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AND CYPRUS - THE STORY SO FAR**

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Introduction

During the Late Bronze Age copper was traded in a variety of shapes. These are best illustrated in the cargo of the Uluburun ship which dates to the end of the 14th century BC. The ship carried bun or plano-convex ingots, oval shaped ingots and of course ox-hide ingots (Pulak 2005, 59-63; 2000, 141-142). The latter are the ones that we more normally associate with the Late Bronze Age and with Cyprus.

The first oxhide ingots were actually discovered at the site of Serra Ilixi on the island of Sardinia in 1857 (Lo Schiavo 2005a, 305). It was not long after that a similar ingot was uncovered on Cyprus (Fig.1). This was found at Enkomi in 1897 during excavations by a team from the British Museum. In the excavation report published in 1900 it is described as follows:

"Among the bronzes from the foundry site (Fig.25, No 1535) is a thick, heavy slab of copper, having the Cypriote letter si stamped on the surface, apparently when the metal was in a spongy state. Its weight is 81lb 10oz. An analysis kindly made by Prof Church shows 98.05 per cent of copper. In Sardinia similar slabs of copper bearing "letters" or sigla have been found, from which it may be inferred that the metal ready for melting was usually sent out in this form" (Murray et al 1900, 17).

In 1904 Luigi Pigorini published the ingots from Aghia Triadha and in 1906 Svoronos published examples from Phaistos and Mycenae (Lo Schiavo 2005a, 305). The study of oxhide ingots, therefore, began at the turn of the 20th century, when it was observed that ingots made of practically pure copper, of standardised shape and weight, and bearing inscribed symbols, which were found on the islands of Sardinia, Cyprus and Crete, seemed to be the form in which metallic copper was traded in the Mediterranean area during the Late Bronze Age.

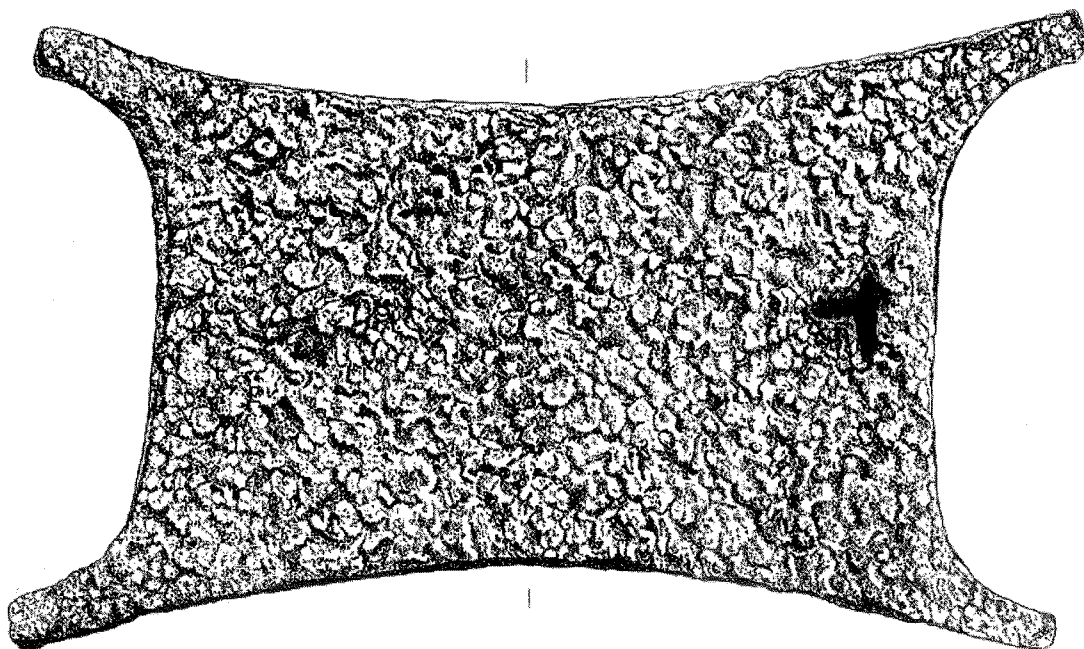
Buchholz in an article published in 1959 was the first to try and compile all the available evidence regarding oxhide ingots, as well as offering a typology of the known varieties of oxhide ingot shapes (Buchholz 1959, 7). In the opening paragraph of his article he pinpoints a key issue that is hotly discussed to this day, and that is the origin of these oxhide ingots. In 1964, Hector Catling published his book entitled "*Cypriot Bronze Work in the Mycenaean World*" in which he dedicated a section to the oxhide ingots found on Cyprus and in Greece, while in 1967 George Bass published the report on the Cape Gelidonya shipwreck, where the largest concentration of oxhide ingots up to that point had been found. In his publication, Bass (1967, 52-78) presented not only the ingots from Cape Gelidonya but also a detailed list of all known ingots and representations of ingots in different media (mainly in Egyptian wall-paintings).

Since then, there have been many more publications discussing the copper oxhide ingots and the issues that had been raised from the very beginning. Many of these will be quoted in this paper. It is not surprising that the questions of the origin of the metal, the shape of the ingots, and indeed the more general issue of the metals trade during the Late Bronze Age, have been the most debated aspects of the study of oxhide ingots.

The aim of this paper is to briefly review the evidence regarding the relationship of oxhide ingots and Cyprus and to support the idea that although in the past Cyprus, Crete, Sardinia and even Egypt were suggested as possible places of origin, today the overwhelming evidence shows that Cyprus is where most of the oxhide ingots were most probably produced.



