EARLY BRONZE TECHNOLOGY AT THE LAND'S END IN NORTH WESTERN IBERIA

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The North Western Iberia metal ore wealth, especially tin ore and gold, have been proposed as the main reason for the development of intense trade routes since early prehistory. Several authors have argued the existence of interactions between the northwest of the Iberian Peninsula and other cultures of the European Occident and the Mediterranean area. Ancient sources comment on the abundance of minerals and metals in the *Cassiterides* or *Tin Islands*. These accounts must have originated from sailors who from time immemorial were trading in these coasts. The name *Cassiterides* represents the first vague knowledge of the Greeks that tin was found overseas somewhere in or off Western Europe. The word *κασσιτερος* was known to Homer and is mentioned ten times in the Iliad. Cape Finisterre (*Land's End* for the Romans) was proposed as the northernmost point recorded in the *Periplous* of Pytheas the Massaliot, which seems to be the basic source used by Rufus Festus Avienus. B.Cunliffe has suggested that if Cape Finisterre was the place called Oestrymnis by Avienus in *Ora Marítima*, then *Periplous* could be seen as the guide that led Greek sailors from Marseille to the northwest of Iberia to trade for the coveted Galician tin some time around 500 BC.

Recently, the study of prehistoric bronze working places more emphasis on technological aspects as a means of detecting changes in the pattern of metal production in the archaeological record. Bronze working appears in North Western Iberia at the end of the 3rd and the beginning of the 2nd millennium BC for short-scale production, distribution and consumption, mainly as prestige goods. Metals are a major component of the prestige economy described in the Homeric Epics and his accounts of Phoenician traders carrying metals hither and thither constitute the earliest literature reference. They suggest a prestige economy based in interchange of presents (most of them metals) that contribute to the perpetuation of the aristocracy, excluding ownership by the rest of the population.

Recent preliminary analyses carried out at the synchrotron and the neutron sources at the Daresbury and Rutherford Laboratories have contributed to the understanding of technological details of this very early bronze metallurgy. Archaeological evidence sustains the hypothesis of an increase of the production during the late Bronze Age. Most of these objects are produced locally, imitating foreign styles, especially in the Atlantic area, with singular features related to the alloy composition and other features. Indeed, as early as the beginning of the 8th century BC, the Phoenicians had established a trading post at Gadir. From here Phoenician ships regularly sailed north up the Atlantic coast of Iberia. We can observe differences between the Late Bronze Age-Iron Age north-western metal production and the so-called *tartesic bronzes*. The technical aspects of the production of bronze during the Orientalising Period in the Iberian Peninsula favours the individualization of different manufacturing traditions.

ΟΙ ΠΗΓΕΣ ΤΟΥ ΚΑΣΣΙΤΕΡΟΥ: ΠΡΩΙΜΗ ΤΕΧΝΟΛΟΓΙΑ ΧΑΛΚΟΥ ΚΑΙ Ο ΔΡΟΜΟΣ ΠΡΟΣ "ΤΗΝ ΑΚΡΗ ΤΗΣ ΓΗΣ" ΣΤΗΝ ΒΟΡΕΙΟΔΥΤΙΚΗ ΙΒΗΡΙΑ

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Ο ορυκτολογικος πλουτος της Βορειοδυτικης Ιβηριας, ειδικα σε κασσιτερο και χρυσο, εχει προταθει σαν ο κυριος λογος για την αναπτυξη εμπορικων ανταλλαγων απο την αρχη της πρωιμης προϊστοριας. Πολλοι συγγραφεις εχουν υποστηριξει την ιδεα αλληλοεπιρροης μεταξυ των πολιτισμων της Βορειοδυτικης Ιβηριας και της Ανατολικης Μεσογειου. Αρχαιες πηγες αναφερουν την αφθονια ορυκτων και μεταλλων στις *Κασσιτεριδες Νησους*. Οι αναφορες αυτες μαλλον ξεκινησαν απο εμπορευομενους ναυτικους. Το ονομα *Κασσιτεριδες* αντιπροσωπευει την πρωτη γνωση των Ελληνων για πηγες κασσιτερου καπου μακρυα, ειτε στο εσωτερικο ειτε στην ακτη της Δυτικης Ευρωπης. Η λεξη *κασσιτερος* ηταν γνωστη στον Ομηρο και αναφερεται στην Ιλιαδα δεκα φορες. Το ακρωτηριο Finisterre, *Ακρη της Γης* για τους Ρωμαιους, θεωρουταν οτι ηταν το πιο βορειο σημειο που ειχε φτασει ο *Πυθεας ο Μασσαλιωτης*, οπως το περιεγραψε στο *Περιπλους*, και το οποιο φαινεται πως ηταν η βασικη πηγη πληροφοριων για ενα νεωτερο Ρωμαιο συγγραφεα, τον Rufus Festus Avienus. Ο B.Cunliffe εχει προτινει οτι αν το Finisterre ηταν το ακρωτηριο Oestrymnis που αναφερεται στο *Ora Martimia* του Avienus, τοτε περιπλους και ο *Περιπλους* να θεωρηθει σαν ο οδηγος που ακολουθουσαν οι Ελληνες ναυτικοι που ταξιδευαν απο την Μασσαλια στη βορειοδυτικη Ιβηρια γυρω στα 500 π.Χ..

Προσφατα, η μελετη τεχνολογιας προϊστορικου χαλκου δινει μεγαλυτερη εμφαση σε τεχνολογικες λεπτομερειες των αρχαιολογικων ευρηματων για την ανιχνευση αλλαγων στη μεταλλουργικη τεχνη. Η χαλκουργεια πρωτοεμφανιζεται στην Βορειοδυτικη Ιβηρια στο τελος της 3ης εως την αρχη της 2ης χιλιετιας π.Χ., κυριως για παραγωγη, διακινηση και καταναλωση *αντικειμενων κυρους*. Τα μεταλλα ειναι σπουδαιο συστατικο αυτου του ειδους οικονομιας οπως περιγραφεται στα Ομηρικα Επη. Οι Ομηρικες αναφορες σε Φοινικες εμπορους που μεταφερουν μεταλλευμα απο εδω κι εκει ειναι οι πρωτες γραπτες αναφορες που εχουν διασωθει. Δειχνουν οτι η οικονομια της Εποχης του Χαλκου εστηριζε την διαιωνηση του αριστοκρατικου συστηματος, χωρις την δυνατοτητα ιδιοκτησιας αγαθων απο τον υπολοιπο πλυθησμο.

Προσφατες προκαταρτικες αναλυσεις στα εργαστηρια του Daresbury (συνχροτρον φως) και Rutherford (πηγη νετρονιων) και αλλα δεδομενα εχουν συμβαλλει στην κατανοηση των τεχνολογικων λεπτομερειων αυτης της πολυ πρωιμης τεχνολογιας χαλκου. Η αρχαιολογικη μαρτυρια υποστηριζει την υποθεση εντονης αυξησης της παραγωγης στην εποχη αυτη. Τα περισσοτερα αντικειμενα που εχουν εξεταστει κατασκευαστηκαν τοπικα, απομιμησεις ξενου στυλ, ιδιαιτερα στην περιοχη της ακτης του Αντλαντικου, με ιδιαιτερα χαρακτηριστικα που συνδεονται με την συνθεση του κραματος και αλλα στοιχεια. Πραγματι, ηδη κατα τον 8ο αιωνα π.Χ. οι Φοινικες ειχαν εγκαταστησει εμπορικο σταθμο στο Gadir. Απο εκει, τα Φοινικικα πλοια ταξιδευαν συχνα Βορεια μεχρι την Ιβηρικη ακτη του Αντλαντικου. Παρατηρουμε διαφορες μεταξυ της παραγωγης μεταλλικων αντικειμενων της Οψιμης Εποχης του Χαλκου και της Εποχης του Σιδηρου, τα λεγομενα *tartesic bronzes*. Οι τεχνικες λεπτομερειες παραγωγης χαλκου κατα την περιοδο ανατολικης απομιμησης (Orientalising Period) στην Ιβηρικη Χερσονησο ευνοουν την εξατομικευση μεταλλουργικων παραδοσεων.

