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THE COMPOSITION OF COPPER-BASED SMALL FINDS FROM A WEST PHOENICIAN SETTLEMENT SITE AND FROM NIMRUD COMPARED WITH THAT OF CONTEMPORARY MEDITERRANEAN SMALL FINDS

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About 100 Phoenician copper alloy artefacts from Morro de Mezquitilla (Spain) have been analysed by inductively coupled plasma spectrometry and atomic absorption spectrometry. The results of the analysis are compared with previously unpublished analyses of contemporary material from Nimrud and with small finds of the same period from several Mediterranean areas. There are no published large-scale analyses of Phoenician metalwork and few analyses of the copper-based, very minor objects of the sort typically recovered from excavation and the comparisons show both similarities and differences in techniques and alloys of the various civilizations and classes of objects.

KEYWORDS: SPAIN, NIMRUD, PHOENICIAN, INDUCTIVELY COUPLED PLASMA ANALYSIS, ATOMIC ABSORPTION ANALYSIS, BRONZE, ALLOY COMPOSITION, REFINING

INTRODUCTION

The purpose of this paper is to present the results of the analysis of about 100 Phoenician bronze items, found during excavation at Morro de Mezquitilla in the Andalusian area of Torre del Mar (province of Malaga, Spain) by a team from the Deutsche Archäologische Institut (DAI) Madrid, under the direction of Professor H. Schubart, and to evaluate these results in a broader context. Large groups of Phoenician copper alloy artefacts have not been analysed previously and very little is known about the alloys used in the west Mediterranean, whereas large-scale analyses have been carried out on Greek and Etruscan material (Craddock 1977; Craddock 1986b). Furthermore, there are few analyses of small finds such as come from excavations. Most of the published analyses are of items from museum collections and tend to be fine art or decorative objects and large relative to normal detritus; very few can be considered minor metalwork.

The first reason for analysing the copper alloy artefacts from Morro de Mezquitilla, therefore, is to study the composition and the metallurgical techniques of extraction and alloying used by the Phoenicians and to compare these analyses with analyses of material from the same period produced by other civilizations and in particular with analyses of a previously unpublished group of similar finds from Nimrud. The second reason for analysis is to investigate the differences or similarities in the composition of very minor utilitarian items, such as nails and hooks, and of the more decorative objects, such as fibulae and pins, from the excavated material.

THE MATERIAL

The attention of the excavators was drawn to the site at Morro de Mezquitilla in 1964 by a study of west Phoenician settlements in the Andalusian area of Torre del Mar (Niemeyer *et* *al.* 1964). The site was subsequently more extensively excavated by a team from the DAI, Madrid, under the direction of Professor H. Schubart (Schubart 1977, 1982 and 1983). Fieldwork was halted following the 1982 campaign to allow more detailed study of the excavated material. The excavations had revealed the existence of a Bronze Age settlement (second half of the third millennium to the early second millennium BC), of a Phoenician settlement (eighth to fifth century BC) and of a third settlement, dated to sometime between the fourth and first century BC. In the period between the early second millennium BC and the beginning of the Phoenician period in the eighth century BC the absence of finds indicates that the site was not inhabited. All the items analysed have been found in layers dated to the Phoenician period of the seventh to sixth century BC and can be considered very minor everyday metalwork.

Analyses of this material from Morro de Mezquitilla are compared in this paper with the previously unpublished analyses of a group of small artefacts from Nimrud carried out by Paul T. Craddock in the Research Laboratory of the British Museum. Both groups of objects are dated to the same period and come from excavations. There are also connections between the two civilizations which could be reflected in the metallurgical techniques.

Another comparison can be made with artefacts found during excavation at Tejada la Vieja which is in a copper mining area in the province of la Huelva, Spain (Craddock 1981). The objects were excavated from the Iberian level and are therefore slightly later (sixth to fourth century BC), but the Phoenician heritage of the site and the type of small metalwork allow the comparison with the material from Morro de Mezquitilla.

A further comparison is made with the many hundreds of analyses of small Archaic Greek, Etruscan, Sardinian and Italic decorative objects now in the British Museum (Craddock 1977, 1982 and 1986b) and with a group of small finds of the Late Atlantic Bronze Age (Craddock 1980), which are all comparable in date.

Although all the comparative material is small metalwork, it is composed of recognizable categories such as brooches, fibulae, weights, etc., whereas much of the Morro de Mezquitilla consists of much more minor items that almost defy description, such as rods, patches, etc. The latter sort of material rarely finds its way into the collections of international institutions such as the British Museum and thus has not often been scientifically examined or analysed.

ANALYSIS

Samples of the copper alloy objects from Morro de Mezquitilla were taken in the Deutsche Archäologische Institut, Madrid, by P. Craddock, with a 12-volt portable jewellery drill with a size 60 drill bit of ordinary hardened steel, by the method described by Hughes *et al.* (1976). The small size of the objects and the corrosion did not always allow samples of adequate size to be taken and inevitably some corrosion products found their way into the metal drillings to be analysed. Analysing corroded material there is always the danger of obtaining results that do not add up to 100% or in which the presence of some elements is due to contamination with soil; however, before weighing the visible bits of corrosion were removed from the drillings.