1. Oxhide ingot said to be from Enkomi now in the British Museum (Inv. 1897/4-1/1535).



2. Oxhide ingot said to be from Enkomi now in the Cyprus Museum (Inv. 1939/VI-20/4)
(Drawing by Clara Vassitsek)

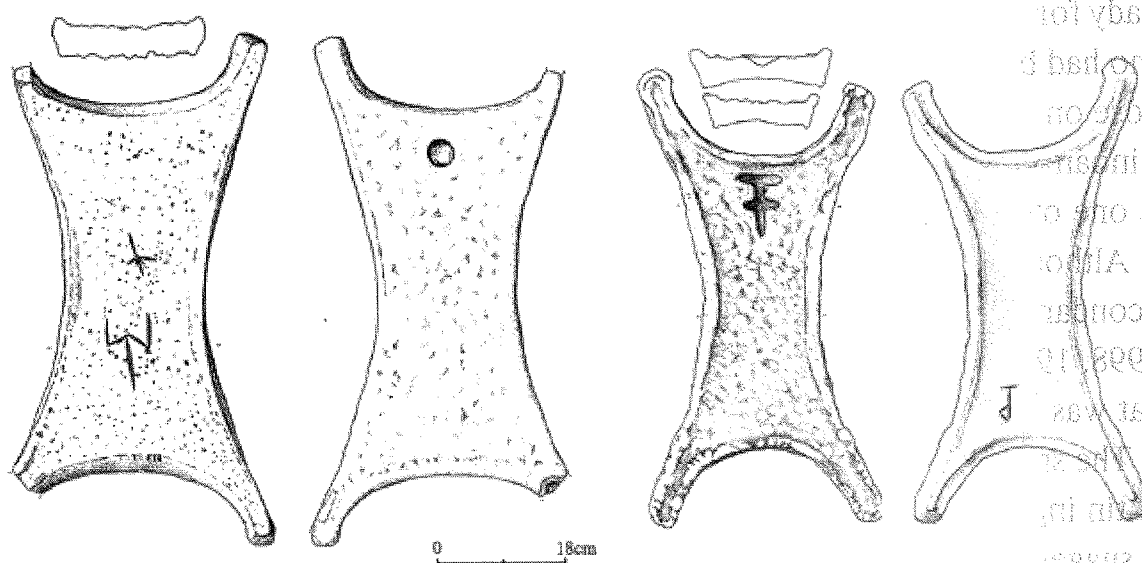
Oxhide ingots

Copper oxhide ingots are rectangular slabs with a length averaging sixty centimetres, a width averaging forty centimetres and a thickness of about four centimetres (Bass 1967, 52) (Fig. 2). They weigh from 23 to 39 Kg but many of them weigh around 29 kg, the equivalent of a talent (Buchholz 1959, 8; Rice Jones 2007, 85). The corners are usually protruded to form four extremities or handles. One surface (what is now known to be the top one) is rough and the other is smooth but bears many small air holes and is often outlined by a raised rim (Fig. 3) (Bass 1967, 52). The rough surface of these ingots, as well as, the resemblance of their shape to hides of oxen depicted in Egyptian wall paintings is what led archaeologists to use the term "oxhide" to describe them (Bass 1967, 69)). In 1924 in his book entitled *Athens, its History and Coinage before the Persian Invasion*, Charles Seltman (1924, 5) suggested that since the ox used to have monetary value in Antiquity, each ingot would have had the value of an ox and, therefore, it was an early type of currency in this premonetary society. As recently explained by Muhly (2009, 18), in what he calls the early "numismatic phase" of oxhide ingot studies, this idea seemed to be further supported because the weight of an ingot was the equivalent of a talent. This proposition, however, was strongly opposed by many, including Buchholz (1959, 8-9). Bass (1967, 71) showed that the weight of the ingots is not always the same while fragments are never accurate fractions of the whole. Thus ingots cannot have been used as currency. Furthermore, Buchholz's (1959, 7) typological study showed that the earlier ingots are almost rectangular and only the latter ones actually have four well defined handles which make them resemble hides. He argued that the shape changed in order to facilitate carrying and transport (Buchholz 1959, 9). Moreover, it has been argued that the rough top surface of the ingots is a result of the casting conditions and the use of an open mould (Tylecote 1982, 94). In other words, the resemblance to the shape of a stretched hide is accidental and not deliberate while the whole idea of the value of an ingot in relation to an ox cannot be supported. Therefore the proposal that oxhide ingots were early forms of currency is no longer accepted (for a detailed discussion see Muhly (2009, 18-21)).

Oxhide ingots, and bun ingots, often bear symbols on the top, rough surface. The symbols fall under two categories: those which are stamped and



3. Bottom surface of a complete oxhide ingot found in da Ozieri in Sardinia.



4. Ingots from Sardinia bearing impressed and inscribed symbols

those which are engraved (Fig. 4). For example at least 160, of the 176 copper oxhide ingots from the 348 oxhide ingots on the Uluburun ship that had been cleaned and conserved, bear marks on the rougher side (Pulak 2000, 141). The oxhide ingots were incised with one, and some with as many as three marks (Pulak 1997, 235; Pulak 1998, 194; Pulak 2000, 146) and they had been stored in such a way on the ship, that the marks would have been visible (Pulak 2000, 141). Many of the other oxhide ingots such as those from the Cape Gelidonya (Bass 1967, 52), the ones from Enkomi (Catling 1964, 267-8), Mycenae (Buchholz 1959, 36) Sardinia, (Vagnetti and Lo Schiavo 1989, 225, Amadasi Guzzo 2009) and elsewhere, bear impressed signs. As stamped marks have to be produced when the metal has not yet fully hardened, it has been suggested that these must have been produced just after the casting of the molten metal, in other words at the place of production (Bass 1967, 72). They were, therefore, termed "primary" marks by Bass (1967, 74). Inscribed marks, on the other hand are considered to be "secondary", as they could have been produced either at the place of production, or at the point of export and even at the point of import. The question of the meaning of the primary and secondary marks had been extensively discussed by Bass (1967, 72-4), who suggested that the primary marks identified the source of copper, while the secondary marks, may have been incised by a person inspecting the material ready for export, by the merchant who received them or even by the merchant who had bought them. Many of the marks on these ingots, including some of those on the Uluburun ingots (Sibella 1996, 10), can be assigned to the Cypro-Minoan script (for a recent discussion Amadasi Guzzo 2009). This used to be one of the strongest links between this type of ingot and Cyprus.

Although we still cannot understand the significance of these primary and secondary marks they are still very important, because as suggested by Pulak (1998, 196), the secondary marks probably relate to the people and the centre that was involved in the trade of these metals.

The strong possibility that the marks found not only on the copper but also on tin ingots and even lead ingots belong to the Cypro-Minoan script led me to suggest (Kassianidou 2003, 115-116), as indeed Maddin, Muhly and Stech in several occasions had suggested more than twenty five years ago (Maddin et al., 1977, 46; Muhly 1978, 45; Wheeler 1977, 24; Wheeler et al. 1979, 148),

that this centre or centres (taking into consideration the number of LBA Cypriot urban centres on the coast) was located on Cyprus and that it was involved in the distribution of metals around the Eastern Mediterranean.

To support this argument I drew a parallel between the inscribed ingots and the inscribed pottery of this period. Hirschfeld (1993; 2000; 2001) has been studying and recording Cypro-Minoan signs and inscriptions on ceramic vessels. The marks are inscribed on handles or other obvious locations after firing, which sets them apart from potters marks, which are usually at the bottom of the vase and are made before firing. The Cypriots commonly inscribed different types of their pottery both before and after firing (Hirschfeld 2001, 123). The practice of inscribing marks extended to imported pottery including Aegean Wares which are found in all the major Cypriot sites of the period, as well as, Near Eastern sites such as Ras Shamra, Minet el Beidha (in other words Ugarit and its port), Alalakh, Byblos, Beth Shan, and many more (Hirschfeld 1993 312; Hirschfeld 2000). The fact that Cyprus has a long tradition of marking pottery, in contrast with the Aegean where the practice is very rare, in combination with the fact that large numbers of Aegean wares of a great variety of shapes marked with Cypro-Minoan signs are found on the island led Hirschfeld (1993, 313) to the conclusion that the incised marks point to a connection with Cyprus and to the following statement:

This final observation supports the hypothesis that marking Aegean pottery with signs incised after firing is a specifically Cypriot practice. This in turn, implies that vessels with these signs on them have either been routed via Cyprus at some stage, or that they have been handled by people familiar with the Cypriot marking system.

I believe it would not be unreasonable to borrow Hirschfeld's ideas and to make a similar statement. In other words, marking of metal ingots, whether they are copper oxhide ingots, copper bun ingots, tin oxhide ingots or tin plano-convex ingots, indeed even lead ingots, seems to be a specifically Cypriot practice which implies that the ingots have either been routed via Cyprus or that they have been handled by people familiar with the Cypriot marking system (Kassianidou 2003, 116).

Chemical and microscopic analysis of oxhide ingots

Most of the oxhide ingots and fragments from Cyprus (for a detailed discussion see Kassianidou 2009), Greece (Mangou and Ioannou 2000), Sardinia (Atzeni et al. 2005, 125-140) and Uluburun (Hauptmann et al. 2002) have been analysed. What the available analytical data clearly shows is that the oxhide ingots are made of unalloyed copper. Other elements are present only as traces. In all the ingot fragments that have been studied microscopically, sulphide inclusions were detected, indicating that the metal was extracted from sulphide ores (e.g. for Cypriot ingots see Muhly et al. (1980, 91-3), Muhly and Maddin (1988, 471), and Tylecote (1982, 94) and for ingots found in Greece (Mangou and Ioannou 2000, 210-12)). The most detailed and enlightening study is that by Hauptmann, Maddin and Prange on the Uluburun oxhide and bun ingots. Based on the chemical and microscopic analysis they performed on a series of samples they stated that:

"We, therefore, conclude that the ingots reflect the composition of "pure" copper ores that were smelted to produce the metal and with but few exceptions we see few indications that bronze scrap could have been added as has been suggested (Hauptmann et al 2002, 13)."

This fits very well with the composition of Cypriot ore deposits, which are almost exclusively sulphidic and consist mainly of sulphur and iron with small amounts of copper and zinc and trace amounts of cobalt and nickel (Constantinou 1992, 336-337). Modern geological surveys have not detected any copper carbonates or copper silicates in any of the Cypriot ore deposits (Constantinou 1982, 15). This offers, therefore, another strong argument for the connection of oxhide ingots to Cyprus.

