediterranean" (Panagiotaki, Maniatis et al. 2002, 150). This

ingredient “acts as a catalyst,” lowering the melting point of silica and making it “manageable” for ancient craftsmen (Ingram 2005, 106; Forbes 1966, 114). According to Forbes, limestone itself could have been added, rather than sea shells; in Egypt, he specifies, dolomitic limestone was used (Forbes 1966, 117). Although lime would increase both stability and durability, it might have been an accidental inclusion (Ingram 2005, 106). Despite the fact that glass is made from a soda-lime-silica compound, a variety of compositions have been recorded (Forbes 1966, 117).

Regardless of the means by which the ingredients were collected, once obtained they would have been ground together and made into frit (Ingram 2005, 111). This product would have been ground up a second time and mixed with a coloring agent, heated again, and then pulled into canes or annealed (Ingram 2005, 111; Forbes 1966, 125). Coloring agents included cobalt, iron, and copper in addition to other metals, although it is possible that sometimes these ingredients were included accidentally (Forbes 1966, 128).

Although faience and glass are made of the same or similar materials, faience is “merely sintered” while glass is “fully melted to a liquid state” during its manufacture (Ingram 2005, 106). According to Tite and Shortland, the two products consist of the same ingredients, but in different proportions (Tite and Shortland 2008, 147). Additionally, Forbes describes their “mode of manufacture” as entirely different (Forbes 1966, 112). Panagiotaki confirms that the two products are fired at different temperatures (Karetsou, Andreadaki-Vlazaki and N. Papadakis 2001, 454). On the surface the two products may look similar, but if sliced open, glass will remain the same throughout while faience appears as a vitrified shell surrounding a core. The high temperatures

needed to fully melt glass and achieve this effect would have required an ancient kiln to have been preheated "for a number of hours" before this process could begin (Ingram 2005, 111).

During the melting process, Bronze Age glass would have been heated slowly in a cylindrical, ceramic crucible (Rehren and Pusch 1977, 134; Forbes 1966, 112–114). Rehren and Pusch state that a copper rod would have been used to stir the molten glass; bronze would not have stood up to the heat, and a ceramic tool "might have contaminated the melt" (Rehren and Pusch 1977, 137). Due to the rarity of complete crucibles that have been recovered, as well as the presence of vitreous product on the inside of many existing fragments, it has been suggested that crucibles were chipped away to break out the hardened glass inside them (Rehren and Pusch 1977, 139).

After the raw glass had been created, it could have been used to create beads for jewelry or clothing. The body of glass beads such as those found at Chryssi and Mochlos, or "wire-wound beads," would be made around a heated metal rod, commonly called a mandril (Ingram 2005, 114). Forbes suggests that ancient mandrils might have been made out of copper (Forbes 1966, 125). One end of the mandril would need to be dipped in a clay slip; this would prevent the glass from sticking to the rod and allow for eventual removal of the bead. To build the body of the bead, a droplet of hot glass would have been allowed to drip onto the mandril. Within the edge of a flame, the mandril would then be slowly but consistently rotated, allowing the hot glass to settle into a globular shape. Once the bead became satisfactorily round, the mandril would be removed from the flame, although it could be "flashed" in and out of the heat to soften the glass and

repeat the process if necessary. At this point, the coagulating bead could be quickly rolled along a hard surface, resulting in a more cylindrical shape if desired.

According to Ingram, glassworking usually took place in "small, local workshops," although larger installations are not out of the question (Ingram 2005, 112; for discussion of a large-scale operation see Rehren and Pusch 1977, 129). Evidence for bead-making around a mandril has been found at both Amarna, in Egypt, and Nuzi, in Mesopotamia (Ingram 2005, 117). Tubes and canes of glass, as well as "imperfect glass beads with trailing ends" at Amarna "confirm the technique of winding" (Nicholson 1997, 385–386; Ingram 2007, 117; for publication of these finds see Petrie 1894). At Nuzi, "analysis of some of the thousands of glass beads" reiterates use of the winding technique (Ingram 2007, 117).

In order to create the feathered design displayed on the finds from Mochlos and Chryssi, a second color of glass would be applied to the body of the bead. The still-warm bead would be again placed in the edge of a flame, and the second rod of colored glass would be allowed to drag across its surface. The glassmaker would rotate the mandril as before, resulting in a series of roughly parallel lines made with the second color of glass. To pull these lines into the feathered or zigzig design exhibited by the Mochlos and Chryssi beads, the glassmaker would then drag a thin, and perhaps pointed, instrument across the surface of the bead in a direction perpendicular to the parallel lines. This would pull the newly-applied stripes downward in the middle, resulting in a fanned or feathered display of stripes. According to Phillips, this technique "had already been introduced before the end of Thutmose III's reign" (Phillips 2005, 94). Forbes further suggests that a "wooden comb or spike" could have been used to create such a pattern (Forbes 1966,

125). A thin needle could be also have been used for this purpose, although the author has witnessed a modern glassmaker use a thin rod of glass itself to achieve identical effects. The dragging process happens in a matter of seconds, and the glass, if used for this purpose on something as small as a bead, does not have time to melt into the design. Finally, the beads could have been smoothed lightly with pumice, or exposed briefly to heat, to soften and polish the surface (Ingram 2005, 116).