The samples were dissolved according to the method described by Hughes *et al.* (1976) to be used for the analysis with inductively coupled plasma (ICP) and atomic absorption spectrometry (AAS). The first analysis was carried out on the simultaneous ICP system with vacuum spectrometer and roving detector at the Department of Geology, King's College, London (Giumlia 1985).

The detection limits for the different elements expressed in weight per cent are: copper 0.00036, tin 0.0017, lead 0.0028, arsenic 0.0035, cobalt 0.00047, nickel 0.0010, antimony 0.0021, silver 0.00047, zinc 0.00012, bismuth 0.0050, iron 0.0010. The quoted standard deviation is about 1% (Thompson and Walsh 1983, 94 ff.), but the very small size and the corrosion of some of the objects (nos. 11, 29, 30, 32, 67, 71, 84, 107) created the problem of very high totals and the fact that the system was calibrated for silica analysis caused matrix effects and so suspect copper results, which should therefore not be considered. The corrosion problems are probably small and analyses of corroded samples are omitted where the contamination was likely to be significant (e.g. iron). The main comparison is based on the lead and tin results, which are more rigorous. The tin was determined by adjusting the vacuum spectrometer for the measurement of the 189.9 Sn line and its standard deviation was estimated to be about 5%. The vacuum spectrometer is employed to measure the lines below 200 nm and gives much more accurate results than the usual air-path spectrometers. The lead, zinc and arsenic results given in the tables have been determined by AAS in the Research Laboratory of the British Museum, under M. Cowell's supervison, using the methodology described in Hughes *et al.* (1976). A flameless graphite atomiser was employed to determine low arsenic concentrations. The AAS results have an accuracy of +2% for the major elements, +10% for the elements between about 0.5 and 0.05 weight %, and +30% for trace elements under 0.05 weight %.

RESULTS AND DISCUSSION

Alloying elements (tin, lead)

The common additions used in antiquity to form an alloy with copper are tin and lead. Early sheet metalwork tends to have about 10% tin, whereas castings generally have less tin (about 7–8%), but can have an addition of up to 2% lead which improves the fluidity and lowers the melting point. Bronze items which are to be shaped by hammering should not contain lead because lead is not soluble in copper and if the percentage of lead in the alloy is too high globules of lead appear and form lines of weakness when hammered (Craddock and Giumlia-Mair 1988).

At Morro de Mezquitilla and at Nimrud we find the use of leaded bronze for castings (Morro de Mezquitilla nos. 18, 25, 45, 50, 55, 58, 76, 90, 103; Nimrud nos. 1, 4, 9, 16, 18, 19, 20, 22, 31) and a tin content similar to that of other civilizations in the Mediterranean area. The pattern of the histograms of the overall tin content in the Morro de Mezquitilla and in the Nimrud objects are rather similar (Figure 1), if we ignore the items of unalloyed copper, which are mostly nails and rods and will be discussed next. The very high frequency of objects with a tin content between 6% and 7% on the Nimrud histogram is due to the large number of fibulae while, on the other hand, there are no nails, rods or fragments of small implements. By comparing items with the same function (as for example the fibulae) we find an analogous tin content. It is also worth noting the very similar composition of the finds from the Spanish sites of Morro de Mezquitilla and Tejada la Vieja (Craddock 1981). Lead seems to occur more often in the Nimrud artefacts (Figure 1), but the lead content of the Morro de Mezquitilla objects (omitting the unalloyed copper items) is comparable with that