INTRODUCTION

The North Western Iberia metal ore wealth, especially tin ore and gold, have been proposed as the main reason for the development of intense trade routes since early prehistory. Several authors have argued the existence of interactions between the northwest of the Iberian Peninsula and other cultures of the European Occident and the Mediterranean area. Ancient sources comment on the abundance of minerals and metals in the *Cassiterides* or *Tin Islands* [1]. These accounts must have originated from sailors who from time immemorial were trading in these coasts.

The name *Cassiterides* represents the first vague knowledge of the Greeks that tin was found overseas somewhere in or off Western Europe. The word *κασσιτερος* was known to Homer and is mentioned ten times in the Iliad (Table I). Curiously, very often in connection with Hephaestonian metal-working, an age-old art. Cape Finisterre (*Land's End* for the Romans) was proposed as the northernmost point recorded in the *Periplous* of Pytheas the Massaliot, which seems to be the basic source used by Rufus Festus Avienus. B.Cunliffe has suggested [2] that if Cape Finisterre was the place called Oestrymnis by Avienus in *Ora Maritima*, then *Periplous* could be seen as the guide that led Greek sailors from Marseille to the north-west of Iberia to trade for the coveted Galician tin some time around 500 BC.

Recently, the study of prehistoric bronze-working places more emphasis on technological aspects as a means of detecting changes in the pattern of metal production, distribution and consumption in the archaeological record. Several works [3] have highlighted the importance of physical techniques in addressing specific problems, i.e. the composition of the alloy, particularly the concentration of tin and how variations in time reflect evolution of bronze production.

Bronze-working appears in North Western Iberia in the beginning of the 2nd millennium BC for short-scale production, distribution and consumption. Traces of bronze metallurgical production have been reported from the *A Sola* (A Sola IIb) settlement site (Portugal) [4], and from *O Fixón-A Costa da Seixeira* (Galicia, Spain) [5] by the middle of the 2nd millennium B.C. (Fig. 1). Important evidence of bronze metallurgical production was recently detected at the settlement site of *Fraga dos Corvos* (Trás-Os-Montes, North Portugal) (dated to the 1700 B.C. CAL) [6]. The production of flat-flanged axes has been indirectly confirmed by the presence of stone moulds (Fig. 2).

Archaeological evidence from North Western Iberia supports the hypothesis of an increase in the production of bronze objects, such as axes, during the Late Bronze Age. Most of

Table I. Verses using the word ***κασσιτερος*** in the Iliad. English translation from [7].

Λ24 του δ ητοι δεκα οιμοι εσαν μελανος κυανοιο Λ25 δωδεκα δε χρυσοιο και εικοσι κασσιτεροιο	Ten rods indeed were of dark metal, twelve of gold, and twenty of tin
Λ33 καλην ην περι μεν κυκλοι δεκα χαλκεοι ησαν Λ34 εν δε οι ομφαλοι ησαν εεικοσι κασσιτεροιο Λ35 λευκοι εν δε μεσοισιν εην μελανος κυανοιο	Round which were ten brazen orbs. Upon it were twenty white bosses of tin, and in the midst was one of dark metal.
Σ474 χαλκον δ εν πυρι βαλλεν ατειρεα κασσιτερον τε Σ475 και χρυσον τιμηντα και αργυρον αυταρ επειτα	He cast into the fire impenetrable brass, and tin, precious gold and silver;
Σ561 εν δ ετιθει σταφυλησι μεγα βριθουσαν αλωην Σ562 καλην χρυσειην μελανες δ ανα βοτρυες ησαν Σ563 εστηκει δε καμαξι διαμπερες αργυρεησιν Σ564 αμφι δε κυανεην καπετον περι δ ερκος ελασσε Σ565 κασσιτερου μια δ οιη αταρπιτος ηεν επ αυτην	On it likewise he placed, of huge size, a vine-yard, heavy with grapes, beautiful and golden ; but the clusters were black ; and they (the vines) stood against silver poles, placed in order. Round it he drew an azure ditch, about which he planted an edge of tin.
Σ574 αι δε βοες χρυσοιο τετευχατο κασσιτερου τε	But the oxen were made of gold and of tin
Σ609 αυταρ επει δη τευξε σακος μεγα τε στιβαρον τε Σ610 τευξ αρα οι θωρηκα φαεινοτερον πυρος αυγης Σ611 τευξε δε οι κορυθα βριαρην κροταφοις αραρυιαν Σ612 καλην δαιδαλεην επι δε χρυσεον λοφον ηκε Σ613 τευξε δε οι κνημιδας εανου κασσιτεροιο	But when he had completed the shield, huge and solid, he next formed for him a corselet, brighter than the splendour of fire. He also made for him a strong helmet, fitted to his temples, beautiful and variously wrought, and put upon it a golden crest; and formed greaves for him of ductile tin.
Υ268 ρηξε σακος χρυσος γαρ ερυκακε δωρα θεοιο Υ269 αλλα δυω μεν ελασσε δια πτυχας αι δ αρ ετι τρεις Υ270 ησαν επει πεντε πτυχας ηλασε κυλλοποδιων Υ271 τας δυο χαλκειας δυο δ ενδοθι κασσιτεροιο Υ272 την δε μιαν χρυσην τηι ρ εσχετο μειλινον εγχος	But the gold stayed it, the gifts of a god. Through two folds, however, it past, but there were yet three; since Vulcan had drawn five folds over it, two brazen, two of tin, and one golden ; where at length the brazen spear was stopped.
Φ592 αμφι δε μιν κνημις νεοτευκτου κασσιτεροιο Φ593 σμερδαλεον κοναβησε παλιν δ απο χαλκος ορουσε Φ594 βλημενου ουδ επερησε θεου δ ηρυκακε δωρα	But the greave of newly-wrought tin around it sounded horribly ; and the brazen weapon leaped back from it when struck, nor penetrated
Ψ503 αρματα δε χρυσωι πεπυκασμενα κασσιτερωι τε	The chariot, ornamented with gold and tin,
Ψ560 δωσω οι θωρηκα τον Αστεροπαιον απηυρων Ψ561 χαλκεον ωι περι χευμα φαεινου κασσιτεροιο Ψ562 αμφιδεδινηται πολεος δε οι αξιος εσται	I will give him the corselet which I took from Asteropaeus, brazen, round which is poured a rim of shining tin ; and it is of great value.

the objects found are considered to have been produced locally, imitating foreign styles, especially of the Atlantic area, with singular features related to the alloy composition and others. Indeed, as early as the beginning of the 8th century BC, the Phoenicians had established a trading post at Gadir. From here Phoenician ships regularly sailed north up the Atlantic coast of Iberia [8]. It is interesting to observe technological differences between the so-called tartessic bronzes and the other LBA bronze traditions in Iberia. The technological aspects of bronze production during the Orientalising Period favour the development of individual manufacturing traditions between the tartessic bronzes [9]. High-leaded bronzes are usual in North Western Iberia, whereas in South Western Iberia the absence of ternary alloys is almost total. These regional peculiarities could be related to the availability of the raw material [10]. But to know about this LBA tradition, we must understand about the origins of bronze alloy in the northwest in a technological and archaeological context. An interesting question is whether the bronze alloy is related to the tin sources. Different technological domain systems have been identified also for gold [11].