CHAPTER 4

GLASS TRADE IN THE LATE BRONZE AGE AEGEAN

Although its exact nature is unclear, LM IB Crete engaged in extensive overseas shipping (Knapp 1998, 124). Due to the rarity of glass objects on Crete from this period, as well as the lack of convincing evidence for local production, the glass beads from Mochlos, Papdiokambos, and Chryssi were mostly likely imported (Phillips 2005, 97). As such, these beads are indicative of the ample trade networks in which Late Minoan Crete participated. Minoans made and worked with faience, and while it is not impossible that they also created glass, the evidence for manufacture on the island during the LM IB period is inconclusive (Panagiotaki 1999, 621). At this time, it is more likely that raw glass was worked on Crete after being imported from abroad. If not created locally, glass objects would probably have originated in Egypt or the Levant (Forbes 1966, 130). Relationships and exchanges with both of these partners have been well-documented. These trade networks are visible in chronological relationships, physical characteristics of trade goods, and the logistics of overseas travel in the Aegean Bronze Age.

Both direct and indirect connections between Egypt and Crete are well-established (Karetsou, Andreadaki-Vlazaki and N. Papadakis 2001, 16–17; Cline 1994, 32). When Pharaoh Tuthmosis III pursued military campaigns through the Levant ca. 1450 B.C., glass-making technology was brought back from Western Asia into Egypt (Davison 2003, 18; Karetsou, Andreadaki-Vlazaki and N. Papadakis 2001, 94). This is the same period as the Aegean frescoes from Tell el-Dab'a (Bietak 2008). The glass beads recently found at Mochlos and Chryssi were found in LM IB-Final contexts, which is slightly too early to have been affected by the campaigns of Tuthmosis III. The Hyksos

were newly ousted from Egypt, and the Pharaoh pursued them back to Syria (Cline 1994, 7–8). If Egypt did not develop a glassmaking industry on a large scale until after these Syrian excursions, it would have been too late for Egyptians to have been responsible for the glass beads from Mochlos and Chryssi (Forbes 1966, 129; Cline 1994, 7–8). It should nevertheless be reiterated that Aegean chronology is still fiercely debated. Absolute dates for major events remain unconfirmed, and, chronologically speaking, it is not inconceivable that Egypt was in fact the producer of the glass beads excavated at Mochlos and Chryssi.

In contrast, during the 16th and 15th centuries, "the Levant played an important part in the trade in raw glass and finished products" (Davison 2003, 18). Western Asia and Mesopotamia had been producing glass for a longer period of time than Egypt, and they perhaps would have been better equipped to supply the Aegean with vitreous goods (Oppenheim 1973, 262; Forbes 1966, 132). Not only did the Levant transmit glassmaking to Eighteenth Dynasty Egypt, but the technique of trailed designs was also adopted by the Egyptians (McGovern, Fleming and Swann 1993, 3). Despite Mesopotamia's long history of glassmaking, "comparatively few glass objects have been excavated there" (Davison 2003, 17). Of course, the limited amount of recovered glass may be due to relatively humid soil conditions, rather than lack of production. Within this limited number of vitreous artifacts, a great number of glass beads have been recovered in the Levant (Ingram 2005, 116; McGovern, Fleming and Swann 1993, 3).

Physical comparisons exist between glass objects found in Late Minoan Crete and those produced in other regions. For example, CHR 654 and CHR 651 are decorated with a zigzag of the type described in the previous chapter. Similarly decorated fragments of

glass have been found in Egypt at Amarna and Malkata (Nolte 1971, 170). While these objects are of a slightly later date than the Chryssi beads, the surface designs are strikingly similar (Nolte 1971, 167–170). According to Phillips, Aegean glass objects are stylistically comparable to glass in "the Near East" (Phillips 2005, 95). She does not state more specifically what locations are included in "the Near East," which makes it difficult to discern whether she is referring to Egypt, the Levant, Mesopotamia, or all of the above. Panagiotaki notes that glass imports arrived in Crete from Mesopotamia, but she states that the "white and yellow thread decoration" resembles Egyptian vase-decoration (Panagiotaki, Maniatis, et al. 2002, 164). Panagiotaki also writes that "glass vases found in Crete...do not look stylistically different" from Egyptian examples; yet the vessels to which she refers date to LM III, and do not prove the origin of earlier beads (Panagiotaki, Maniatis, et al. 2002, 163). There is also evidence of comparable designs from Mesopotamia and the Levant (McGovern, Fleming and Swann 1993; Luckner 1994, 7; Nicholson 1997, 379). Excavations in what is now Israel have unearthed not only glass, but specifically cylindrical beads that exhibit zigzag designs of colored glass (McGovern, Fleming and Swann 1993, 3–4).