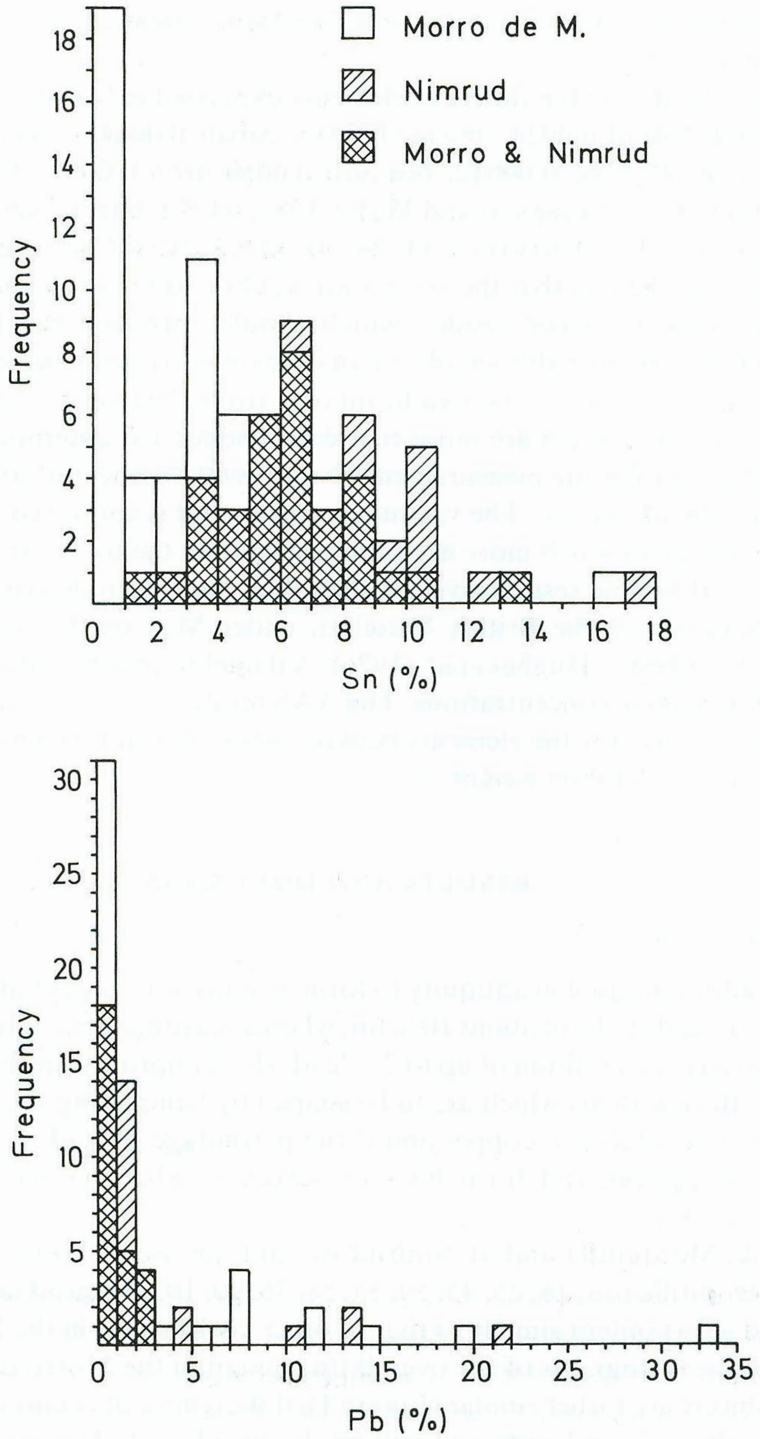

Figure 1 (Upper) *Comparison of Sn (%) content of the objects from Morro de Mezquitilla (nails with less than 1% Sn omitted) and from Nimrud.* (Lower) *Comparison of the overall Pb (%) content of the objects from Morro de Mezquitilla (unalloyed Cu items omitted) and from Nimrud.*

of the Etruscan, Greek and Italic objects (Craddock 1986b and 1977) whereas the Sardinian items have a lower lead content (Craddock 1982).

Forty-six of the objects from Morro de Mezquitilla are nails or rods and only 14 (nos 20, 35, 56, 60, 63, 68, 69, 78, 82, 85, 94, 98, 104, 107) contain tin or lead in notable proportions;

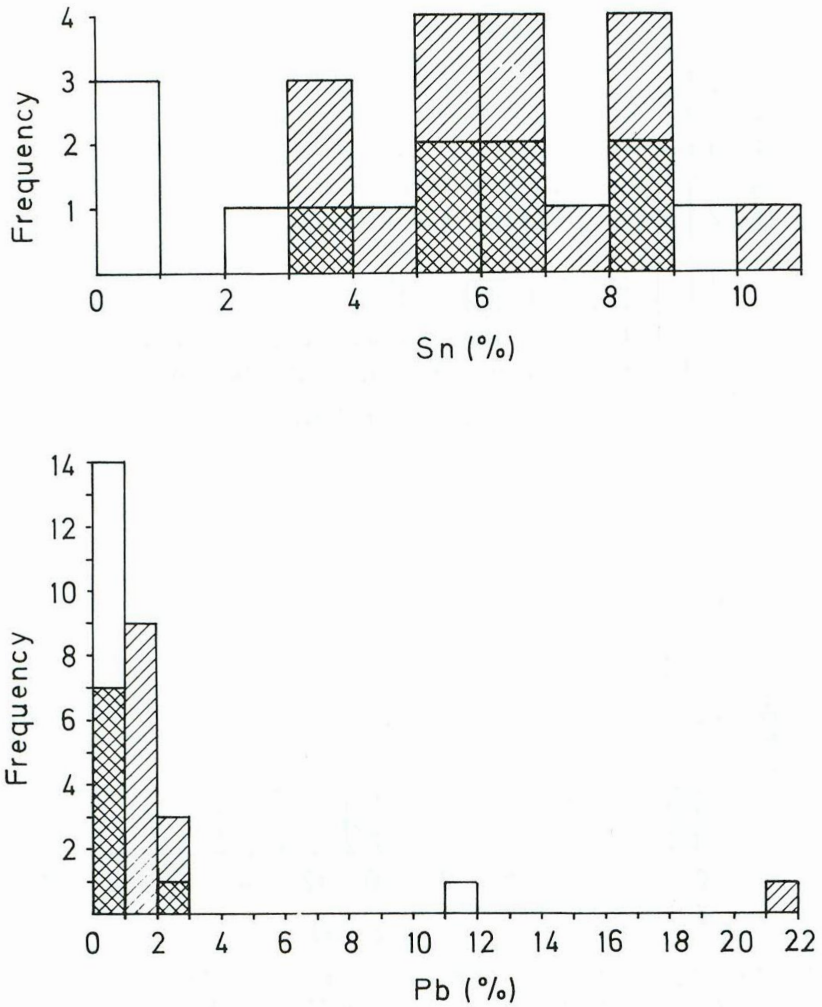

Figure 2 (Upper) *Comparison of the Sn (%) content of the fibulae and pins from Morro de Mezquitilla and from Nimrud.* (Lower) *Comparison of the Pb (%) content of the fibulae and pins from Morro de Mezquitilla and from Nimrud.*