Production of oxhide ingots

The thorough study of the Uluburun ingots has confirmed that the oxhide ingots could not have been produced with copper tapped directly from a smelting furnace (Hauptmann et al. 2002, 12), as had been suggested in the

past (Tylecote 1977, 317). Their analyses showed that, the oxhide ingots were produced by batches of copper that were melted together to form a single oxhide ingot weighing 25-39 kg (Hauptmann and Maddin 2005, 136). In other words, there are at least two stages in the production of an ingot: first is the extraction of the metal from its ores, which in the case of sulphide ores is itself a multi-stage process, and second is the melting of enough metal to cast an ingot. The two stages need not be carried out at the same place.

Metallographic study of a number of ingots revealed the dendritic structure that is characteristic of cast objects (Muhly et al. 1977, 359-360; Tylecote 1982, 94). The fact that the top and the lower surfaces of the ingots are so different indicates that they were cast in an open mould: the smoother side is the one that was in contact with the surface of the mould, while the rougher was exposed to the air. It is believed that as gases, formed during the casting process, escaped from the surface they left behind this characteristic texture (Tylecote 1982, 94). The microscopic analysis of the Uluburun ingots also showed that they were porous and that they contain angular pieces of slag (Hauptmann and Maddin 2005, 135). These characteristics are not necessarily negative as they would facilitate the breaking of ingot to smaller, more easy, to use fragments such as those that are normally found in most archaeological contexts.

Until today no workshop dedicated to the casting of oxhide ingots has been identified. In Cyprus, although practically all excavated Late Cypriot sites have produced evidence of some metallurgical activity (Muhly 1989, 301-302; Kassianidou 2012), no ingot moulds have been found in any of them and to this date the only mould for casting an oxhide ingot was found in the Royal Palace building of Ras Ibn Hani in Syria (Lagarce 1986, Lagarce and Lagarce 1997, 75-7). This object is a riddle for many reasons. First of all there are no copper sources in this area. Second, the mould was not found in a workshop but rather in the palace. Third, the mould is said to have been made of limestone, a material which is not suitable for casting hot metals (Muhly 2009, 25). Finally, the lead isotope analysis of copper droplets collected from the inner surface revealed that the metal used is consistent with a Cypriot provenance.

It is entirely possible that in fact ingots were not usually cast in a stone or

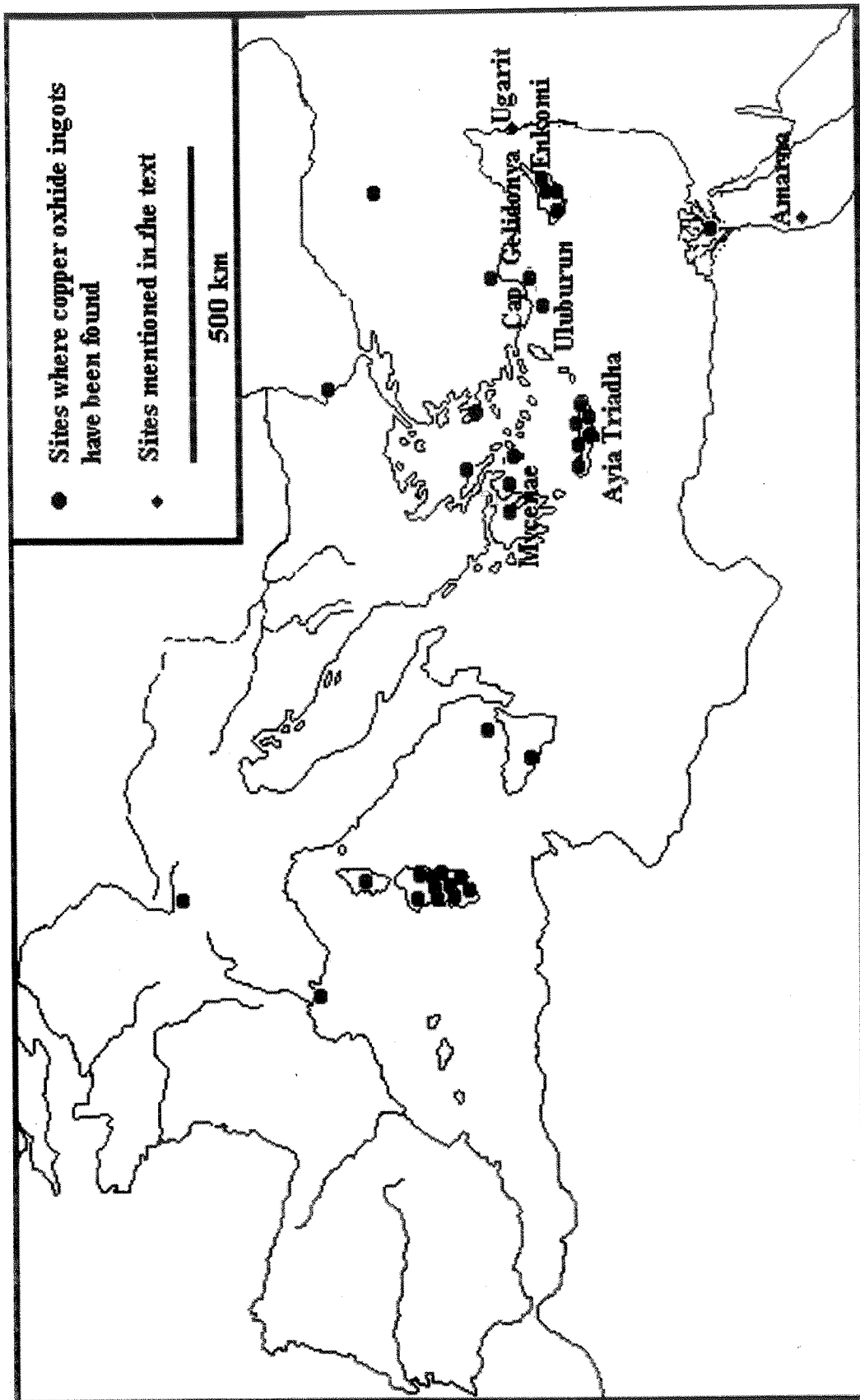
clay moulds, but were cast in sand. In this case no evidence would survive in the archaeological record. Merkel's (1986, 259) and Van Lokeren's (2000, 275) casting experiments have shown that this was possible. Unfortunately, the study of the Uluburun ingots was not able to clarify this question (Hauptmann et al. 2002, 18), and for the moment this remains open.

In the absence of evidence such as ingot moulds, the question of where the ingots were produced remains open.

Distribution of oxhide ingots

Excavations on land and sea undertaken over the last forty years, clearly show that copper, in the form of oxhide ingots, was not only traded throughout the Eastern and Central Mediterranean but even beyond. In 1991 Gale estimated that a total 130 ingots have been found in archaeological sites (Gale 1991, 200) and since then there have been several more discoveries of both complete and fragmentary examples that have not only increased this number but also stretched the geographical distribution of these finds. As the map in (Fig. 5) shows oxhide ingots are known from as far east as the Kassite palace of Dur-Kurigalzu located near Baghdad (Brinkman 1987, 35-36; Muhly 2009, 27), as far west as Marseille (Domergue and Rico 2002, 141), as far north as Oberwilfingen in Germany (Primas and Pernicka 1998, 42; Primas 2005, 389) and as far south as Qantir in Egypt (Pusch 1995, 123). Lo Schiavo (2005c, 407-408) discovered an example on the island of Corsica while a couple of ingots were lately dredged from the river Gökus in the province of Urfa, in Turkey (Sertok and Güllüce 2005).