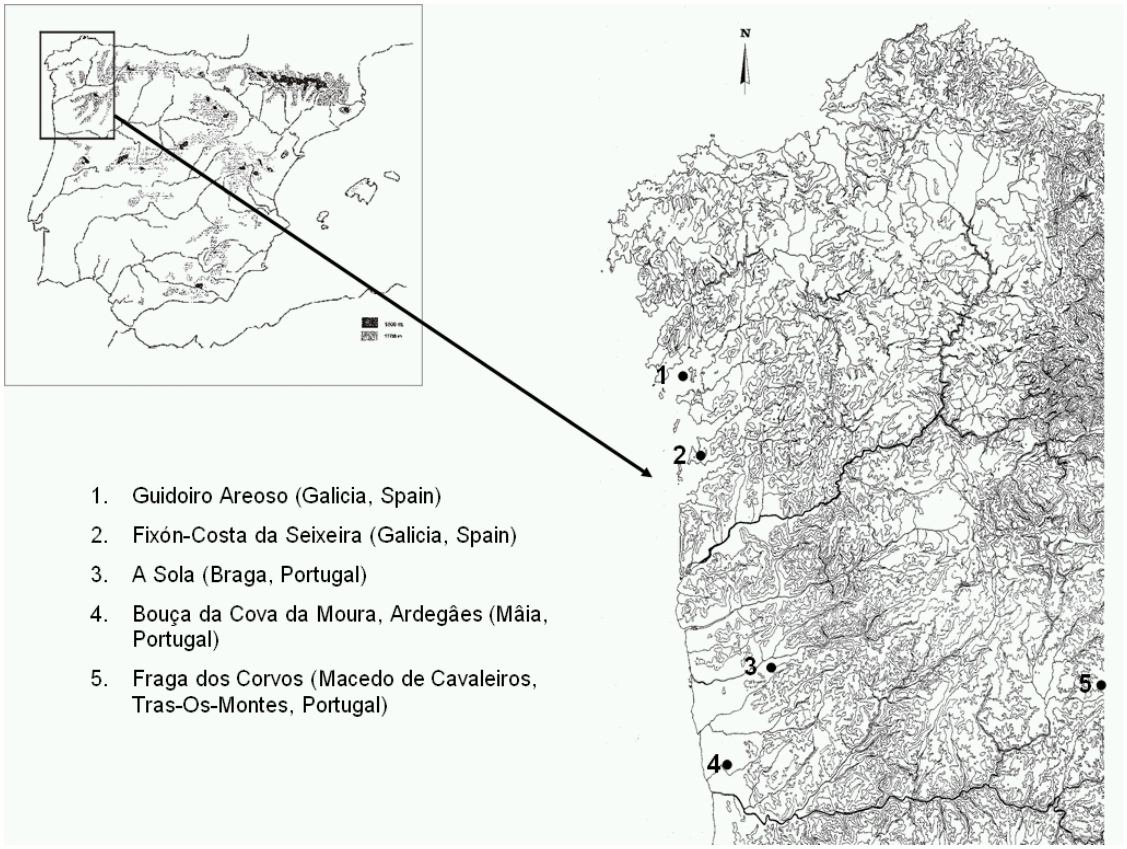


Figure 1. North Western Iberia. Main archaeological sites quoted.

Metallurgy appears related primarily to power and not with domestic and functional use. As for cultural interaction, let us talk about "imitation" or "trade", but we can not solve this question only with typological discussions. And we must talk about technological transmission. The analysis of different aspects, composition, craft techniques, morphology, distribution, etc, help us distinguish different productions.

TIN IN EARLY BRONZES

A few of these Iberian early bronzes have been previously examined using Energy Dispersive X-ray Fluorescence (ED-XRF) and metallography [12]. Two metal droplets and a bronze bar from the Bronze Age settlement site *A Sola* (Level IIb) (Braga, Portugal) dated to 1600-1500 B.C. (Fig. 3), and two large-sized bronze awls from the site on the islet of *Guidoiro Areoso* (Vilanova de Arousa, Pontevedra), both considered to be amongst the earliest bronze objects from Iberia [13] (Fig. 4). A new find, not previously examined, was a metal drop in two parts from the archaeological site of *Ardegães* (Bouça da Cova da Moura, Maia, Porto, Portugal) [14] (Fig. 5).

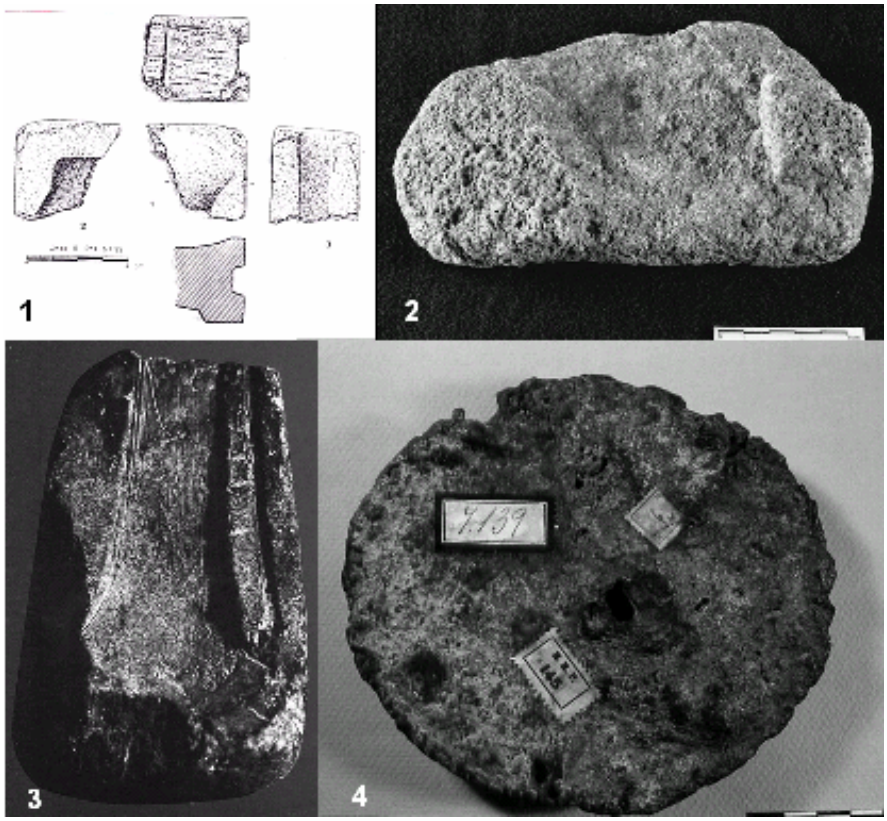


Figure 2. Stone Moulds: 1. *Monte das Carballas* (Guillade, Galicia); 2. *A Sola* (Braga, North Portugal); 3. *A Erosa* (Galicia); 3. Bun ingot from *Santo Ovidio* (North Portugal).