the rest are of unalloyed copper with only traces of other elements. The two nails found in Tejada la Vieja are of leaded bronze (Pb 6.7% and 0.15%, Sn 6.4% and 7.8%). Small utilitarian items of unalloyed copper, where iron would be used now, seem to have been common and to have existed also through the Roman period and up to the Middle Ages throughout the Mediterranean area (Craddock 1976; Panseri and Leoni 1956; Mattusch 1977; Roncalli 1973; Faltenmayer 1978; Formigli 1981; Riederer and Briese 1972; Riederer 1974; Ucelli 1940, 265; Ebeling 1934; Gramme and Weill 1952). The reasons for the use of unalloyed copper for this sort of object are that copper is more corrosion resistant than iron, is easier to work, it becomes very hard when hammered and is cheaper than bronze.

The composition of the fibulae and of the pins from both Morro de Mezquitilla and Nimrud seems to be more carefully controlled (Figure 2). Omitting a penannular brooch and two fibulae fragments of copper, the fibulae have a tin range of 2.98–9.02% with an average of 6.28% (Nimrud, range 3.20–10.10%, average 6.37%; Tejada, range 2.30–10.20%, average 6.61%; Archaic Greek, average tin content 7.8%: Craddock 1981 and 1977). Three of the fibulae from Morro de Mezquitilla were cast and had a variable lead content (11.75%, 2.72%, 0.14%). The pins have a composition similar to that of the fibulae: two are of copper,

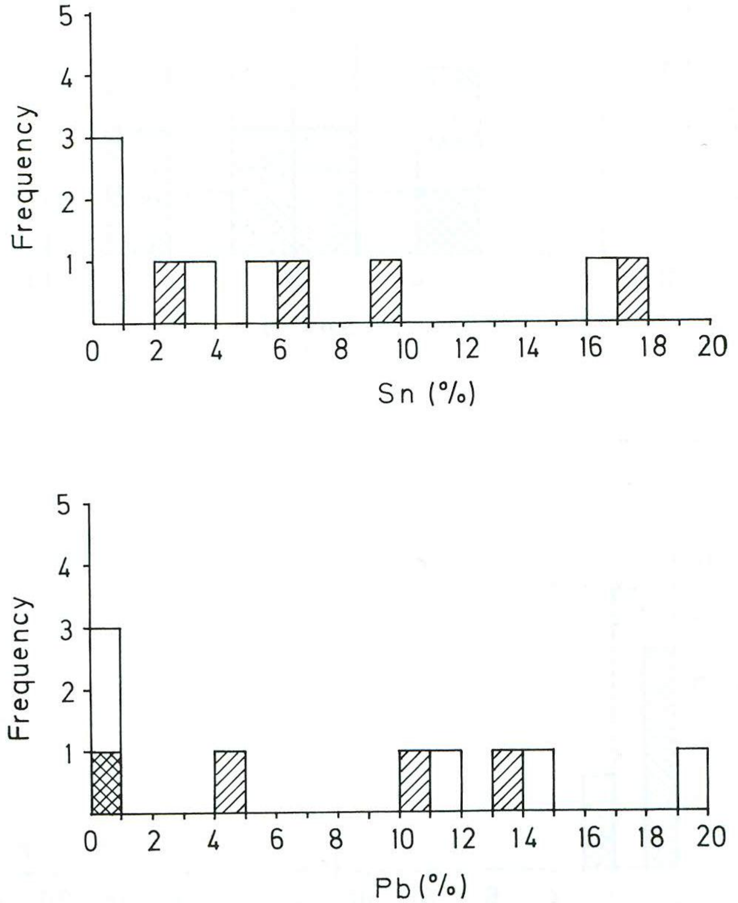

Figure 3 (Upper) *Comparison of the Sn (%) content of the weights from Morro de Mezquitilla and from Nimrud.* (Lower) *Comparison of the Pb (%) content of the weights from Morro de Mezquitilla and from Nimrud.*

the tin range is 4.90–6.43%, with an average of 5.7% and only traces of lead (pins from Tejada 5.6% average tin content, traces of lead; Archaic Greek 8.5% tin and 3.4% lead average; Nimrud 8.4% tin and 9.3% lead average). If we compare the composition of Sardinian, Italic and Etruscan small decorative metalwork of the same period, we note a higher tin content in the Sardinian items (average about 8–9%), whereas the Italic and Etruscan items have an average tin content of about 6%, comparable with those of the groups considered earlier. The lead content of the Sardinian items is quite low (about 1% on average). The Sardinian tin and lead contents reflect a conservative Bronze Age alloying tradition (Craddock 1982).

Two of the weights from Morro de Mezquitilla are of copper with no noticeable tin or lead, one is of leaded copper (11.40% lead), and three are of leaded bronze but with very different tin (16.84, 5.88, 3.11%) and lead (14.52, 19.02, 0.32%) contents. The weights from Nimrud also have a very irregular composition. The tin range is 2.8–17.20%, one of the weights does not contain lead at all and the others all have different lead percentages (Figure 3). The few sheet metal items from Morro de Mezquitilla contain, as expected, only traces of lead to avoid the splitting of the metal when hammered. Two of the objects (nos. 22 and 67) are of unalloyed copper. The two vessels (nos. 87 and 89) contain 7.61% and 7.17% tin. This kind of alloy can be relatively easily hammered, being only moderately hardened by the tin and malleable when annealed.