However, the largest concentrations of ingots were recorded in the two shipwrecks excavated off the south western coast of Asia Minor. The first to be discovered was that at Cape Gelidonya which dates to the second half of the 13th century BC (Bass 1967). It was carrying a total of one ton of copper in the form of 34 complete oxhide ingots, 20 plano convex ingots, numerous ingot fragments and scrap metal (Bass 1967, 52). The second is the already mentioned Uluburun shipwreck (Pulak 2001; 2005) which was carrying a total of ten tons of copper in the form of 354 oxhide ingots, 120 plano convex ingots and 7 oval ingots (Pulak, 2000). It dates to the end of the 14th century BC. Apart from the shipwrecks, large concentrations ingots and ingot



5. Map of the Mediterranean showing the distribution of copper oxide ingots.

fragments were found on the island of Sardinia where according to Lo Schiavo (2005b, 317-326) complete ingots and more commonly ingot fragments were found in 31 sites all over the island. Over thirty complete and fragmentary ingots have been found in several sites in Crete, where in some cases (such as Zakros and Aghia Triadha) they were found in groups (for a recent discussion of the ingots found in Crete see Hakulin 2004, 19). The wide distribution of ingots in Sardinia and the groups of ingots found in Crete are partly the reasons that both of these islands had been considered probable production centres for the oxhide ingots (Buchholz 1959, 17; Gale 1991, 201; Muhly et al. 1988, 283).

Chronology of the oxhide ingots

This type of ingot appears sometime in the 16th century and it seems to go out of use after the 11th century B.C. It is interesting to note that both of the chronological boundaries are not defined by the examples found in Cyprus, most of which date to the 13th century B.C. (Muhly 1996, 48). The earliest oxhide ingots were found in Crete (at the sites of Ayia Triadha, Gournia and Zakro) while the latest examples were found in Sardinia (Muhly, et al. 1988, 283; Lo Schiavo, 1998, 110). This is one of the reasons why some have found it difficult to identify Cyprus as the source of both the Cretan and the Sardinian ingots (Muhly, et al. 1988, 295). However, I would like to argue that this is no longer the case.

When Catling (1964, 267-272) discussed the oxhide ingots of Cyprus, he proposed a date in the 12th century for them, although none of the examples he listed had come from a truly systematic excavation or had a secure archaeological context. The date was based on the typology of the other bronze object which made up the hoards. However, the British Museum's excavation records did not clearly list the objects that were part of the Enkomi "foundry" hoard, and he had to "reconstruct" the hoard based on a variety of documents and inventory numbers which were kept at the British Museum (Catling 1964, 279). Similarly, the Mathiatis hoard lacked a proper archaeological context. It had come to the Cyprus Museum in order to be exported together with other antiquities which constituted part of the private collection of Harvey Mudd. In fact, Catling (1964, 282-285) noted that among

these bronzes were some which were clearly of a later date, which he called "intrusions" and he carefully picked them out. By comparing the contents of these hoards with other hoards mainly from Enkomi, such as the Trésor des Bronzes, which did have a secure date within the twelfth century, he came to the conclusion that all three hoards containing oxhide ingots (the Enkomi "foundry" Hoard, the Enkomi "ingot" Hoard and the Mathiatis Hoard) were of the same date and subsequently that all the ingots from Cyprus dated solely to the 12th century (Catling 1964, 289-291).

There was another reason why Catling dated the ingots to the 12th century BC and this had nothing to do with the actual archaeological evidence. It was his belief that the Cypriot copper industry only really developed after the arrival of Mycenaean settlers on the island, who took over the production and trade of Cypriot copper, cast in the shape of oxhide ingots (Catling 1964, 271). Therefore the ingots in Cyprus could not be earlier than the arrival of the Mycenaeans.

For many years, this 12th century date of oxhide ingots in Cyprus was accepted and used by all those who studied them (e.g. Stos-Gale et al. 1986, 128; Muhly et al. 1980, 90). As a result Cyprus' role in the metals trade during the Late Bronze Age could not be properly appreciated. If oxhide ingots appeared in Cyprus only after the 12th century BC, then those oxhide ingots found elsewhere in the Eastern Mediterranean could not have been made in Cyprus. Furthermore, the archaeological evidence seemed to contradict the textual evidence. According to the ancient sources, copper from Alashiya, widely accepted to be Cyprus, had been exported since the 18th century BC (Muhly 1972, 204). By the 14th century BC, Cypriot copper was exported in truly great quantities: in the letters sent by the king of Alashiya to the Pharaoh of Egypt, found in the archive of Amarna, a total of 897 talents of copper, corresponding to 26 tons of metal, are said to have been sent to Egypt (Knapp 1985, 238; Knapp 1996, 8; Muhly 1972, 21; Muhly 2005, 139-140). As the copper was traded in the form of oxhide ingots, and no ingots had been found in Cyprus from before the 12th century, then it was argued that perhaps Alashiya should not be identified with Cyprus.

As more Late Cypriot sites were excavated and more ingot fragments were found it became clear that the date of oxhide ingots from Cyprus should be

pushed back, at least to the middle of the 13th century: most of the ingots listed and discussed above came from LCIIC levels. Furthermore, a re-appraisal of Late Bronze Age Cypriot and Aegean hoards by Knapp, Muhly and Muhly (1988, 244-248) showed that many of the Cypriot hoards, including those which contained ingots, dated to the 13th rather than the 12th century BC.

Two Late Cypriot sites have, however, produced ingot fragments of an even earlier date. The first is Enkomi where according to Lagarce and Lagarce (1986, 66) Schaeffer found an oxhide ingot fragment in a metallurgical workshop located somewhere within the Quartier 5W and dating to the LCII period or the 14th century BC. A similar date is assigned to the oxhide ingot fragments from Maroni *Vournes*, found below the Ashlar building, which was constructed in the LCIIC period and on the floor of the Basin building, which was built and used during the LCIIA-B period.

For the moment, no ingot fragments dating prior to the 14th century have been found on Cyprus. This may have to do with the fact that the early part of the Late Bronze Age, in other words the LCI-LCIIB periods, is not very well known, as most of the excavated settlements date to the LCIIC. Although it is now becoming clear that there are earlier habitation levels in a number of them (for example Kalavassos *Ayios Dhimitrios*, Maroni *Vournes* and of course Enkomi), these have not been extensively studied or uncovered. Although not a strong argument, it is possible that the absence of earlier oxhide ingots from Cyprus may have to do with the fact that no workshops, or storerooms dating to this period where such finds might be expected, have yet been excavated to any great extent.

The excavation of the smelting workshop at Politiko *Phorades*, dating to the beginning of the Late Bronze Age (16th-15th century BC) (Knapp and Kassianidou 2008, 140) showed that copper was produced at this period and that the technology was very advanced (Knapp and Kassianidou 2008, 140-144). Furthermore, the copper workshops excavated by Dikaios in Enkomi were already active from the earliest phase of habitation. Describing the excavated remains dating to the LCI he stated:

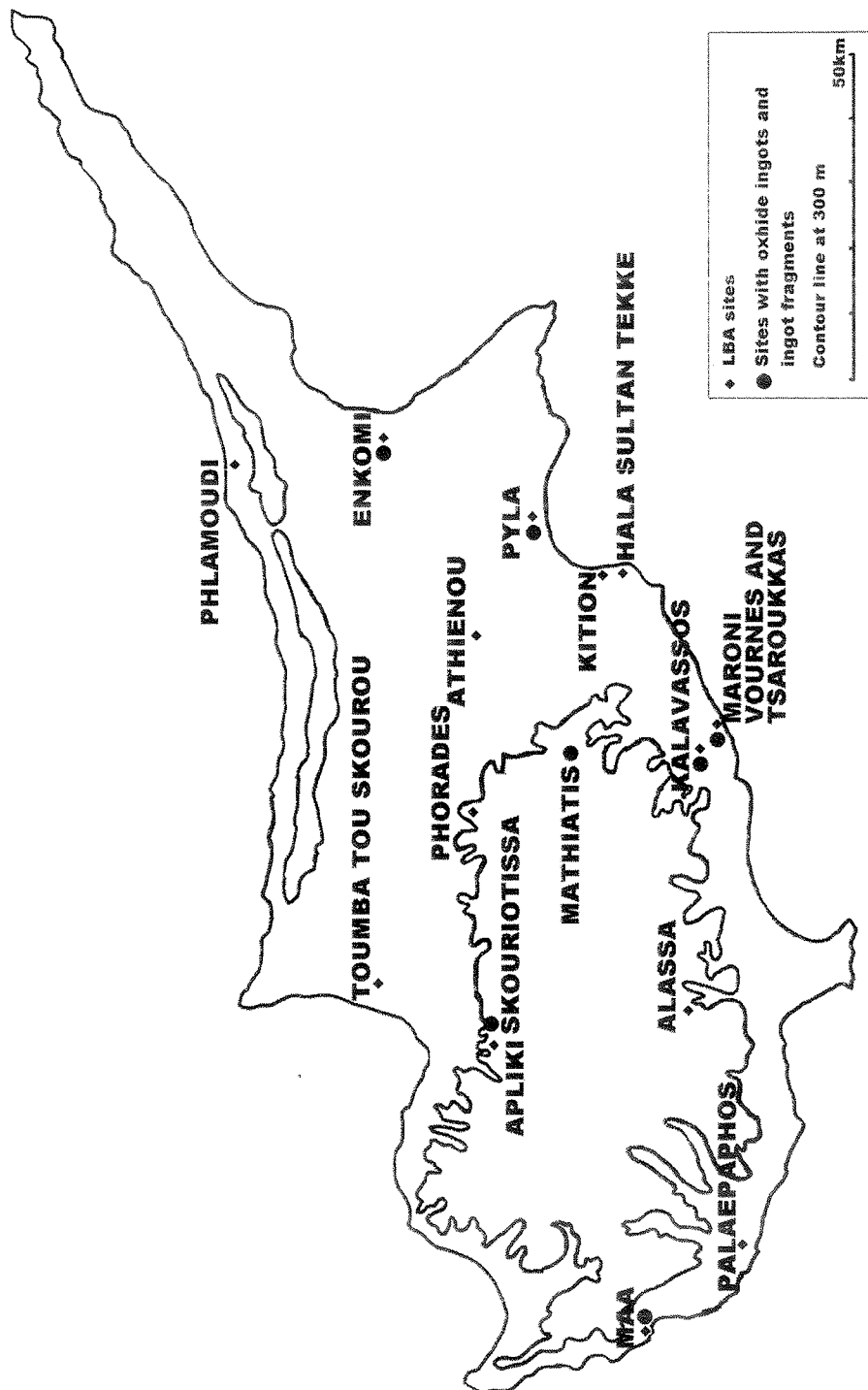
"In many of these (rooms) we found remnants on successive floors of

furnaces littered with masses of tuyères and broken crucibles, together with much copper oxidation and other debris from copper smelting establishments" (Dikaïos, 1971, 505).

What is extremely interesting is the fact that, among the finds from these rooms, was also a fragmentary clay tablet of Cypro-Minoan script (Dikaïos, 1971, 503). Dating to the 15th century BC, this is one of the earliest written texts from the island and its discovery within a metallurgical workshop is significant. The Cypriot copper industry was already well established and there is no reason why some of the copper produced could not have been exported in the shape of oxhide ingots. In fact, if we accept the lead isotope data, the oxhide ingots from Gournia (Stos-Gale et al. 1997, 112-113) and more recently from Mochlos (Scales and Stos-Gale 2004, 58), dating to the Late Minoan IB (1500-1450 BC) were made of copper coming from the mine of Apliki. What this means is that Cypriot copper was already being cast into oxhide ingots by the 15th century BC.

The most recent oxhide ingots come from Enkomi. They are the two fragments from Point Topographique 783 in Quartier 3W, which according to the excavator date to the end of the 12th century BC. So the use of the oxhide ingot on the island of Cyprus can be confirmed from the 14th down to the end of the 12th century BC. It is to be hoped that future excavations will expand these chronological boundaries.

Regarding the production of copper after the 12th century in Cyprus a close look at the evidence reveals that the industry does not come to an end. Direct evidence to support this statement is found in Kition, one of the few LBA sites that survives the transition to the Iron Age: the Northern workshops of the temple complex, which were involved in metallurgical activities, continued to be active in the 11th century (Karageorghis and Demas 1985, 135-138). Furthermore, during field work in the mining district of Mitsero, in the North foothills of the Troodos mountains, undertaken by the Sydney Cyprus Survey project, we recorded two sites related to mining and metallurgy, which according to C14, date to the Geometric Period (Kassianidou 2004, 39-40). The continuation of the production and export of Cypriot copper can further be deduced indirectly, from the wealth in the



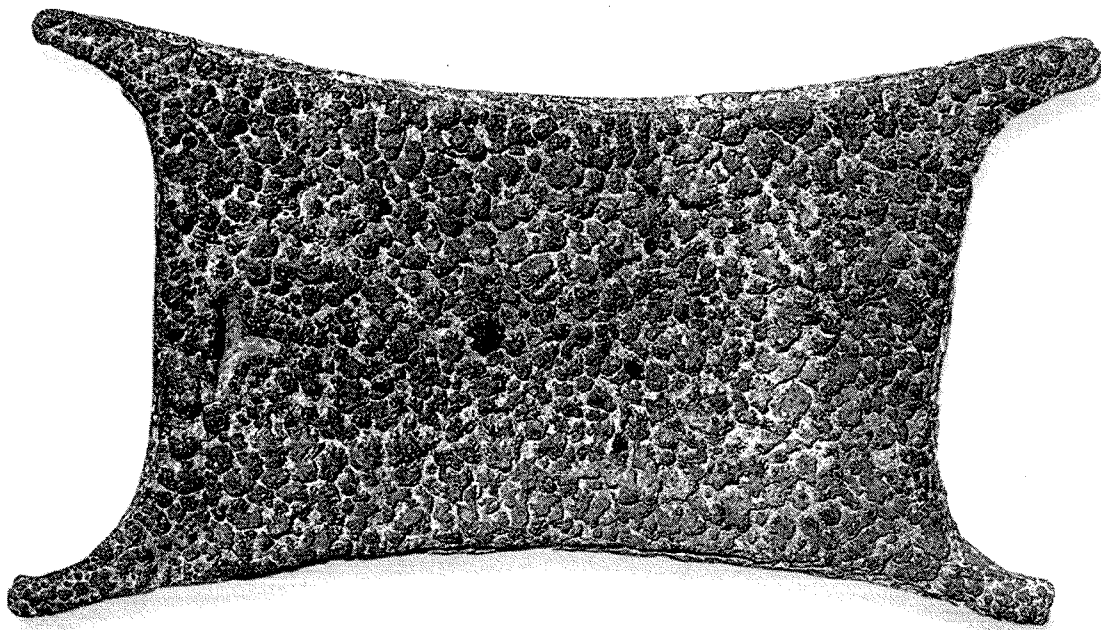
6. Map of Cyprus with Late Cypriot sites mentioned in the text.

tombs dating to the 11th and 10th centuries B.C., especially those from the necropolis of Palaepaphos-Skales. According to Karageorghis (1983, 372), "No other necropolis of the Cypro-Geometric period in Cyprus has produced so many and such extraordinary bronzes as Skales." Cypriot bronze smiths, therefore, were as active as ever and were, furthermore, producing objects using novel techniques which were introduced on the island in the 11th century.

Oxhide ingots in Cyprus: distribution and context

In Cyprus oxhide ingots have been found only in the following eight sites (for a detailed discussion see Kassianidou 2009): Enkomi, Maroni *Vournes*, Maroni *Tsaroukkas*, Kalavassos *Ayios Dhimitrios*, Maa *Palaeokastro*, Pyla *Kokkinokremos*, Mathiatis and Alassa *Pano Mandilaris* (Fig. 6). Furthermore, unlike Sardinia and Crete, in Cyprus only three complete oxhide ingots have been found to date and of these, only one comes from an archaeological excavation. Unfortunately, it is from the British Museum's excavation at Enkomi that took place in 1896-7, which was less than entirely systematic. The archaeological context of the other two complete ingots is even less certain as they came from the antiquities market: one was purchased in Nicosia and the other in Famagusta (Muhly et al. 1980, 91). The first one is in the Cyprus Museum (Inv. 1939/VI-20/4) (Catling 1964, 268). It weighs 39,18 Kg and measures 72 cm in length, 42 in width and is 3,9-5,5 cm thick. It bears an impressed mark (Fig. 7). The second was purchased by Harvey Mudd, the owner of the Cyprus Mines Corporation, and exported to California together with many other Cypriot antiquities, including a significant proportion of the ingot fragments from the so called Mathiatis Hoard (Muhly et al. 1980, 91). The ingot is now in the Cypriot collection of Harvey Mudd College, Claremont, California (Muhly 2005, 139). It weighs 32,1 Kg, and measures 65 cm in length, 35 cm in width and is 3,75-5,6 cm thick. A quatrefoil mark is impressed on its surface (Muhly et al. 1980, 92) (Fig. 8).