Not only does Egyptian-style glass appear on foreign soil, but foreign-made glass has been excavated in Egyptian territory. In the Tomb of the Foreign Wives of Tuthmosis III at Wadi Qirud, over a thousand glass beads were found along with a glass goblet and lotiform chalice (Nicholson 1997, 378–379). While these objects were excavated in Egypt, the colorants used in the goblet as well as its shape are Mesopotamian imports (Nicholson 1997, 379). The lotiform chalice, on the other hand, is stylistically Egyptian.

Additionally, not all of the glass was manufactured in the same location; some was made locally, while some was imported (Nicholson 1997, 379).

Glass beads found on the Ulu Burun shipwreck appear to have been wire-wound. Ingram identifies them as such based on their striations, perforation deposits, and the peaks present at their ends (Ingram 2005, 118). Additionally, Ingram likens these glass beads to those from Nuzi (Ingram 2005, 118). Although the Ulu Burun evidence is later than the beads from Mochlos, Papadiokambos, and Chryssi, it can still provide a potential format for the patterns of Late Bronze Age trade in glass (Nicholson, Jackson and Trott 1997, 152).

Beyond the surface appearance of the glass beads in question, their chemical makeup is available for consideration thanks to Kathy Hall at the INSTAP Study Center of East Crete. Experiments conducted at the Study Center have established that CHR 651 and CHR 808 both possess a high concentration of copper. It has been determined that CHR 808 is also high in manganese. This does not, unfortunately, identify the place of manufacture. While both of these substances were used as colorants in Bronze Age glass production, Hall wondered in her notes if it were possible to determine the difference between "deliberately added manganese, and manganese occurring as a soil contaminant" (Hall 2009; Forbes 1966, 128). Forbes has noted that manganese might come from dolomitic limestone which, he writes, was used specifically in Egypt (Forbes 1966, 117). Perhaps the raised levels of manganese in CHR 808 indicate an Egyptian origin for this bead. In her notes, Hall specifies that the chemical compositions of the beads were "assumed to be seriously affected by deterioration" and as a result, her aim was to determine instead the original colors of the beads (Hall 2009). It remains uncertain how

much manganese was actually present in the bead at its time of manufacture, and thus the association with Egypt remains unproven.

If neither chronological associations nor physical characteristics can determine the origin of the glass beads found at Chryssi and Mochlos, perhaps the answer can be found in the patterns and logistics of Bronze Age Aegean trade. Not only did goods move around the region, but an "increased mobility of craftsmen" occurred during the Late Bronze Age (Peltenberg 1971, 11). It has been noted that glazes and glaze-working took place in close association with metalworking (Peltenberg 1971, 11). While neither faience nor "glaze" is the same thing as glass, it is a related process that uses similar materials; perhaps it still stands to reason that vitreous objects of all types were created and worked alongside metalworking. Perhaps it can be further assumed that if vitreous craft was so "familiar to metalworkers," the two products could have been traded alongside one another (Peltenberg 1971, 10). While not impossible, this is merely a hypothesis that remains unsubstantiated.

According to Soles and other scholars, there is evidence at Mochlos for trade with Syria, and specifically with Ugarit (Soles 2005, 429; Karetsou and Andreadaki-Vlazakis 2001, 158). The largest number of these Syrian imports comes from LM IB (Soles 2005, 429). Presumably because Crete, while self-sufficient in many areas, was severely lacking in metal, the "main reason for the voyage" was to bring copper, tin, and lead (Soles 2005, 429). There were many other types of objects that perhaps came on Syrian ships, such as cylinder seals, raw ivory, sealstones, and a bronze trident (Soles 2005, 429). Crete was "dependent on other regions" for semiprecious stones and metals (Karetsou, Andreadaki-Vlazaki and N. Papadakis 2001, 93). As a luxury item, perhaps

glass was shipped along with other valuable goods. Although Soles does not mention glass in this article, it is certainly possible that it could have been included amongst the trade goods on board ships arriving on a Syrian ship.

One of the biggest obstacles to determining the origin of a foreign import found on Cretan soil is the indirect and non-exclusive nature of trade routes used during the Bronze Age (Karetsou, Andreadaki-Vlazaki and N. Papadakis 2001, 14). The Minoans received objects from multiple sources, including Egypt, the Levant, and Mesopotamia (Cline 1994). Instead of exchanges that took place directly between two parties or locations, it is probable that trading vessels stopped at multiple places along the way while dropping off and picking up goods (Karetsou, Andreadaki-Vlazaki and N. Papadakis 2001, 84; Cline 1994, 27). As a result, even if scholarship is able to determine the "national identity" of a trading vessel, the origins of its goods cannot necessarily be pinpointed (Cline 1994, 50). This could result, for example, in an Egyptian object arriving at Minoan shores on a Levantine boat. The circumstances could also be reversed, as Knapp states that West Asian goods "were transshipped to Egypt on *Keftiu* ships" (Knapp 1998, 125). Even though evidence indicates that "Semites, Hurrians, Anatolians, Egyptians, Minoans, Cypriots and perhaps even Mycenaean Greeks were involved" in intra-Aegean trade, it is unclear which parties (if any) "controlled or directed trade" (Knapp 1998, 128).