The wrought metal objects (i.e. fragments of small implements, Morro de Mezquitilla nos. 79, 92, 94, 95, 106, 107) have a tin range of 3.19–7.40% and an average of 4.8% tin, and contain about 1.5% lead, but this is unlikely to be a deliberate alloy. The lead content is probably the result of mixing scrap metal and reflects carelessness in the production of very minor artefacts. The same carelessness is evident in some similar objects from Nimrud (e.g. nos. 23, 24, 27, 30, 37) and Tejada (nos. 1902–4, 1911, 1912, 1915), with very irregular tin contents.

The composition of a small bell from Morro de Mezquitilla (no. 42) is especially interesting with 13.15% tin. The higher tin content hardens the alloy and makes it brittle, but also improves the sound of the bronze. It seems that the metalworker was aware of this fact when preparing the alloy for the small bell as the tin content is much higher than for the majority of the metalwork.

Trace elements

A common trace element in ancient copper alloys is iron, which can be an indicator of the smelting process (Tylecote and Boydell 1978). We can consider an iron content averaging around 0.05% as an indication of a primitive process for copper smelting with relatively poor reducing conditions and probably non-slagging, while by comparison an iron content averaging around 0.3% can be considered as an indication of the more efficient process (Craddock and Meeks 1987).

The iron content of the Morro de Mezquitilla items compares well with the similar contemporary material from Nimrud and also with the Tejada objects, showing that Phoenician smelting practice was almost the the same as in the Sardinian, Greek and Etruscan civilizations (Craddock 1986) and more advanced than the contemporary Late Atlantic Bronze Age of north-west Spain (Craddock 1980; Craddock and Giumlia-Mair 1988). The average iron content of the items from Morro de Mezquitilla is 0.24%; the range is very wide and 30% of the 99 objects had less than 0.05% iron (corroded samples are omitted). The objects from Nimrud had an average iron content of 0.57%, including the weights, which had an exceptionally high iron content (10%, 3.3%, 2.3%, 0.1%); without the weights the average would be 0.22%. In the case of the weights the smiths were not concerned about the quality of the metal employed, but much more about producing pieces of metal of the required weight. It was therefore not worth bothering about the refining of the copper. Only 7.6% of the 99 objects contain less than 0.05% of iron. By comparison the average iron content of the 20 objects from Tejada was 0.36% with 15% of the whole group containing less than 0.05% of iron.

Six objects from Morro de Mezquitilla (nos. 28, 29, 37, 94, 105, 108) have an arsenic content of about 1%. It is interesting to note that in all these objects the antimony content is also higher than in the others (about 0.2–0.3%) and is always proportional to the arsenic content. This suggests that the arsenic comes from the use of a sulphide ore which had not been completely roasted. Zinc is present only as a trace element, as expected: the objects analysed are too early to be made of brass. One object (no. 26), a large nail, had a very high bismuth content (1.35%). This is rather surprising and it is probably due to a failure in the roasting of a fahl ore from the enriched zone of the ore body. The antimony (0.13%), nickel (0.26%) and arsenic (0.82%) contents of the nail are also relatively high and seem to confirm the use of a fahl ore.

This indicates again that for every-day minor objects the metalworkers used whatever metal was at hand and only refined their basic stock of raw metal when it was necessary for particular types of objects. It also suggests that the smiths had to refine their copper which was delivered as blister copper from the smelting sites. This would be sensible, since in the absence of an analytical control, the only way the smith could be sure of the quality would be to refine the metal himself.

A rod (no. 63) with a 7.46% lead and 7.07% tin content had an unusually high silver content of 1.07%. The next highest silver content in the samples analysed is 0.34% and the average silver content is 0.05%. The silver may originate from a mixed silver-copper ore or by mixing with some copper-silver scrap metal. Note that only three of the 13 objects containing more than 0.1% of silver also contain appreciable amounts of lead; one is of bronze and the rest of almost pure copper. The traces of silver therefore seem to be more likely to come from the copper ores used than from the added lead.

CONCLUSIONS

The analyses of the objects from Morro de Mezquitilla and Nimrud presented here manifest the differences in the refining and alloying practices for very minor objects destined to be used in everyday life compared with those for objects with very particular functions or with a decorative purpose. The metal used for minor items is less refined, there are more impurities and therefore less quality control, the tin and lead contents are generally lower, although some of the objects (Morro de Mezquitilla nos. 45, 50, 58, 76, 82, 90, 104; Nimrud nos. 16, 19, 20, 31) had a very high lead content, and there is a much higher incidence of unalloyed copper. Comparison with material from other civilizations in the Mediterranean area and of the same period shows similar characteristics for the same class or type of object. The composition of the fibulae and decorative objects demonstrates the skill of the metalworkers in obtaining the type of alloy required and their ability to control the quality of their artefacts, whereas with very minor items much less care was employed and any alloy or unrefined or scrap metal was used. This also provides evidence that the metalworker had to refine the copper and to make up the alloys in the workshop. The metallurgical techniques employed at Morro de Mezquitilla and at Nimrud followed the broad trends of those of other civilizations in the Mediterranean area, with a very similar tin content for hammered articles and the use of leaded bronze for castings. For most of the very minor items, such as nails and rods, unalloyed copper was used. The most important reason for this is that tin was very expensive, even in Spain where it occurs but is less common than copper; in addition, the properties of copper make it very suitable for these sorts of objects.