The contrast in both the number of find-spots and the number of complete ingots in Cyprus, with those excavated in Sardinia and Crete, is acute and is one of the reasons why in the past some found it difficult to accept Cyprus as



7. Oxhide ingot said to be from Enkomi now in the Cyprus Museum (Inv. 1939/VI-20/4)



8. Oxhide ingot said to be from Enkomi now in the Cypriot Collection of Harvey Mudd College, Claremont California.

the sole producer of all these ingots. However, one has to take into consideration how many Nuraghi have been excavated (even if many of these excavations have not been published) and by contrast how few Late Cypriot sites have been excavated. Although archaeological surveys over the last fifty years have identified around 350 sites dating to the Late Cypriot period (Knapp 1997, 47), only about twenty of them have been excavated to any extent. In other words, the difference may simply have to do with the fact that there are many more excavated Nuraghi than Late Cypriot settlements.

When Catling published the oxhide ingots and fragments from Cyprus in 1964, he listed only two sites: Enkomi and Mathiatis (where neither systematic nor rescue excavation had ever taken place). Six more sites have now been added to the list, all of which were excavated after the publication of his book. It is indicative that the latest find comes from Maroni *Tsaroukkas*, the most recently excavated site in the group (Kassianidou 2009, 47-48). Of course, in the last thirty years other important Late Cypriot settlements such as Toumba tou Skourou, Kition, and Hala Sultan Tekke have also been excavated, but have not produced any oxhide ingot fragments. However, none of these (with the exception of Hala Sultan Tekke) have been extensively excavated and, therefore, the absence of oxhide ingots may simply be due to the fact that those parts of the settlement, where one would expect to find oxhide ingots (i.e. copper workshops and/or storerooms) have not yet been uncovered. Furthermore, many settlements were abandoned at the end of the LC IIC period and they were usually thoroughly cleared of all valuables, including metal. The absence of oxhide ingots from Late Cypriot sites may therefore only be circumstantial.

As shown in Fig. 6, oxhide ingots have been found in sites on the east coast, on the south coast, on the south-west coast and inland. The absence of ingot fragments from the northern coast of Cyprus most probably has to do with the fact that apart from the site of Phlamoudi (Smith 2005, 32-65), no Late Bronze Age settlement had been excavated in that area before 1974. Since 1974 that part of the island is under Turkish occupation and therefore, protected by UNESCO's guidelines, which prohibit excavations in occupied territories. This means that over the last 30 years archaeological research has focused on the southern part of the island, about which we now know much

more than about the occupied part of the island.

Ingots have been found in coastal settlements, which were clearly involved in long-distance trade, such as Enkomi, Maroni *Tsaroukkas*, and Maroni *Vournes*, in inland settlements which were involved both in the control of agricultural products (mainly olive oil and grain) and copper production such as Alassa *Pano Mandilaris*, Kalavassos *Agios Dhimitrios* and Mathiatis. It was Catling (1962, 144) who first suggested that the Late Cypriot sites can be divided into three categories: inland settlements which were involved in agriculture, inland settlements which were involved in the exploitation of the copper orebodies and finally, large urban centres located on the coast and involved in sea-borne trade. Keswani (1993) suggested instead that the sites should be divided into four groups, urban centres, inland-sanctuary centres, agricultural villages and mining sites. Knapp (1997, 48) also suggested a four tiered classification of Late Cypriot sites but his categories are the following: Primary ('metropolitan centres'), secondary ('town' centres), tertiary sanctuary sites and finally peripheral agricultural and mining villages. Using Knapp's classification, oxhide ingots have been found in primary sites (Enkomi, Kalavassos, Maroni), secondary sites (Pyla and Maa) and peripheral sites (Mathiatis). They seem to be absent from the tertiary sites, in other words the sanctuaries. This, in a way, is surprising for Cyprus. Not because of the suggestion that copper production was temple-based and under religious control (Catling 1971, 30), against which I have recently argued (Kassianidou 2005), but because metallurgical workshops have been associated with sanctuaries, as both Kition (Karageorghis and Demas 1985, 81; Karageorghis and Kassianidou 1999) and Athienou *Bamboulari tis Koukouninas* (Dothan and Ben Tor 1983, 140) clearly show. Neither of these sites has produced a single fragment of oxhide ingot. Nevertheless, the fact that the ingots are found not only in primary sites, but also in secondary and peripheral sites is important, because it shows that they are not only associated with settlements that were involved in sea borne trade.

In all cases, where the archaeological context is preserved, and even in those two where it is not, the oxhide ingots have been found either in areas where there was clear evidence of metallurgical activity (namely at Kalavassos *Ayios Dhimitrios*, Maroni *Vournes* and *Tsaroukkas*, Maa *Palaeokastro*), or as

part of a hoard. All the hoards that contained ingot fragments also contained broken or damaged bronze artefacts, scrap metal and in some places even slag. They can, therefore, be classified as "founders' hoards", defined as (Knapp et al. 1988, 237):

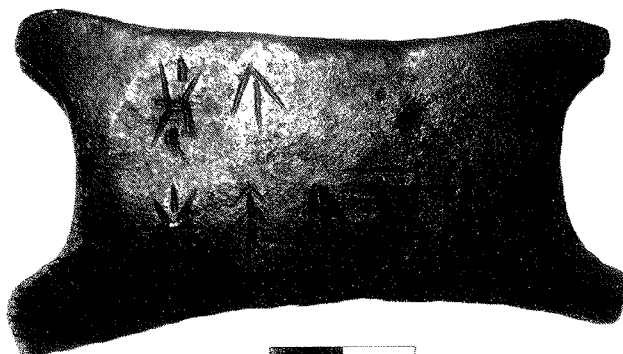
Founders hoards should be represented by materials collected together for their value as metal not for the intrinsic value of the original objects. They may be characterised particularly by broken objects or scrap metal, by castings, and slag, and by ingot fragments, all items lacking special significance and all being reduced to their lowest common metal denominator.

The only possible exception might be the Enkomi Ingot Hoard, although one should bear in mind that its composition is only based on information gathered by Schaeffer many years after its discovery. If his informants were correct and the two complete ingots were indeed found together with many more ingots, whose whereabouts are now unknown, it is possible that what the clandestine excavators found was in fact a warehouse full of ingots, not unlike those found at Aghia Triadha (Buchholz 1959, 32-34) and Zakros (Platon 1974, 100). The ingots may have either been intended for export or for local use, as according to Courtois (1982, 160), they are believed to have been found within an area of Enkomi, where there is ample evidence for metallurgical activity. In the former case, they could very well have been the products of those workshops, rather than the raw material they used. Unfortunately, however, there is absolutely no evidence, such as mould fragments, that would indicate the existence of a workshop dedicated to the production of ingots in Enkomi.

Whatever the case may be regarding those two complete ingots, the fact is that in all the other cases the ingot fragments represented raw material for the use of the Cypriot metalsmiths. I, therefore, disagree with Gale's (1999, 117) assertion that copper oxhide ingots were chiefly produced for export and were not used on the island because as argued above, in all Late Cypriot sites, except Enkomi where complete examples have been found, oxhide ingots were found in pieces, usually as part of founders' hoards or within



9. The Ingot God from Enkomi



10. Inscribed miniature ingot from Enkomi

metallurgical workshops. As I have argued before for the case of Sardinia (Kassianidou 2001, 105), this is clear evidence that copper oxhide ingots in Cyprus were being used locally and were not only intended for export.