This is not to say that direct relationships between regions or sites were impossible, merely that they do not constitute the whole reality of the Bronze Age Aegean. Minoan contacts with Egypt have been well-documented, but the Aegean also traded with Western Asia (Knapp 1998, 125; Cline 1994; Karetsou, Andreadaki-Vlazaki

and N. Papadakis 2001, 21). Crete not only had connections to Western Asia, but this relationship may have begun as early as Middle Minoan (Betancourt 2008, 217; Davis 2008, 198). Minoan-style frescoes found in the northeastern Nile Delta are indicative of Crete-Egypt contacts, but Younger and Rehak note the existence of "Minoan motifs" at other locations such as Miletos, Alalakh, and Tel Kabri (Younger and Rehak 2008; for discussion of Tell el-Dab'a frescoes, see Karetsou, Andreadaki-Vlazaki and N. Papadakis 2001, 279). Theban tomb paintings show Aegean gift-bearers, but they also depict "Syrian tributaries," which attests to a complex and varied system of "multicultural exchanges among the populations of the eastern Mediterranean" (Younger and Rehak 2008, 157; Karetsou, Andreadaki-Vlazaki and N. Papadakis 2001, 91). Although Cline states that LM I–II Crete had four times as many Egyptian imports than from anywhere else, it is unlikely that Egyptians travelled directly to Crete on a regular basis (Cline 1994, 9; Lambrou-Phillipson 1991, 14). Knapp writes that the island "enjoyed good economic relationships with Egypt, Mari and Ugarit" (Knapp 1998, 125).

A further complication in the pursuit of the Mochlos and Chryssi beads' potential origins is the nature of the glass trade in particular. Not only was Aegean Bronze Age trade in general full of complexities, but the specific realities of glass exchange remain unclear as well. While too late to be contemporaneous with the Mochlos and Chryssi beads, the Ulu Burun shipwreck has shed a great deal of light on the nature of Late Bronze Age trade (Pulak 1988; Ingram 2005, 121). Most relevant to this study is the presence of glass beads aboard the ship, some of which were stored in a Canaanite jar (Ingram 2005, 121–122).

The Ulu Burun shipwreck contained raw glass in addition to finished vitreous products (Ingram 2005, 113). The vessel carried many colored ingots, which demonstrates the significant place held by raw glass in the trade and exchange of vitreous materials (Rehren and Pusch 2005, 1758; Phillips 2005, 95). If raw glass was exported to a new location where local craftsmen worked the material into final products, does one define the finished object as local or imported? It is conceivable that Minoans possessed beads made of Egyptian glass, but worked on Levantine soil. While the Ulu Burun shipwreck sheds light not only on trade, but specifically on the exchange and movement of glass in the Bronze Age Aegean, many of the details are still unclear.

Egypt has been identified as the probable source for the Ulu Burun ingots, and scholars have even been able to identify two Egyptian locations responsible for particular colors of raw glass (Nicholson, Jackson, and Trott 1997, 145–146; Nicholson 1997, 385). In light of the Canaanite jar containing glass beads, the Ulu Burun vessel appears to have been leaving Western Asia with both Egyptian and Levantine glass products on board.

While consistent contacts between Egypt and the Aegean are not being contested here, due to water and weather patterns, Minoan vessels would have reached Egypt more easily than the reverse. It makes sense, then, to assume that even if the Chryssi, Papadiokambos, and Mochlos beads were Egyptian in origin, they arrived on Crete via intermediary stops in Western Asia. This state of affairs, combined with the multitude of similarities between Levantine and Egyptian glass, makes identifying the source of these beads impossible at this time.

Considering Neopalatial Crete's "interest in long-distance travel," it is no wonder that the glass beads up for discussion were recovered from coastal or island locations

such as Mochlos (Betancourt 2007, 88). Chryssi is also small island located off the southeastern coast of Crete. Papadiokambos was a Minoan site located on the northeastern coast. It has been suggested that merchant ships following the currents would have been carried from east to west on the southern side of the island, and west to east on the northern side (Younger and Rehak 2008, 142). This route would have brought ships past all three locations; Mochlos in the northeast, Amnissos in the north, and Chryssi in the southeast.