A comparison of the iron contents of the objects from Morro de Mezquitilla, Nimrud and the late Atlantic Bronze Age shows that the Phoenicians introduced more developed copper smelting techniques in the western Mediterranean; the relatively high iron content of the analysed items indicates the use of copper smelted in furnaces with facilities for tapping the slag and therefore close contact with the civilizations of the eastern Mediterranean (Craddock and Meeks 1987). The similarity with the copper alloy artefacts from Nimrud reflects similar links with Phoenician metallurgical techniques.

The trace elements present in the material from Morro de Mezquitilla indicate the use of sulphide ores with traces of lead and silver, relatively high arsenic, low zinc and no detectable cobalt. Serious provenancing studies, however, are not possible without a good knowledge of the potential sources and analyses of discarded ores, fluxes, slags, etc., from the mining and smelting sites (Craddock and Giumlia-Mair 1988).

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APPENDIX: TABLES OF ANALYTICAL RESULTS

Table 1 *Morro de Mezquitilla: nails*

No.	*Cu %*	*Pb %*	*Sn %*	*Ag %*	*Fe %*	*Sb %*	*Ni %*	*As %*	*Bi %*	*Zn %*
26	95.85	0.05	0.92	0.02		0.13	0.26	0.82	1.350	
27	93.59	0.30	0.06	0.17	0.26	0.04	0.03			
28	90.77				0.27	0.03		1.21		
29	102.93	0.29		0.06	0.14	0.38	0.04	1.03		0.02
33	90.64	0.04		0.09	0.07	0.04		0.22		
36	86.35	0.01			0.36	0.04		0.04	0.004	
38	96.93	0.51	0.05	0.01	1.03	0.07	0.11	0.22		0.01
39	85.82	0.49	0.03	0.02	0.86	0.06	0.09	0.20	0.030	
40	92.31	0.51	0.04	0.01	1.01	0.07	0.10	0.24	0.001	
56	87.06	0.40	4.43	0.06	0.34	0.05	0.01			0.01
60	78.92	6.19	5.61	0.04	0.04	0.12	0.02	0.28	0.047	0.01
61	87.58	0.02		0.02	0.39	0.05	0.07	0.05		
62	89.94	0.03			0.06	0.05	0.01	0.04		
64	93.91	0.05		0.02		0.07	0.04			0.04
65	93.00	0.05				0.06	0.04	0.06		
68	93.31	1.04	3.23	0.04		0.13	0.03	0.26		
69	86.15	5.50	2.94	0.03		0.06	0.02	0.01		
70	93.93	0.02		0.15	0.10	0.13	0.01	0.43		
73	85.92	0.01		0.09		0.03			0.003	
74	86.70	0.04		0.10		0.29		0.67	0.004	
78	88.94	0.72	6.59			0.08		0.15		
80	92.74	0.01		0.03	0.01	0.05	0.08	0.14		
81	95.14	0.07		0.02	0.05	0.07	0.03	0.42		
82	74.71	7.21	4.94	0.01		0.08	0.01	0.15		
83	84.56	0.03		0.09	0.09	0.35	0.03	0.78	0.008	
91	78.18	0.63		0.13	0.14	0.15	0.09	0.70	0.029	
93	79.58	0.04		0.03	0.22	0.05	0.03	0.05		
96	87.79	0.02			0.23	0.04				
97	96.21	0.04		0.07	0.23	0.28	0.01	0.53		
98	78.74	1.40	2.04	0.06		0.14	0.01	0.42	0.002	
99	88.77	0.03				0.04	0.02	0.55		0.01
100	95.23	0.01		0.34	0.47	0.25		0.52		
101	80.99	0.07		0.10		0.32		0.82	0.001	
102	87.42	0.16		0.09		0.30	0.01	0.69		
104	73.05	7.07	1.55	0.03		0.08	0.02	0.17		
105	82.03	0.19	0.39	0.11		0.33		1.37	0.010	

Table 2 *Morro de Mezquitilla: weights*

No.	*Cu %*	*Pb %*	*Sn %*	*Ag %*	*Fe %*	*Sb %*	*Ni %*	*As %*	*Bi %*	*Zn %*
18	74.96			0.01		0.03		0.07	0.007	
25	90.49					0.03		0.72		
58	55.37	14.50	16.80	0.11	0.03	0.23	0.04	0.60	0.001	0.004
76	72.12	11.40		0.17		0.17		0.11	0.023	
90	59.53	19.00	5.88	0.05		0.11		0.38	0.026	
103	85.10	0.33	3.11	0.02		0.09		0.17		