Figure 3. Bronze objects from *A Sola* (IIb) (Braga, North, Portugal).

Figure 4. Bronze objects (awls) from the site on the inlet of *Guidoiro Areoso* (Galicia, Spain).

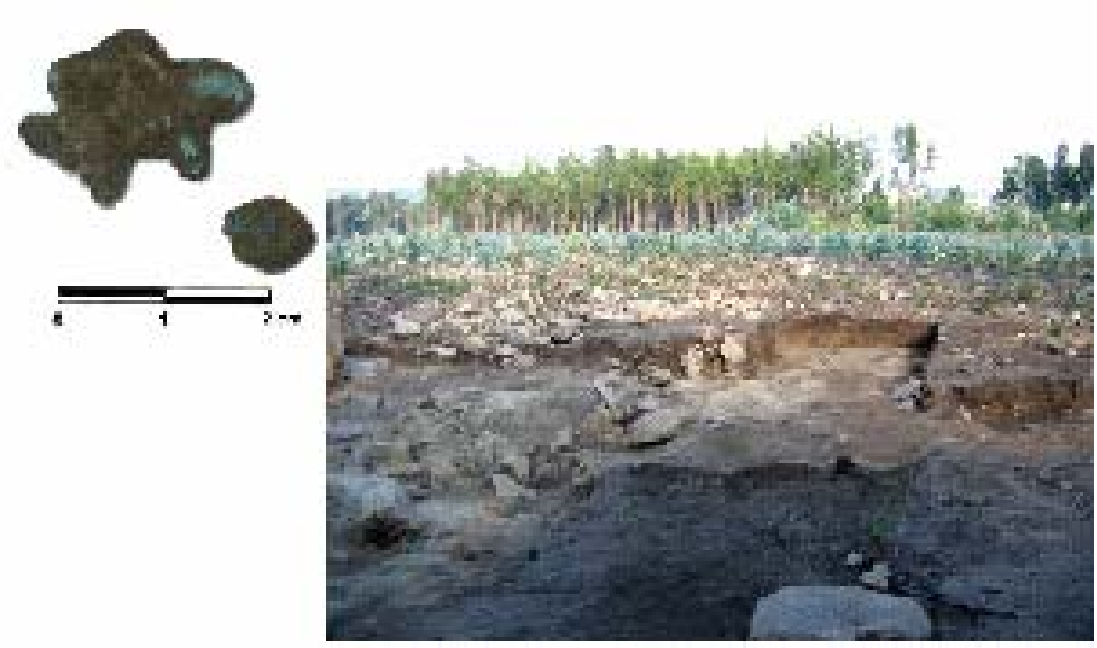


Figure 5. Bronze drop from the site of *Ardegâes* (Bouça da Cova da Moura, Maia, Porto, Portugal).

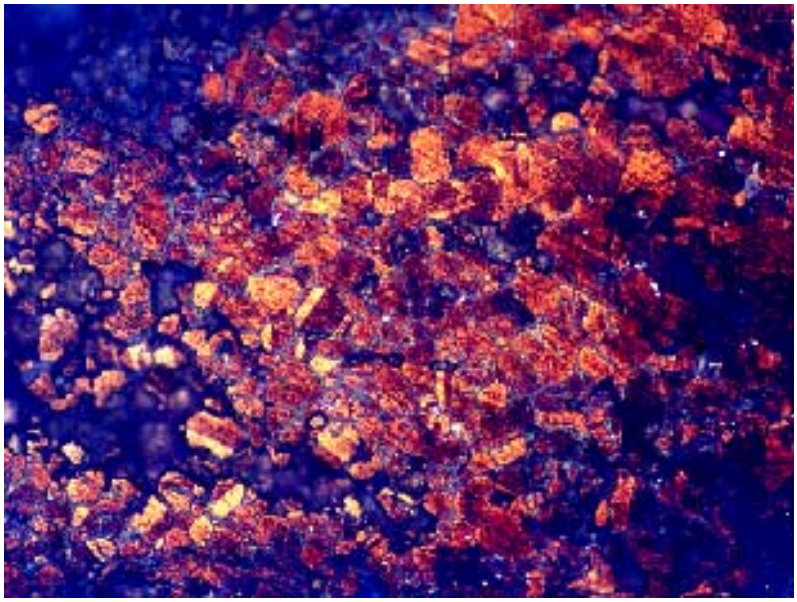


Figure 6. Metallography of the big awl of Guidoiro Areoso (Galicia, Spain), showing a metal cold worked and annealed, a feature certainly rare at the sight of the general reckoning of Chalcolithic workshop techniques. Bronze, polished at the edge of the butt end of the object. Etched by ferric chloride and hydrochlroric acid in alcoholic solution, magnification x250.

The values of tin measured by ED-XRF are relatively high with most of the analysis showing tin percentages higher than 20wt% with a small amount of trace elements that

are considered to be impurities (As, Sb and other). However, it should be noted that ED-XRF is a surface characterization technique and that the conclusions reached thus far were based on the analysis of a limited number of objects. Moreover, bronze artefacts can have considerable variations of bulk and surface (corrosion) compositions [15]. Metallographic examination (Fig. 6) suggests that one of the examined objects was annealed, a practice which rarely occurs during the Chalcolithic and EBA period. Rovira [16] revised the values of tin measured by ED-XRF (21,9wt%) and conclude that it is due to the presence of corrosion layers, and that the original concentration values of tin for the bronze object studied are between 10-12 wt%.

This paper focuses on the utilisation of the Synchrotron Radiation Source (SRS) at Daresbury Laboratory and the Neutron Spallation Source ISIS at the Rutherford-Appleton Laboratory during a Short Term Scientific Mission (STSM) in the frame of the EU COST Action G8 "Non-destructive analysis and testing of museum objects" [17]. The objective of these preliminary analyses on a few selected samples has been the understanding of technological details of this very early bronze metallurgy.

NEUTRON AND SYNCHROTRON X-RAY DIFFRACTION ANALYSIS

The instrumentation employed for the time-of-flight (TOF) neutron diffraction measurements on bronze and other metal objects has been described previously [18,19,20]. The high penetration power of neutrons for most materials allows a non-invasive bulk analysis of relatively large, intact objects which can be studied in situ without preparation. Neutron diffraction allows identification of crystalline phases throughout the examined area including information on the phases present in the bulk alloy and the corrosion phases on the surface of the object. For the measurements on the ROTAX diffractometer at ISIS, the samples were illuminated with a beam of cross section 20x20 mm^2. This means that a large part of the sample was immersed in the neutron beam, thus a more representative volume of the whole object is sampled than with any other methods which normally study small surface areas at a time.

Figure 7 shows the neutron diffraction patterns and the bronze objects from which the data was obtained. The concentration values of tin for these objects are between 5-10 wt%. There are also indications of tin-rich alloy phases in some of the samples. For this early production, the absence of control on the final product could result in achieving the bronze alloy by co-smelting of copper and tin ores, even the use of natural Cu-Sn ores [21]. Firm conclusions on this rather important and much discussed issue [22] can not be reached from the small number of objects we have studied in this work. The concentration of trace elements is another important parameter which can actually be

obtained using a different neutron technique, Prompt Gamma Activation Analysis (PGAA) [23], not available on the instrument we used at ISIS.