Apart from the actual oxhide ingots that have been found on the island, there is a whole range of artifacts dating to the Late Cypriot period that depict oxhide ingots or oxhide ingot bearers (for a discussion of the iconography of the oxhide ingots see Papasavvas 2009). The most famous of these is of course the Ingot God from Enkomi, which has recently been discussed by Papasavvas (2011) (Fig. 9). Equally important are the four sided stands that depict men carrying ingots in processions (discussed in detail by Papasavvas in a paper in this volume) and the miniature ingots some of which bear inscriptions (Giulia Mair et al. 2011) (Fig. 10). Apart from Egypt, where oxhide ingots are depicted in wall paintings and stone reliefs, either in store rooms or brought to the Pharaoh by tribute bearers, Cyprus is the only other Mediterranean country which has produced so many different objects that depict oxhide ingots (Papasavvas 2009, 84). This fact indicates the importance of the copper industry and trade for the Late Cypriot society and economy and further supports the proposition that there is a direct relation between the island and the oxhide ingots.

Organization of the Production

Even if the actual finds of oxhide ingots on the island are few, Cyprus fulfils two of the basic requirements to have been the main, if not the sole, source of copper for the oxhide ingots; it has the richest copper deposits in the area and it has solid evidence of copper production and working (in the form of slag, crucibles, tuyères, bellows etc) spanning the period of use of the oxhide ingots (for a recent discussion of these finds see Kassianidou 2012). How would the production of ingots be organized and where were the workshops? In Cyprus, all the copper ore deposits are located within the Pillow Lavas which form a ring around the Troodos mountains and logically, this is where first stage, the extraction of the metal, would have taken place. The discovery and excavation of a smelting workshop, that of Politiko *Phorades* (Knapp and Kassianidou 2008; Knapp et al 2001, 1999, 1998, Kassianidou 1999), dating to the LCI period and a miners' village involved in the production of metal,

that of Apliki *Karamallos* dating to the LCIIIC (Du Plat Taylor 1952; Muhly, 1989), which are both located within the Pillow Lavas of the Troodos, indicates that indeed copper was smelted near the ore source. However, the analysis of the slag from *Phorades* showed that, the workshop did not produce metallic copper, but an intermediate product, matte. In order for matte to be turned into copper metal, further smelting steps would have been necessary. According to the available evidence these were not taking place at the same workshop.

Archaeologists and archaeometallurgists alike have long been trying to understand why smelting slag and furnace conglomerate is often found in the urban centres of the Late Cypriot period (Muhly 1989, 302; Stech 1982, 105). Dikaios (1969, 46), for example, reported on a significant slag heap which he found in association with the copper workshops in his Area III. Enkomi is probably the site that is located at the farthest distance away from the copper deposits, as well as from the forests of Troodos, which would have provided the furnaces with the necessary large quantities of fuel (Stech 1985, 103). Furthermore, one of the products of the initial stages of the smelting process is sulphur dioxide, an obnoxious gas, which would not be welcome inside the confines of an urban environment (Stech 1985, 103). Thus the suggestion that primary smelting of copper ores was taking place at Enkomi, or any of the other coastal urban centres, was questioned (Stech 1982, 102). Rather it was suggested that the slag and the furnace conglomerate represented a primitive technology. The conglomerate was produced somewhere near the mining districts, and then transported to the urban centres. There it was smelted in small furnaces forming a pool of copper at the bottom of a mass of slag, which also contained prills of copper. It was then argued that copper was recovered largely through the crushing of the slag, and the removal of the copper prills trapped within it, which were then melted together to form a copper ingot (Stech et al. 1985, 399; Muhly 1989, 303).

The study of the archaeometallurgical material from Politiko *Phorades*, the only primary smelting workshop dating to the Late Bronze Age to be excavated until recently, has shown that even from the beginning of the Late Bronze Age the smelting technology was anything but primitive (Knapp and Kassianidou 2008, 140-144). Well-designed and controlled smelting

installations resulted in two well-separated products, slag and matte, which had to be processed further in order to produce copper (Knapp and Kassianidou 2008, 144). This step in the process was not performed at the same workshop and it is therefore very likely that the matte was transported to an urban centre for secondary smelting. The slag found in urban centres could very well be a product of this stage in the production of copper, although we must bear in mind that there is a chronological difference between Phorades, which dates to the LCI, and the archaeometallurgical finds from the urban settlements most of which date to the LCIIC.

Our understanding of the organization of the Cypriot copper industry is severely hindered by the fact that we know very little about the political organization of the island, in other words whether it was divided into city-kingdoms as it was in the Iron Age or whether it was a single political entity centrally governed. In the former case, each city-kingdom would control the ore deposits within its territory and produce copper both for its own use and for export, which seems to have been the instance in the Iron Age (Muhly 1989, 303), while in the latter case the production, local distribution and trade of oxhide ingots made of Cypriot copper would have been controlled by one entity, the capital. The fact that throughout the island the same type of ingot is used, and accepting the suggestion (from lead isotope analysis (see below)) that all the metal came from one mine, might be arguments in support of this latter scenario. The wealth of metallurgical material from Enkomi led Muhly (1989, 299) to suggest that:

It is entirely possible that Enkomi actually controlled the copper industry of the entire island by virtue of its status as the capital of the kingdom of Alashiya. I would even venture to suggest that the city was probably called Alashiya; the name served both as designation of the capital and of the kingdom, exactly as at nearby Ugarit.

It is indeed very likely that one of the main products of the extensive metallurgical workshops of Enkomi were copper oxhide ingots. However, whether oxhide ingots were only produced in Enkomi or were also produced in other settlements remains an open question, as there is no conclusive

archaeological evidence for or against this idea.

What can be definitely be refuted are earlier suggestions that the copper industry was not controlled by the Cypriots. In the past Catling (1964, 271) had suggested that the production of copper only started after the arrival of the Mycenaeans, who also controlled the export of the metal in the shape of oxhide ingots, while Bass (1991, 73) maintained that it was the Syrians who were the driving force behind the trade in Cypriot copper, and they were the ones who had the Cypriots cast the metal into ingots in a form of their choice. However in his review of 13th century Cyprus, during the period in which oxhide ingots are found all over the Mediterranean, Cadogan (1998, 12) categorically stated that: "Nothing suggests that foreigners were in charge in Cyprus or living in resident enclaves, let alone governors' houses." There is no question therefore, that the copper industry was under the control of anyone else but the indigenous population. Furthermore, new discoveries such as those at the site of Pyrgos *Mavrorakhi* from the Middle Cypriot period (Belgiorno 2004) and Politiko *Phorades* from the beginning of the Late Cypriot period (Knapp and Kassianidou 2008, 140), as well as the evidence from Enkomi (Dikaios 1971, 500) clearly show that by the 13th century the Cypriot copper industry had already had a long history.

Provenance studies

The strongest, however, support for a Cypriot origin of most analysed oxhide ingots derives from Lead Isotope Analysis (Gale 2011, 214-218; Gale and Stos-Gale 1999, 272-3). There is a group of ingots dating to the LMIB, i.e. the 16th century BC, from a series of sites in Crete, namely Aghia Triadha, Tyliossos and Kato Zakros which have clearly different isotopical fingerprint and whose provenance remains unknown (Stos-Gale 2011, 226) but the rest seem to be consistent with a Cypriot provenance. The literature on the subject is extensive (here are just a few publications on this issue: Budd et al. 1995; Gale 1991, 1999, 2005, 20011; Gale and Stos-Gale 1986, 1999, 2005; Hauptmann 2009; Knapp 2000; Muhly 1983, 1995; Stos-Gale and Gale 1994; Stos-Gale et al. 1997). By now most archaeologists are aware of the benefits of the technique, as well as, its limitations. The identification of provenance is based on the principle that an ore deposit has a lead isotope fingerprint

(defined by three ratios of the four isotopes of lead), and that this fingerprint does not change through the process of smelting and refining. Thus the metal has the same isotopic fingerprint as that of the ores from which it was extracted (Gale 1978, 529-530; Stos-Gale 2009, 198; Stos-Gale and Gale 1994, 99-104). It has been argued that this is also the case even with artefacts made of tin bronze: because tin usually contains no lead, the lead isotopic fingerprint is that of the copper metal (Gale and Stos-Gale 1985, 87-88). Problems do, however, arise with leaded tin bronzes, an alloy which we know was already in use during the Late Bronze Age (Muhly 1985). In this case, lead isotope analysis will determine the provenance of the added lead and not that of the copper (Gale and Stos-Gale 1985, 97).