Table 3 *Morro de Mezquitilla: fibulae and pins*

No.	*Cu %*	*Pb %*	*Sn %*	*Ag %*	*Fe %*	*Sb %*	*Ni %*	*As %*	*Bi %*	*Zn %*
12	81.11	0.05	8.21		0.34	0.09	0.04	0.51	0.007	0.01
23	72.09	0.09	8.50		0.19	0.04		0.16		0.01
34	71.45	0.53	2.98	0.19	0.61	0.04	0.02		0.002	0.04
41	88.80	0.79	6.43		0.31	0.08	0.06	0.05		0.01
43	83.61			0.10		0.03				0.16
45	75.07	11.80	5.44	0.06		0.45	0.02	0.78		
46	93.61	0.42	5.87	0.08	0.14	0.25	0.05	0.44		0.02
47	91.92	0.07	4.90		0.38	0.07	0.03	0.02		0.01
49	83.32	2.63	9.02	0.07	0.31	0.11	0.05	0.19		0.06
55	87.56	0.15	6.84	0.05	0.05	0.45	0.02	0.81		
66	92.42		3.81		0.80	0.05	0.07			0.03
71	106.30	0.03			0.01	0.16	0.04	0.63		0.01
72	88.36	0.10	6.43	0.03	0.01	0.11	0.14	0.11		
75	86.12	0.75	5.30	0.04	0.12	0.06	0.04	0.14		
84	102.07				0.11	0.05	0.04	0.27		0.03
86	94.35	0.10		0.08		0.24	0.02	0.66		

Table 4 *Morro de Mezquitilla: miscellaneous objects*

No.	*Description*	*Cu %*	*Pb %*	*Sn %*	*Ag %*	*Fe %*	*Sb %*	*Ni %*	*As %*	*Bi %*	*Zn %*
7	Droplet	66.86	0.03	5.17	0.03	0.02	0.04		0.35		
8	Droplet	47.60	2.10	9.28	0.06	0.34	0.07	0.01	0.57	0.010	0.25
9	Molten fragment	82.43	0.04		0.20		0.03	0.08	0.12		
10	Droplet	74.42			0.06		0.03		0.56		
11	2nd sample of no. 10	104.35	0.38	1.38		0.70	0.09	0.03	0.48	0.001	0.01
13	Droplet	68.89	0.21	6.23	0.02	0.36	0.03		0.14		
14	Arrowhead	64.04	0.47	7.18	0.03		0.05	0.01	0.12		
15	Rod	87.84	0.82	0.63	0.03	0.12	0.09		0.11		
16	Scale armour	54.28	0.56	1.24	0.01	0.73	0.04				0.01
17	Fragment	71.16				0.84	0.04	0.01		0.013	0.01
19	Spill	90.50	0.49		0.02		0.04	0.04		0.005	
20	Rod	88.51	1.38	2.25	0.05	0.19	0.09	0.04	0.14	0.012	
21	Rod	90.95	0.03		0.07	0.23	0.07			0.006	
22	Sheet metal	89.98	0.04			0.88	0.05	0.05	0.30	0.040	
24	Ladle	79.75	0.95	5.70	0.03	0.12	0.05	0.01	0.24		
30	Pennanular brooch	101.58	0.03			0.21	0.05				0.01
31	Rod	97.77	0.70	0.30	0.03	0.89	0.05	0.11	0.14		0.01
32	Rod	103.00	0.05	0.63		0.09	0.03			0.007	0.02
35	Rod	72.70	1.42	10.60	0.02	0.79	0.08	0.03	1.42	0.002	
37	Lump	82.50	0.06		0.12		0.20		1.00	0.110	
42	Small bell	70.11	0.95	13.50	0.03	0.90	0.09	0.04	0.02		
44	Square wedge	90.72	0.01	8.34	0.01	0.21	0.38	0.04	0.30		
48	Rod	99.98	0.07		0.11		0.43	0.02	0.63	0.001	
50	Cast shell	51.81	32.60	2.35	0.01		0.03	0.01			
51	Bar fragment	78.03	0.09			0.67	0.09				
52	Fish hook	90.35	0.31	6.82	0.05	1.16	0.07	0.04	0.13		
53	Ring	75.92	0.02	0.62	0.06	0.55	0.03				
54	Spill	81.32	0.63	8.76	0.01	0.81	0.06	0.02	0.08		0.02
57	Ring	71.56	0.44	3.94	0.02	0.15	0.05	0.02	0.32		0.20
59	Spill	80.48	0.12		0.05		0.14	0.77			
63	Rod	73.20	7.46	7.07	1.07	0.51	0.13	0.03	0.20	0.009	
67	Thin sheet lid	120.43	0.06			0.68	0.06	0.06			0.11
77	Strip	70.57	0.16	3.70	0.01	0.01	0.06				
79	Serpentine fragment	52.30	0.75	5.07	0.03	1.23	0.14	0.18			
85	Rod	70.34	7.06	3.45	0.06		0.21		0.24	0.030	
87	Vessel fragment	76.78	0.69	7.61	0.07		0.11	0.14	0.17	0.002	
88	Fish hook	89.93	0.78	3.52		0.51	0.11	0.09	0.04		0.06
89	Vessel	86.94	0.02	7.17		0.19	0.06	0.03	0.57		
92	Wrought fork	76.35	3.64	7.40			0.09	0.01	0.33		0.03
94	Tapering rod	80.53	2.45	4.48	0.08		0.17	0.06	0.96	0.008	
95	Forked fragment	75.76	2.15	4.44	0.06		0.16	0.05	0.43	0.012	
106	Point	92.68	1.32	3.19	0.05	0.29	0.08	0.01	0.11		0.02
107	Rod	104.44	0.20	4.53	0.03	0.05	0.09		0.03		
108	Hook	91.49	0.46	3.91	0.09	0.30	0.22	0.09	1.26	0.008	
109	Tapering rod	90.84	0.06		0.02	0.01	0.05		0.57		0.02