Object Sola 127.92, was also analysed using X-ray powder diffraction in flat-plate geometry at the SRS station 2.3 [24] with the aim of identifying surface corrosion products in order to assess the preservation state of the object (Fig. 8a). The diffraction patterns showed broad and weak Bragg reflections. Some of these reflections can be assigned to the oxides tenorite (CuO) and cassiterite (SnO_2). Although tenorite is not an unusual corrosion phase to be found, cassiterite is less frequently observed. Because of the roughness of the object it was not possible to do depth-profiling of the corrosion layers, in order to establish the order in which the various corrosion phases were present. Such measurements are possible by varying the wavelength or the angle of incidence of the X-ray beam [25]. X-ray powder diffraction of six micro-size corrosion fragments from both Guidoiro awls and other objects were measured on the SRS station 14.1 using a fast 2D CCD detector and a multi-sample cassette on a computer controlled x-y stage (Fig. 8b and Fig. 9) [26].

Analysis of the diffraction patterns revealed the presence of cuprite, paratacamite and atacamite. In the case one fragments from one object (the big Guidoro awl) there is clear evidence of cassiterite. The identification of copper chlorides in particular (Fig. 10), indicates the different preservation state of these objects, and allows the development of a conservation plan for the stabilisation of these objects.

The hypothesis of high values in tin for the early bronzes developed in earlier work [27], (surface analyses) is not put to doubt by the present measurements which clearly show that the tin content of the bulk alloy is below 10 wt%. The high values obtained by ED-XRF could be interpreted as tin enrichment in the surface due to corrosion/burial environment. ED-XRF analysis made on the surface of an archaeological metal artefact is able to characterise it, that is to provide important information on whether, for example, the alloy is bronze, leaded bronze or brass, but can not identify it (that is quantify the tin content of the unexposed bulk), because of possible segregation phenomena. To determine the bulk composition of archaeological bronzes with ED-XRF one has to either study sections where the uncorroded interior of the object is exposed or to use techniques such as neutron diffraction which permits precise and non-destructive determination of the bulk alloy percentages of the copper-tin phases, even in the presence of corrosion layers [18,28].

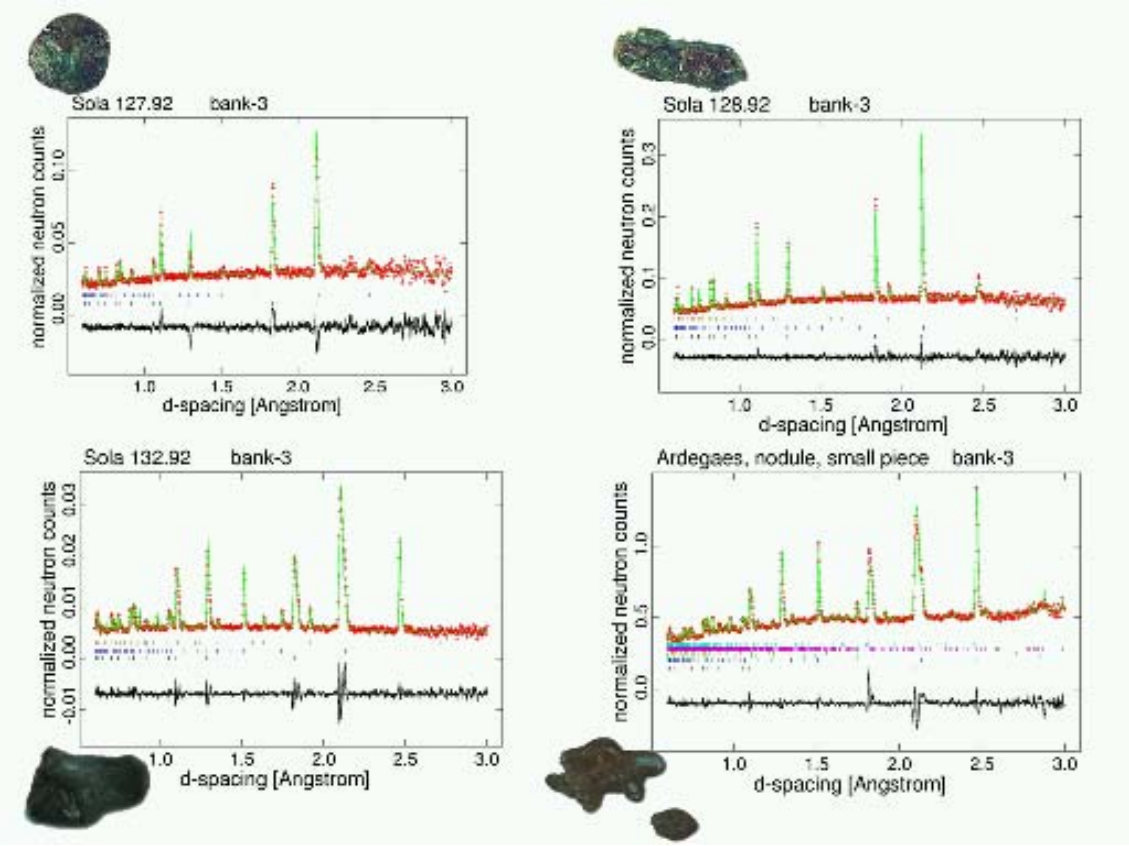


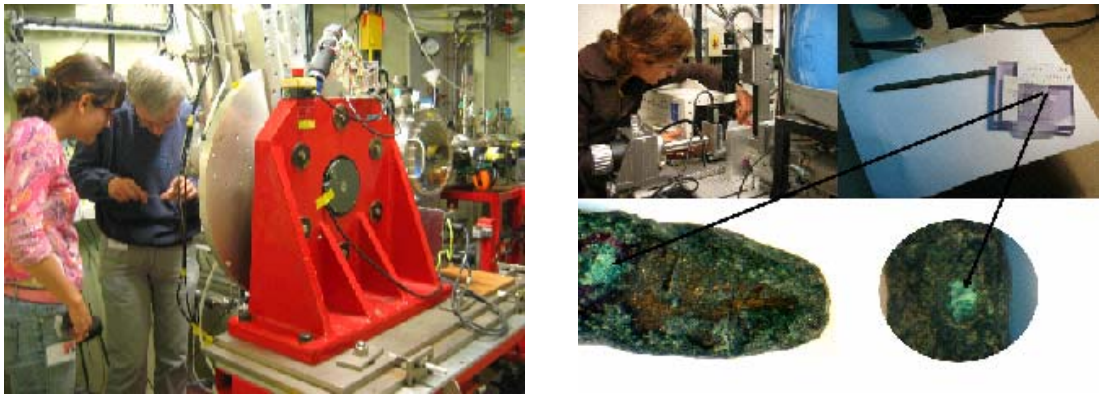
Figure 7. Neutron diffraction patterns were collected from bronze artefacts on ROTAX in order to determine the alloy compositions, and to look for indications of microstrains as a result of cold working. Broad and narrow diffraction peaks are observed as a result of cold working and thermal annealing, respectively.

a) A SOLA 127.92: 90/10 Cu/Sn bronze, with a small amount of cuprite. The bronze peaks are only slightly (almost insignificantly) broadened, suggesting that the samples have been subjected to a homogenisation process. The presence of tin-rich-delta and eta-phases cannot be excluded.

b) A SOLA 128.92: 90/10 Cu/Sn bronze, with a small amount of cuprite. The bronze peaks shapes are only slightly broadened, suggesting that the samples have been subjected to a homogenisation process. There are no high-tin phases present.