While many questions about the exact nature of LM IB Crete remain unanswered, it is clear that trade networks existed between the island and Western Asia, including Egypt. Minoan culture also spread its own influence across the Aegean through "trade and the exchange of ideas" (Betancourt 2008, 217). Although scholars are not yet certain of the specific dynamics of these relationships, "by one means or another, the Minoans engaged in substantial amounts of shipping" (Betancourt 2008, 218).

CHAPTER 5
CONCLUSIONS

Mochlos, Chryssi, and Papadiokambos, all of which are located in eastern Crete, contained glass beads in LM IB-Final contexts. Not only are these sites all found in East Crete, but they are all situated along the coast. The island of Chryssi is roughly fifteen kilometers off the southern coast, while Mochlos and Papadiokambos are located on the northern side of the island. As such, these sites would have been convenient stopping points for vessels navigating the eastern shipping lanes. It has been suggested that Bronze Age trade was "partly seasonal, opportune" and even "random" (Lambrou-Phillipson 1991, 15). While use of the word "random" is probably extreme, it is entirely possible that traders or merchant ships would stop and make exchanges at convenient locations, such as Mochlos, Chryssi, and Papadiokambos.

While later glass objects on Crete have been found in palatial sites, the glass beads discussed above were excavated in non-palatial contexts. It is worth noting that these were not items intended for palatial display. On the contrary, these glass beads were instead used for personal adornment in the form of jewelry. This alone does not negate the possibility of palatial involvement in either bead trade or bead production, however. While the LM IB-Final beads' eastern and coastal find-spots would have been easily accessible to merchants, it is still possible that the objects arrived via Knossian exchange. It has been suggested that Knossos was the primary recipient of finished glass objects, redistributing them amongst the island's settlements (Cline 1994, xvii). As raw glass was also traded in the Bronze Age Aegean, local workshops created objects from imported material (Karetsou, Andreadaki-Vlazaki and N. Papadakis 2001, 102–103; Panagiotaki,

Maniatis, et al. 2004, 149). As a result, glass beads might have been made from foreign, raw glass at a central location and then exchanged or moved within Minoan society in place of, or in addition to, importation. Yet no Knossian items can be proved for LM IB-Final contexts at either Mochlos or Papadiokambos, as the Marine Style vases are all within LM IB (Betancourt 2009, passim). The Marine Style pottery and other signs of Knossian influence in eastern Crete end before LM IB-Final. This fact, in conjunction with the rarity of these glass beads, and their sole location at coastal sites, makes it unlikely that palatial involvement explains their presence.

It is clear that the glass beads found at Mochlos, Chryssi, and Papadiokambos must have originated on foreign, rather than Cretan, soil. An artisans' quarter at Mochlos, now located across from the island on the coast, was also associated with the settlement (Soles and Davares 2003, 2). This craft area exhibited no signs of glassmaking, which suggests that any vitreous objects found there had to have been imported. While it is possible that the beads were made in Egypt and only shipped to Crete via the Levantine coast, it is also likely that these glass beads were made in Western Asia. Glass, colored with iron and manganese, among other materials, was being made in the Levant (McGovern, Fleming and Swann 1993, 1). Furthermore, glass beads decorated with trails of colored glass have been excavated in what is now Israel (McGovern, Fleming and Swann 1993, 3–4). As a result, it is apparent that that the glass beads excavated at Mochlos, Chryssi, and Papadiokambos arrived by sea, from the East.

Five glass vessels have been included in this catalog to serve as comparisons against the LM IB glass objects mentioned above. Vitreous vessels dated to LM IB have also been recorded at Knossos, but these were made of faience rather than glass, and were

not decorated with patterns of trailed glass, and so have not been included in the catalog (Cline 1994, 220–221). Three of these vessels, all found in LM III contexts, exhibit decoration that consisted of trailed threads of glass resulting in a zigzag design nearly identical to the beads from Mochlos and Chryssi (Karetsou, Andreadaki-Vlazaki and N. Papadakis 2001, 100; Cline 1994, 196). While none of the glass objects from LM IB Crete were found in Central or Western Crete, two of these later decorated vessels were excavated at Kalyvia and Kommos, on the southern coast of Central Crete. The third was found at Amnissos, on the northern side of the island. Two glass vessels that do not exhibit trails of colored glass were found at Zapher Papoura and Kalyvia. The Kalyvia flask was decorated with an engraved star motif; this piece has been dated both to the 15th–14th centuries B.C. generally, and to LM III (Karetsou, Andreadaki-Vlazaki and N. Papadakis 2001, 99).

These new glass finds from dated to LM IB-Final are representative of a stage in Bronze Age glass trade that has not been previously recorded. It is clear that during this period glass objects, decorated in ways that were previously limited to Western Asia, began to be exported to Minoan Crete. The specific dynamics of the trade pattern remain unclear; these exchanges took place independent of Knossos, and potentially Egypt as well. Not only is the regional identity of the trade facilitators uncertain, the origin of the glass beads themselves remains undetermined. It is certain that the beads arrived at the coastal, non-palatial sites of Mochlos, Chryssi, and Papadiokambos from the east. This distribution pattern is in sharp contrast to that of LM III, during which glass vessels are mostly found in Central Crete. Based on the available evidence, these glass beads were most likely manufactured in the Levant.