Table 5 *Nimrud: fibulae and pins*

No.	*Cu %*	*Pb %*	*Sn %*	*Ag %*	*Fe %*	*Sb %*	*Ni %*	*As %*	*Bi %*	*Zn %*
1	91.00	2.60	3.90	0.15	1.05	0.55	0.03	0.70	0.010	0.60
2	90.50	1.80	5.70	0.07	0.76	0.25	0.05	0.20	0.005	0.01
3	90.00	1.25	5.80	0.10	0.25	0.40	0.05	1.00	0.007	0.70
4	91.00	2.30	6.80	0.05	0.12	0.20	0.09	0.35	0.003	0.01
5	91.00	1.25	6.60	0.10	0.37	0.30	0.07	0.20	0.003	0.04
6	91.00	1.30	6.60	0.07	0.07	0.24	0.03	0.04	0.007	0.07
7	95.00	0.20	3.80	0.04	0.02	0.15		0.85	0.025	
8	88.50	0.40	8.30	0.02	0.12	0.05	2.20	0.20	0.003	
9	89.00	2.20	7.40	0.04	0.20	0.13	0.09	0.09	0.005	
10	89.00	0.31	10.10	0.05	0.11	0.15	0.08	0.12	0.010	
11	88.50	1.90	8.00	0.28	0.15	0.30		0.40	0.010	0.05
12	92.00	1.75	5.90	0.07	0.12	0.05	0.06	0.13	0.001	
13	92.50	0.90	6.00	0.23	0.23	0.20	0.10	0.30		0.03
14	96.00	0.30	3.20	0.06	0.06		0.02	0.15		0.01
15	94.50	0.35	4.90	0.13	0.24	0.15	0.02	0.40	0.010	0.03
16	70.00	21.50	6.20	0.20	0.35	0.95	0.10	0.18	0.010	0.13
33	87.00	1.60	10.40	0.05	0.20	0.10	0.02	0.15	0.002	
41	94.50	1.35	5.30	0.03	0.49		0.03	0.40	0.005	
42	90.00	0.80	8.00	0.06	0.17	0.10	0.05	0.50	0.001	0.08
43	89.00	1.75	8.40	0.06	0.01	0.10	0.12	0.20	0.010	0.02

Table 6 *Nimrud: miscellaneous objects*

No.	*Description*	*Cu %*	*Pb %*	*Sn %*	*Ag %*	*Fe %*	*Sb %*	*Ni %*	*As %*	*Bi %*	*Zn %*
17	Quadruped	88.00	0.50	10.30	0.11	0.07	0.15	0.03	0.12	0.004	0.30
18	Ring	88.50	4.10	5.50	0.09	0.40	1.00	0.04		0.008	
19	Weight	70.00	9.90	9.00	0.05	10.00	0.25	0.11	0.15	0.063	0.03
20	Weight	79.00	13.00	2.80	0.95	3.30	0.15	0.31	0.70	0.010	0.15
21	Weight	90.50		6.60	0.01	2.30		0.15	0.60	0.003	0.01
22	Weight	78.00	4.10	17.20	0.11	0.10	0.70	0.05	0.15	0.005	
23	Holdfast	90.50	1.10	6.30	0.08	0.43	0.50	0.04	0.45	0.013	0.15
24	Holdfast (ring)	90.50	0.20	6.60	0.05	0.13	0.30	0.05	0.80	0.008	0.40
25	Holdfast (hook)	94.50	0.25	4.90	0.09	0.22	0.15	0.01	0.45	0.008	
26	Holdfast (hook)	95.00	0.25	4.80	0.08	0.09	0.15	0.02	0.17	0.002	
27	Split ring	91.50	1.10	5.90	0.07	0.40	0.70	0.03	0.30	0.012	0.15
28	Split ring	88.50	1.15	9.60	0.02	0.12		0.06	0.10	0.025	
29	Holdfast (rivet)	98.00	0.65	1.00	0.01	0.28		0.04	0.09		
30	Holdfast (rod)	87.50	1.10	10.50	0.03	0.09		0.05	0.18		
31	Architectural pin	79.50	13.40	6.40	0.08	0.30	0.60	0.02	0.55	0.007	0.32
32	Architectural pin	87.00	0.73	10.60	0.10	0.28	0.20	0.02	0.20	0.005	0.52
34	Finial	84.00	1.25	12.70	0.11	0.15	0.60	0.02	0.65	0.005	0.11
35	Boss	90.00	0.35	7.00	0.70	0.27	0.10	0.03	0.30	0.007	0.12
36	Boss	91.00	0.45	7.40	0.08	0.28	0.20	0.03	0.40	0.007	0.13
37	Large ring	95.50	0.67	3.20	0.03	0.10	0.10	0.45	0.55	0.005	
38	Arrowhead	84.00	2.35	13.00	0.12	0.01	0.10	0.06	0.45		
39	Arrowhead	90.50	0.20	8.50	0.04	0.07	0.10	0.37	0.50	0.010	
40	Rivet of hinge	90.00	0.65	8.10	0.41	0.42	0.15	0.05	0.70	0.005	0.01