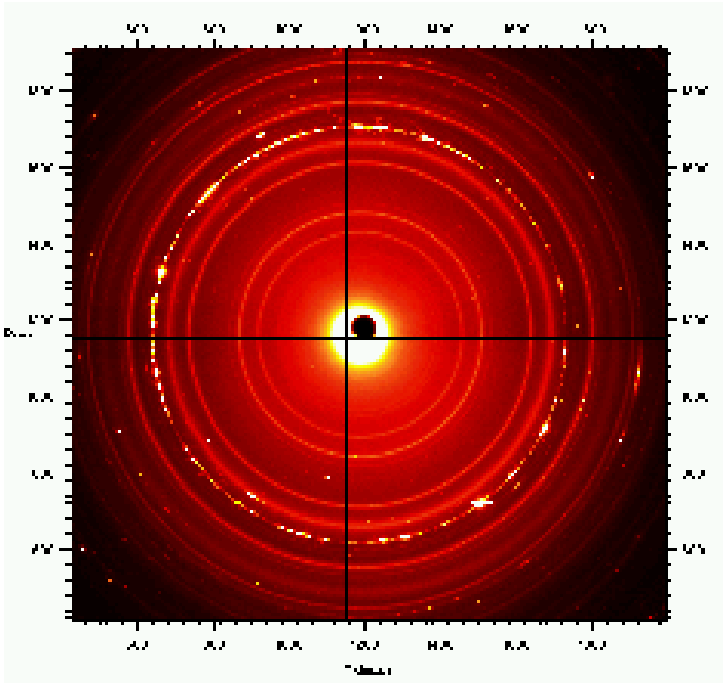
c) A SOLA 132.92: 95/5 Cu/Sn bronze, with amounts of cuprite and nantokite. The bronze peaks are very broad and 'structured', as for an as-cast sample with an inhomogeneous tin distribution. The presence of tin-rich delta- and eta-phases cannot be excluded.

d) ARDEGÂES. Small piece: 95/5 Cu/Sn bronze, with amounts of cuprite, nantokite, and malachite. The bronze peaks are distinctly broadened, as for an as-cast sample with an inhomogeneous tin distribution. The presence of tin-rich delta and eta-phases cannot be excluded.



a b

Figure 8. a) The X-ray diffractometer at the SRS station 2.3 used to study the corrosion products on the surface of a sample from *A SOLA*. b) View of the station 14.1 instrumentation showing the 2D CCD detector, the computer controlled x-y stage and the sample cassette set used to mount small corrosion flakes taken from areas on corroded objects, as indicated.



C3_90mm_1_004.img

Figure 9. Two-dimensional X-ray diffraction pattern recorded by the CCD detector at the SRS station 14.1 from a micro-size fragment of corrosion on the big Guidoiro awl. Data collection time 30 sec.

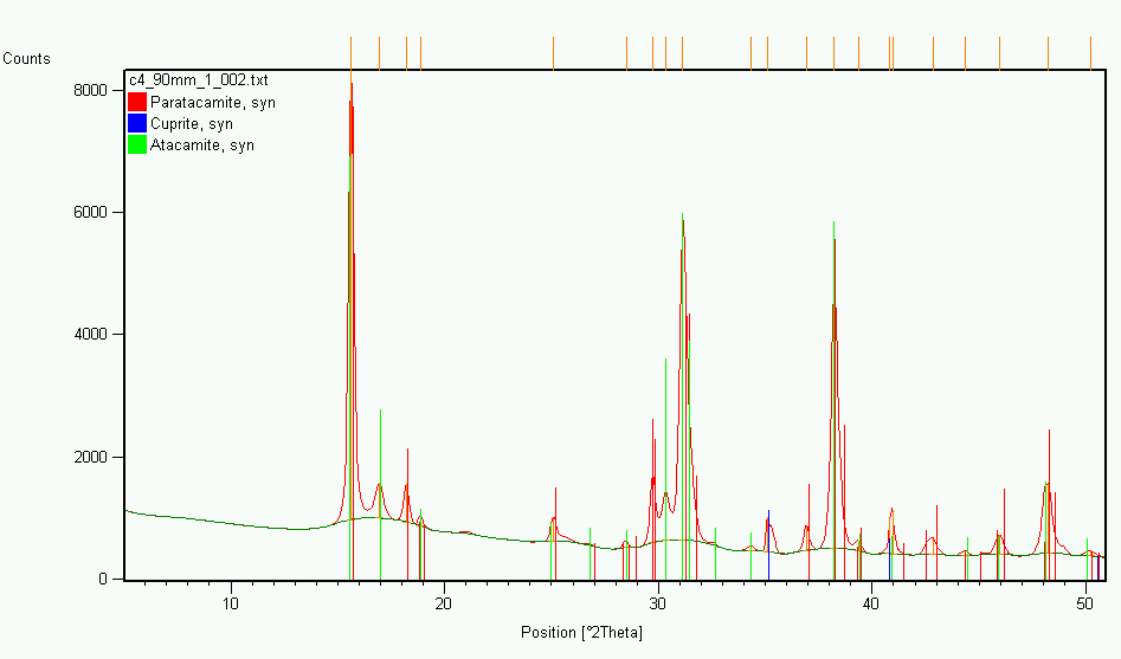


Figure 10. The integrated diffraction pattern corresponding to Fig.9 analysed using the X'Pert Highscore software package. The corrosion phases Paratacamite, Atacamite and cuprite are identified.

METALS AS PRESTIGE GOODS IN THE HOMERIC EPICS

Let us return our attention now to non-technological matters and discuss how technology of production fitted in with customs and daily life practices in the Homeric Age which in most scholars' minds equates to the Bronze Age in Europe. Metals are a major component of the prestige economy described in the Homeric Epics. Homer's accounts of Phoenician traders carrying metals hither and thither constitute the earliest literature reference [29] to metal trading (as well as to the word Phoenician). In ancient societies, it is possible to detect two types of economy co-existing. On one hand the so-called subsistence economy, based on the exchange of necessary products, and on the other hand, the gift economy, which is based on gift exchange. It is precisely the latter aspect referred to in the Homeric poems, which we wish to comment on below.

The Homeric Epics reflect a society whose political and economic power was residing in an aristocracy that was defined by the possession of land and goods. In fact, the *basileus (local king)* or *wanax (chief amongst other kings, for example Odysseus, Achilles, Agamemnon, Menelaos, Nestor)*, had to establish his position by demonstrating that he was the most powerful amongst his aristocrat peers. The purpose of these goods was to be hoarded in the *keimelion (store of precious objects),* generally placed in a secret place of the *anaktoron (palace, the residence of the wanax)*, often in the cellar and jealously

Table II. The gifts offered Achilles by Odysseus, acting on behalf of Agamemnon.
Il. I:260-282. English translation from [7].