In later periods, evidence for contact between Western Asia, Egypt and the Aegean remains strong (Cline 1994, 31–32; Karetsou, Andreadaki-Vlazaki and N. Papadakis 2001, 87). As demonstrated by the Ulu Burun shipwreck, Aegean entities remained integrated in a complex web of trade (Ingram 2005, 122). An LM IIIA:1 vessel was excavated at Kommos which, before it disintegrated, exhibited a design yellow and white zigzags (Shaw and Shaw 1993, pl. 27c). By LM IIIB, trade initiative appears to have shifted from Crete to the Mainland as "Mycenaean merchants asserted themselves" (Cline 1994, 35). The "balance of production" of vitreous objects also shifts to the mainland in the late fifteenth century B.C. (Panagiotaki, Maniatis, et al. 2004, 170). From this time onward, nearly all Egyptian objects are to be found on the mainland (Cline 1994, 36).

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Figure 2. CHR 654 1:1

Figure 3. CHR 651 1:1

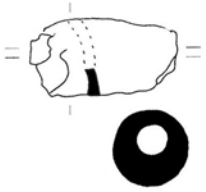


Figure 4. G39 1:1

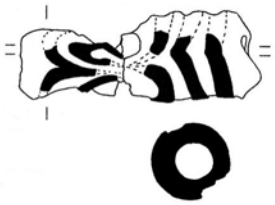
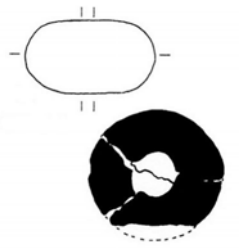


Figure 5. G41 1:1



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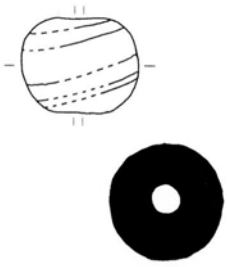

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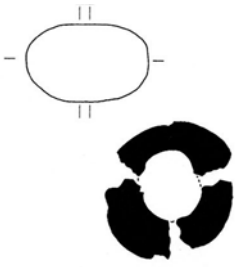

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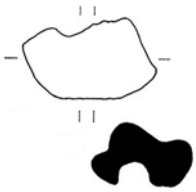

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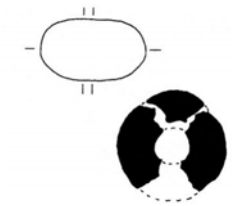

Figure 10. CHR 693 1:1

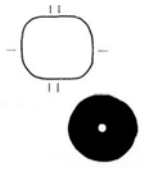

Figure 11. F60 1:1

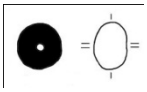

Figure 12. F00002 1:1

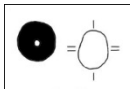

Figure 13. F00003 1:1

Figure 14. G41 and G42 (before joining)

Figure 15. CHR 654 in storage

Figure 16. CHR 651 in storage

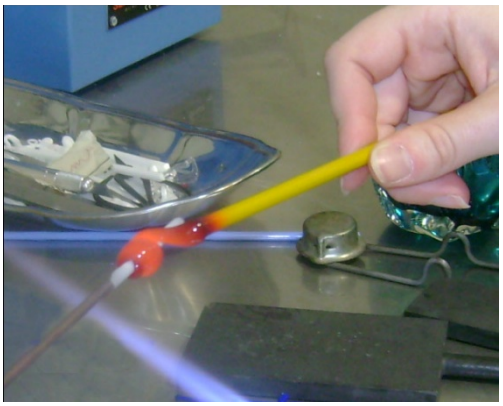

Figure 17. Winding bead onto mandril; with Temple University Glass Area

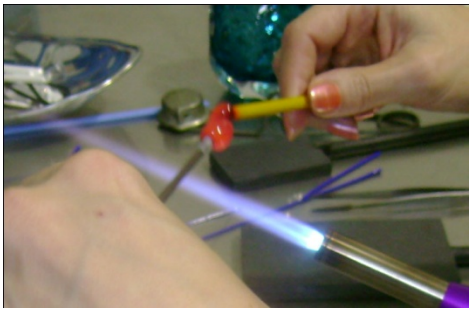

Figure 18. Adding contrasting color of glass onto bead; with Temple University Glass Area