This is not an issue for oxhide ingots, however, as they consist of very pure copper. Early on it had been suggested that they were produced by tapping the metal directly from the smelting furnace but we know now that it is impossible (Muhly et al 1988, 287). First of all, a Bronze Age smelting furnace could not produce such an amount of metal (and the proportional amount of slag) (Merkel 1986, 257). Second, as already pointed out above, we know from analysis, that the copper of these ingots was extracted from sulphide ores (Maddin 1989, 99; Muhly, et al. 1980, 91, 93; Muhly and Maddin 1988, 471; Zwicker 1988, 429). Sulphide ores have to undergo a series of processes such as roasting, primary smelting, roasting and secondary smelting and even then, the product is black copper which needs to be refined. The copper of the oxhide ingots is pure (although some exceptions do exist) and this shows that it has passed through a series of fire refining steps (Merkel 1986, 260).

But let us return to the lead isotope issue: because the oxhide ingots do form a coherent group of artefacts made of raw material, they were considered ideal subjects for the study of provenance using this new analytical method. And, therefore, the team from the Oxford Isotrace lab embarked on a long term research project on the Late Bronze Age metals trade in the Mediterranean. To do so they analysed ore samples, oxhide ingots and bronze artefacts from all over the Mediterranean.

With the new analysis and the new approach came a rather provoking conclusion and that is that all oxhide ingots dating after 1400 BC are derived

from the mine of Apliki and those adjacent to it (Gale 2011, 215; Gale 1999, 116; Gale and Stos-Gale 1999, 271-273). In this group fall the oxhide ingots from Cyprus, Kyme, Euboea, LHIII B Mycenae, the Black Sea coast of Bulgaria, Bogaskoy, Sarkoy, Antalya, Chios, Kommos, Gournia, the sole ingot fragment from Egypt, the ingots from the Cape Gelidonya wreck and finally all the oxhide ingots from Sardinia (Gale and Stos-Gale 1999, 271-273).

Needless to say, many archaeologists have found this suggestion hard to accept (e.g. Muhly 2003, 144 and for a more recent discussion Muhly 2009, 26-30). One of the scholars who opposed this idea more strongly than others is Knapp (1999, 106) who stated:

"The cultural and economic model proposed - namely that a single site and a single ore deposit was producing all or most of the copper oxhide ingots found in the Bronze Age Mediterranean - whilst bold and provocative, and coherent in analytical terms, makes little sense in economic, social, spatial or even mineralogical terms, contradicts the model we can now propose on the basis of our work at Phorades, and represents a marked change from earlier interpretations that proposed exploitation of multiple ore deposits around the Troodos."

It is a fact that the ore deposits of the so-called Solea Axis (Apliki, Skouriotissa and Mavrovouni) are among the largest copper deposits in the whole Mediterranean area and in modern times were the source of 85% of all the copper produced on the island (Constantinou 1982, 15). But one should always bear in mind that the modern industry is based on a completely different set of parameters. Thus I am also sceptical of this proposition (Kassianidou 2001, 110). Apliki is the smallest of the three deposits and the one that is highest up on the foothills of the Troodos, in other words the one farthest from the sea and the Mesaoria plain. It is of course the only mine clearly associated with an excavated Late Cypriot settlement, that of Apliki *Karamallos*, which dates to the LCIIC period (Du Plat Taylor, 1952; Muhly 1989). So there is no doubt that this ore deposit was indeed exploited in this period.

What I, and others, find very surprising is that none of the numerous other ore deposits, scattered all around the periphery of the Troodos mountains,

seem to have been exploited, although many of them, such as those of Kalavassos, are clearly within the hinterland of major Late Cypriot settlements or administrative centres (South 2002, 62-63). There does not seem to be any particular reason why only the Apliki mine would have been preferred over the others. The ore deposit is neither at a more favourable location nor at a level closer to the surface than the others, and fuel would have been just as plentiful in any of the other mines, as they are all located within the forested foothills of the Troodos mountains. On the contrary, Apliki, the other mines of the Solea Axis and those of the area of Limni are the mines which are farthest away from Enkomi, and the other sites which have produced oxhide ingots.

Furthermore, according to the available evidence it seems that the final stages of the production of copper were taking place at workshops within the urban settlements such as Enkomi, where presumably matte or perhaps black copper from various smelting workshops was transported. In order to have enough metal to cast an ingot, the product of several smelting charges would need to be melted together. According to the Lead Isotope Analysis the metal from a single mine was exclusively used for casting ingots, while metal coming from other mines was used for casting artefacts (although it is never clarified which are the other mines which have been identified as sources for contemporary bronze objects) (Gale 2011, 218; Gale 2001, 115; Gale and Stos-Gale 2002, 290). The problem is that if we assume that the final stage in the extraction of copper was taking place in an urban settlement then what this seems to imply is that although matte or some other form of semi-processed material arrived in one site (for example Enkomi) from different mines, only the material coming from Apliki was used to produce copper ingots, while that from the other mines was used to produce copper artefacts. And yet according to the archaeological evidence many of the smiths around the island were supplied with copper in the form of oxhide ingots coming from Apliki!

Is this a problem in the interpretation of the data or an inherent problem of the analytical technique? We don't really know. Nevertheless, as pointed out recently (Gale 2011, 218; Gale and Stos-Gale 2012) the results indicate that all of the analysed ingots with the notable exception of the ones dating to

LMIB from Aghia Triadha, Tyliossos and Kato Zakros whose provenance remains a mystery (Stos-Gale 2011, 226), are consistent with a provenance from Apliki. If one does not accept these results, then this means that one should also not accept Cyprus as the place where oxhide ingots were produced. Clearly the Lead Isotope data cannot be dismissed and we somehow have to try and understand what they mean in terms of the organization of the Cypriot copper industry and in the Late Bronze Age.

Conclusions- Cyprus and the trade of copper oxhide ingots

The study of oxhide ingots is now over 125 years old. In this paper I have tried to summarize the evidence, archaeological and analytical, available until now (although the bibliography is vast) and to argue that they all converge to the same conclusion: Cyprus an inland rich in copper, with an abundance of archaeological evidence that shows that the metallurgical industry was flourishing in the Late Bronze Age, is where the vast majority of copper oxhide ingots was produced. The scale of production must have been significant if we consider the cargo of the shipwreck of Uluburun, which included ten tons of copper whose lead isotope fingerprint is consistent with a Cypriot provenance, and the correspondence of the king of Alashiya with the Pharaoh of Egypt in which a shipment of over 500 ingots is mentioned in a single letter.

I have argued that the oxhide ingots were used locally as well as exported over the seas to near and distant shores. Who was in charge of this trade has been a matter of debate but it is beyond the purpose of this paper to open the discussion. I would like to conclude by saying that, as I have argued elsewhere, I strongly believe that the Cypriots were not only in charge of their own copper industry but they were also major players, rather than passive spectators, in the metals trade within the Mediterranean area (Kassianidou 2001, 110; 2003, 116). Muhly (2009, 32), one of the great scholars who has dedicated much of his research to the study of the trade of copper in the Late Bronze Age, reached the same conclusion and recently stated: "It seems to me that as of 2007 the best evidence available indicates that, in the LBA, maritime commerce in the eastern Mediterranean was in Cypriot hands."

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I would like to thank Andreas Pitsillides and the Cyprus Numismatic Society for inviting me to contribute to this volume of *The Numismatic Report* dedicated to the memory of Dr Danielle Parks. Danielle was a dear friend of mine and my husband Giorgos Papasavvas. I will always remember her as an extremely energetic and sharp person with a great sense of humour and as a dedicated scholar and archaeologist. She is greatly missed, both as a friend and as a scholar. The paper is a summary of ideas on oxhide ingots that I presented in various publications in the past that deal with Cypriot copper production and trade in the Late Bronze Age. Although it falls within the sphere of a different archaeological period than the one that Danielle decided to devote her research, I hope it is a suitable tribute to her.

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