παυε εα δε χολον θυμαλγεα σοι δ Αγαμεμνων
αξια δωρα διδωσι μεταλληξαντι χολοιο
ει δε συ μεν μευ ακουσον εγω δε κε τοι καταλεξω
οσσα τοι εν κλισιησιν υπεσχετο δωρ Αγαμεμνων
επτ απυρους τριποδας δεκα δε χρυσοιο ταλαντα
αιθωνας δε λεβητας εεικοσι δωδεκα δ ιππους
πηγους αθλοφορους οι αεθλια ποσσιν αροντο
ου κεν αληιος ειη ανηρ ωι τοσσα γενοιτο
ουδε κεν ακτημων εριτιμοιο χρυσοιο
οσς Αγαμεμνονος ιπποι αεθλια ποσσιν αροντο
δωσει δ επτα γυναικας αμυμονα εργ ειδυιας
Λεσβιδας ας οτε Λεσβον ευκτιμενην ελες αυτος
εξελεθ αι τοτε καλλει ενικων φυλα γυναικων
τας μεν τοι δωσει μετα δ εσσεται ην τοτ απηυρα
κουρην Βρισηος και επι μεγαν ορκον ομειται
μη ποτε της ευνης επιβημεναι ηδε μιγηναι
η θεμις εστιν αναξ η τ ανδρων η τε γυναικων
ταυτα μεν αυτικα παντα παρεσσεται ει δε κεν αυτε
αστυ μεγα Πριαμοιο θεοι δωως αλαπαξαι
νηα αλις χρυσου και χαλκου νεησασθαι
εισελθων οτε κεν δατεωμεθα ληιδ Αχαιοι
Τρωιαδας δε γυναικας εεικοσιν αυτος ελεσθαι
αι κε μετ Αργειην Ελενην καλλισται εωσιν

"Yet even now desist, and lay aside thy disgraceful anger. Agamemnon gives gifts worthy of thee, if thou wilt, hear thou from me, and I will repeat to thee how many presents Agamemnon in his tents hath promised thee : seven tripods, which have not touched the fire, and ten talents of gold, twenty glittering goblets, and twelve strong steeds, victorious in the race, which have borne off prizes by their speed. The man need not be poor nor needy in precious gold, to whom so many prizes belong as the horses of Agamemnon have born off their speed. He will likewise give seven beautiful Lesbian women, skilful in working, whom he selected when thou didst thyself take the well-inhabited Lesbos, and who then excelled woman-kind in beauty. These will be given thee, and amongst them will be her whom he once took away, the daughter of Briseïs ; and he will moreover add a great oath, that he never ascended her bed, not embraced her, as is his custom. O king, both of men and women. All these shall immediately be thine ; and if the gods even yet grant that we take the vast city of Priam, thou mayst fill thy ships with abundance of gold and brass, entering in when we Greeks divide the spoil. Thou shalt thyself also choose twenty Trojan women, who may be fairest next to the Argive Helen."

…. and more offerings of more women, princesses, cattle and horses, lands, glory and honour. For Hector is about to make life difficult for the Achaeans.

Table II (continued). Achilles refuses the gifts wily Odysseus is offering, on behalf of Agamemnon, with contempt. Il. I:307-322 and 356-369. English translation from [7].

τον δ απαμειβομενος προσεφη ποδας ωκυς Αχιλλευς
διογενες Λαερτιαδη πολυμηχαν Οδυσσευ
χρη μεν δη τον μυθον απηλεγεως αποειπειν
ηι περ δη κρανεω τε και ως τετελεσμενον εσται
ως μη μοι τρυζητε παρημενοι αλλοθεν αλλος
εχθρος γαρ μοι κεινος ομως Αιδαο πυλησιν
ος χ ετερον μεν κευθηι ενι φρεσιν αλλο δε ειπηι
αυταρ εγων ερεω ως μοι δοκει ειναι αριστα
ουτ εμε γ Ατρειδην Αγαμεμνονα πεισεμεν οιω
ουτ αλλους Δαναους επει ουκ αρα τις χαρις ηεν
μαρναsθαι δηιοισι μετ ανδρασι νωλεμες αιει
ιση μοιρα μενοντι και ει μαλα τις πολεμιζοι
εν δε ιηι τιμηι ημεν κακος ηδε και εσθλος
κατθαν ομως ο τ αεργος ανηρ ο τε πολλα εοργως
ουδε τι μοι περικειται επει παθον αλγεα θυμωι
αιει εμην ψυχην παραβαλλομενος πολεμιζειν

Whom answering, the swift-footed Achilles addressed : "Most noble son of Laertes, wily Ulysses, it behoves me undisguisedly to speak my opinion, even as I think, and as will be accomplished, that ye may not, sitting beside me, trouble me one after another. Hateful to me as the gate of hell is he who conceals one thing in his mind and utters another. But I will speak as appears to me the best ; and I think that neither Agamemnon the son of Atreus, nor the other Greeks will persuade me, since there is no satisfaction for fighting ever ceaselessly with hostile men. An equal portion is given to him who hangs back, and if one keenly fight : and the coward is in equal honour, even as the brave. The man who is useless, and he who performs many deeds, equally die ; nor does anything belong to me, because I have suffered sorrows in my soul, always exposing my life in combat."

νυν δ επει ουκ εθελω πολεμιζεμεν Εκτορι διωι
αυριον ιρα Διι ρεξας και πασι θεοισι
νηησας ευ νηας επην αλαδε προερυσσω
οψεαι ην εθελησθα και αι κεν τοι τα μεμηλη
ηρι μαλ Ελλησποντον επ ιχθυοεντα πλεουσας
νηας εμας εν δ ανδρας ερεσσεμεναι μεμαωτας
ει δε κεν ευπλοιην δωηι κλυτος εννοσιγαιος
ηματι κεν τριτατωι Φθιην εριβωλον ικοιμην
εστι δε μοι μαλα πολλα τα καλλιπον ενθαδε ερρων
αλλον δ ενθενδε χρυσον και χαλκον λευκον
ηδε γυναικας ευζωνους πολιον τε σιδηρον
.....

" ... But now since I choose not to combat with the noble Hector, having performed sacrifices tomorrow to Jove and all the gods, when I have dragged to the sea my well-loaded vessels, thou shalt behold, if thou wilt, and if such things be a care to thee, my ships early in the morn sailing upon the fishy Hellespond, and men within them eager for rowing ; and if the glorious Neptune grant but a prosperous voyage, on the third day I shall surely reach the fertile Pthia. I have there very many possessions, which I left, coming unauspiciously hither. And I will carry hence other gold and rudely brass, women elegantly zoned, and bright iron, which I have obtained by lot. But the reward which he gave ,king Agamemnon, the son of Atreus, hath himself taken insolently from me : to whom report all, as I charge you, openly, that other Greeks also may be indignant, if he, ever clothed in impudence, still hopes to deceive any of the Greeks; not let him dare, dog though he be, to look upon my countenance."

guarded by a faithful serf, to be given away as gifts again, an act that was extending the prestige of an already valuable object by enriching it with the genealogy of his previous owners.