Figure 19. Glass bead made by author; with Temple University Glass Area

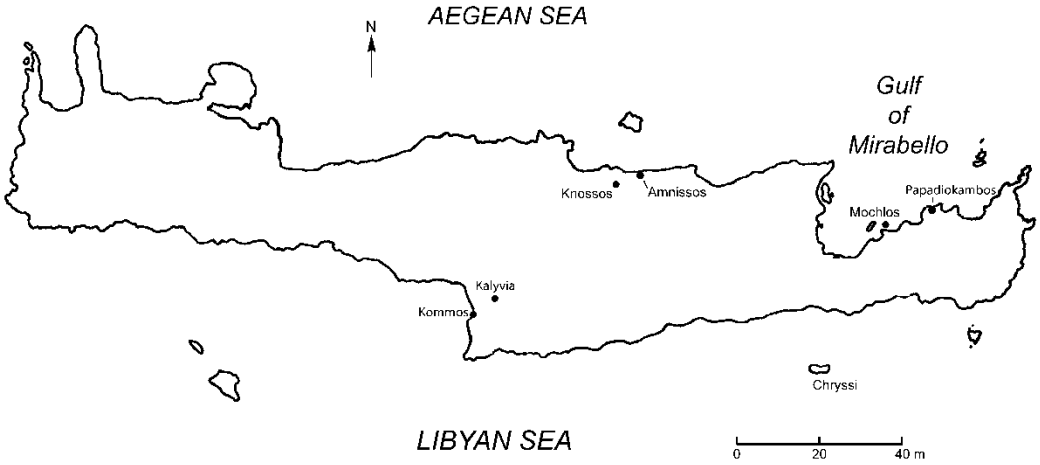

Figure 20. Map of Crete

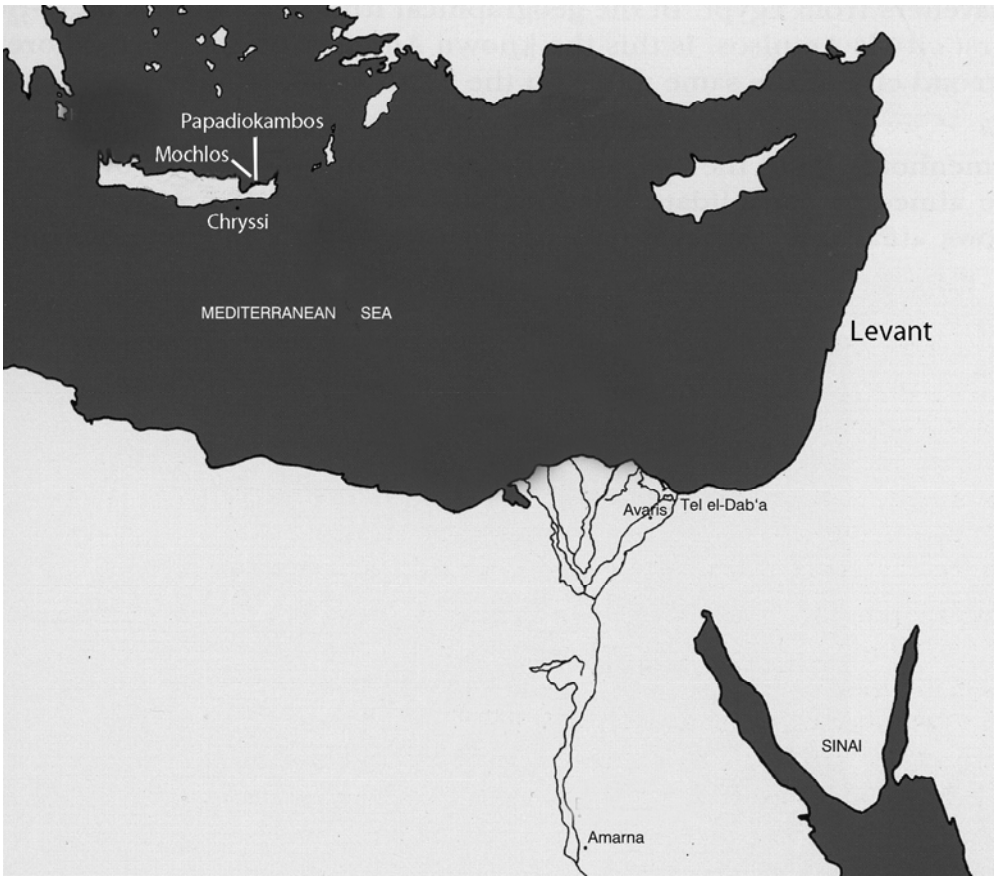

Figure 21. Map including Egypt, Levant, and Crete

APPENDIX A`
CATALOG

1. (CHR 654; Chryssi, Crete). Cylindrical glass bead. Broken on one end. Pres. L. 2.5 cm, pres. d. 0.8 cm. Rest. L 3.0 cm. White. Opalized, white zigzag decoration. Pierced lengthwise. LM IB-Final. Figure 2.