The context and the meaning of these objects is interesting to be discussed. First of all, it is necessary to point out that access to such goods was restricted to a group of aristocrats who were perpetuated in this way, distinguished from other social groups. Acquisition of such goods (never by purchase) was achieved in two main ways: by war, where the goods of the defeated enemies were appropriated by force, and therefore turned into symbols of victory, or they were acquired as symbols of friendship, very often into the bosom of the bonds of hospitality that was implying obligatory exchange of prestigious goods. A third way, halfway in context between the previously quoted routes of gift acquisition, was through athletic competitions carried out in an ambience of warmth, but dominated by the competition. Again, Homer is the first available source of such societal practices.

Gifts and gift exchange, at least as described in the Homeric Epics, had a common characteristic independent of origin; the possibility of changing the "contextual sphere". There may have been regional differences in customs related to offerings to sanctuaries for different periods of times. In many cases the final destination of a prestigious object was to be used as gift (offering) to the gods, whereby its circulation stopped. Metal objects were the most common gifts, especially those made of gold, silver and bronze in that order of importance [30]. Iron, as deduced from the Homeric text (episode in the Iliad where Odysseus attempts to sweet-talk Achilles into cooperating (Table II), seems to be a rather special case in the Homeric Epics.

Il. Z48 , K379 , Λ133
χαλκος τε χρυσος τε πολυκμητος τε σιδηρος
copper and gold and precious iron

One could group metal goods in different categories:
- The first category includes (bronze) tripods, cauldrons and craters, usual objects for water heating, or for mixing wine and water. Perhaps because of their function (suitable objects for ceremonial purposes or for social events) these objects were highly valued, possibly acquiring more value if they had never been used. In this case possession of such an object had the effect of increasing the prestige of its owner.
- The second category includes gold vessels, likely to be objects of ritual character destined, for instance, to perform libations in honour to the gods. Undoubtedly, in giving

this gift there was the hidden intention that the receiver did not forget about the giver at a crucial moment.

Table III. Homeric accounts of prestigious goods handed down or given as gifts.

A. Hephaistos to Zeus to Hermes to Pelops to Atreus to Thyestes to Agamemnon, Il. B:100-108. English translation from [7].

παυσαμενοι κλαγγης ανα δε κρειων Αγαμεμνων
εστη σκηπτρον εχων το μεν Ηφαιστος καμε τευχων
Ηφαιστος μεν δωκε Διι Κρονιωνι ανακτι
αυταρ αρα Ζευς δωκε διακτορωι αργειφοντηι
Ερμειας δε αναξ δωκεν Πελοπι πληξιππωι
αυταρ ο αυτε Πελοψ δωκ Ατρει ποιμενι λαων
Ατρευς δε θνησκων ελιπεν πολυαρνι Θυεστηι
αυταρ ο αυτε Θυεστ Αγαμεμνονι λειπε φορηναι
πολληισιν νησοισι και Αργει παντι ανασσειν

when king Agamemnon arose, holding in his hand the sceptre which Vulcan had toiled to form. Vulcan gave it to king Jove, the son of Saturn, and Jupiter bestowed it upon his messenger, the slayer of Argus. But king Mercury presented it to Pelops, the knight, and Pelops again gave it to Atreus, shepherd of the people. But Atreus, at his death, left it to Thyestes, rich in cattle ; and Thyestes again bequeathed it to be borne by Agamemnon, that with it he might govern many islands, and the whole of Argos.

B. Menelaos offers Telemachos a silver crater, made by Hephaistos for the king of Sidon who in turn gave it as a gift of friendship to Menelaos. Od. δ:613-618. English translation from [31].

δωρων δ οσς εν εμωι οικωι κειμηλια κειται
δωσω ο καλλιστον και τιμηεστατον εστι
δωσω τοι κρητηρα τετυγμενον αργυρεος δε
εστιν απας χρυσωι δ επι χειλεα κεκραανται
εργον δ Ηφαιστοιο πορεν δε ε Φαιδιμος ηρως
Σιδονιων βασιλευς οθ εος δομος αμφεκαλυψε
κεισε με νοστησαντα τειν δ εθελω τοδ οπασσαι

Selected from my stores, of matchless price,
An urn shall recompense your prudent choice:
Not mean the massy mould of silver, graced
By Vulcan's art, the verge with gold enchased.
A pledge the sceptred power of Sidon gave,
When his realm I plough'd the orient wave

C. Alkinoos, the king of Phaiakans, has sent Odysseus back to Ithaca, loaded with presents. Od. ν:135-137. English translation from [31].

κατθεσαν ειν Ιθακηι εδοσαν δε οι ασπετα δωρα
χαλκον τε χρυσον τε αλις εσθητα θ υφαντην
πολλ ος αν ουδε ποτε Τροιης εξηρατ Οδυσσευς

Of brass, rich garments, and refulgent ore ;
And bears triumphant to his native isle
A prize more worth than Ilion's noble spoil.

- A third category includes weapons: swords, spears, shields, helmets and greaves that, on the contrary to the first category, their value was increased if they were reputed to have been used previously by an illustrious warrior. The episodes accounted in the Iliad for the exquisite sceptre (material not specified) made by Hephaistos for Zeus and then given or inherited down generations by Agamemnon (Il. B:100-107), Menelaos' gift to Telemachos (Od. δ:613-618) or King Alkinoos' farewell gifts to Odysseus (Od.ν:134-136) constitute a good example of this type (Table III).

In all cases mentioned above, objects were perpetuating the same reality: the social hierarchical structure of a society marked by the possession of prestige goods that were contributing much to the increase of the power of the giver, who was exhibiting publicly his aptitude to offer gifts. As of the receiver, accepting of gifts was increasing his wealth and therefore also the possibility of turning into giver. In all the cases of exchanging gifts, bonds of friendship but also of dependency were created, since a gift would increase in value (reciprocated) [32] at the moment of an expected exchange.

CONCLUSIONS

The results of neutron diffraction investigation of some of the finds from excavations in North Western Iberia have been compared with ED-XRF results from earlier work which seemed to suggest the production of rather high-tin bronzes during the Iberian Bronze Age. The use of neutron diffraction has pointed out the limitations of the ED-XRF method, when applied on the surface of the corroded objects, in order to provide meaningful data on the bulk alloy composition. These limitations are associated to tin segregation phenomena that occur on bronzes during casting and in the burial environment.

In the case of very corroded objects, as is the case of the objects studied here, they can not be properly cleaned. Rovira [16] always cleaned the surface looking for the bulk, but if the object is very corroded, it is impossible to remove all the corrosion products. The neutron data on four of the objects show that the copper:tin ratio is lower than previously determined by ED-XRF analysis of the surface of such objects. Corrosion phases have been identified unambiguously by either neutron or X-ray diffraction and the procedures followed have demonstrated that results can be obtained non-destructively from whole objects.

We have also set the archaeological evidence from North Western Iberia in the context of the Homeric texts which refer to an era not far removed from the times of tin bronze manufacture in a land, far away from the Aegean, but still within reach of early travellers. Although Homer makes tantalising references to Bronze Age technology, details such as alloy composition, provenance or trading of tin and copper ore and the significance on the social organisation of early metal production can not be deduced directly from the available archaeological evidence or by literary analysis of Homeric verses or accounts of ancient travellers without resorting to hard evidence, i.e. technological facts obtained by employing materials science techniques. This is where archaeology and science meet.

It is clear to us that this pilot study at ISIS and the SRS has set the scene for more systematic studies of archaeological material from North Western Iberia, or indeed other archaeologically documented material from other Bronze Age sites in Europe, the Aegean included.

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