2. (CHR 651; Chryssi, Crete). Cylindrical glass bead. Broken on both ends. Pres. L. 1.5 cm, pres. d. 1.1 cm. Rest. L. 2.0 cm. White. Opalized, white zigzag decoration. Pierced lengthwise. LM IB-Final. Figure 3.

3. (G39; Mochlos, Crete). Cylindrical glass bead. Broken on both ends. Pres. L. 2.09 cm, pres. d. 0.98 cm, pres. d. of hole 0.46 cm. Rest. L. 3.0 cm. White. Opalized, white zigzag decoration. Pierced lengthwise. LM IB. Figure 4.

4. (G41; Mochlos, Crete). Cylindrical glass bead. Two joining fragments (joins with what used to be G42). Pres. L. 2.72 cm, pres. d. 1.15 cm, pres. d. of hole 0.52 cm. Rest. L. 3.0 cm. White. Opalized, white zigzag decoration. Pierced lengthwise. LM IB. Figure 5.

5. (CHR 655; Chryssi, Crete). Flattened globular glass bead. Broken into three pieces. Pres. ht. 1.0 cm, pres. d. 1.5 cm, pres. d. of hole 0.7 cm. White. Pierced through the center. LM IB-Final. Figure 6.

6. (CHR 805; Chryssi, Crete). Globular glass bead. D. 1.8 cm, d. of hole 0.3 cm. White. LM IB-Final. Figure 7.

7. (CHR 807; Chryssi, Crete). Flattened globular glass bead. Broken into three pieces. Pres. Ht.1.0 cm, pres. d. 1.9 cm. White. LM IB-Final. Figure 8.

8. (CHR 808; Chryssi, Crete). Round, flower-shaped glass bead. Incomplete. Pres. ht. 1.2 cm, pres. d. 2 cm. White. LM IB-Final. Figure 9.

9. (CHR 693; Chryssi, Crete). Flattened globular glass bead. Four fragments. Pres. ht. 1.0 cm, pres. d. 1.8 cm, pres. d. of hole 0.5 cm. Mostly white with gray specks. LM IB-Final. Figure 10.

10. (F60; Mochlos, Crete). Rounded glass bead with flattened top and sides. D. 0.9 cm, d. of hole 0.1 cm. Blue. Pierced through the center. LM IB. Figure 11.

11. (F00002; Papadiokambos, Crete). Flattened globular glass bead. Ht. 0.43 cm, d. 0.6 cm, d. of hole 0.1 cm. Blue. Pierced through the center. LM IB. Figure 12.

12. (F00003; Papadiokambos, Crete). Flattened globular glass bead. Ht. 0.4 cm, d. 0.5 cm, d. of hole 0.1 cm. Blue. Pierced through the center. LM IB. Figure 13.

13. (F11; Mochlos, Crete). Glass bead, crushed. Blue. LM IB.

14. (HM 269; Amnissos, Crete). Lentoid glass flask. Long straight neck with everted rim and high base. Three handles: one loop handle on each shoulder and one long vertical strap handle from upper neck to shoulder. H. 12.6, rim d. 2.5, base d. 2.7. Brownish gray, but probably dark blue originally. Decorated with threads of yellow and white glass dragged into loops. Made in the sand-core technique. LM III.

Cline 1994, 196; Karetsou, Andreadaki-Vlazaki and Papadakis 2001, 100; Weinberg 1961–1962.

15. (HM 270; Kalyvia, Crete). Lentoid glass flask. Long straight neck with everted rim and high base. One loop handle on each shoulder. Res. h. 0.156, rim d. 0.03, base d. 0.044. max d. 0.01. Grayish black, but probably originally blue. Decorated with an engraved star motif filled in with white. Vertical line below handles and V-shaped line at the base of the neck. Made in the sand-core technique. LM III.

Cline 1994, 196-–97; Karetsou, Andreadaki-Vlazaki and Papadakis 2001, 99.

16. (HM no. unknown; Pit Cave Tomb 66, Zapher Papoura, Crete). Globular glass bottle. Poorly preserved. Either a pomegranate bottle or high-necked bottle shape. Amber color. Pres. h. 6.5. Made in the sand-core technique. LM IIIA: 2.

Cline 1994, 180.

17. (HM 199; Kalyvia, Crete). Glass krateriskos. Flattened globular body, wide cylindrical neck, and pedestal foot. Fragmentary. Upper part of neck and one shoulder handle are preserved. Pres. h. 7.0, base d. 3.4, max d. 5.6. Mottled grayish black and bluish white. Decorated with yellow and white threads. Horizontal pattern on the neck, loop and garland pattern on the body. Made in the sand-core technique. LM III.

Cline 1994, 206.

18. (Mi 190, Kommos, Crete). Lentoid glass vessel. Two large body fragments. Disintegrated. Dark blue. Decorated with white and yellow threads dragged into loops. Made in the sand-core technique. LM IIIA: 1-2.

Shaw and Shaw 1993; pl. 27c; Cline 1994, 221.