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The Same but Different: A Comparison of Middle Bronze Age Metalwork from Jericho and Tall aḍ-Ḍab'a

Introduction

Traditional typological study and the investigation by scientific means of technological aspects of archaeological material can both produce data of value to the relevant specialist as shown below. However, when these methods are used in combination, they can generate new information of greater interest to the wider archaeological community. The aim of the present paper is to illustrate the information obtained using both approaches, and then to draw together the two data sets and to assess their combined implications for wider archaeological questions.

While a consideration of archaeological context should play a part in any overall comparative analysis, this aspect of the material is not treated here for the following reasons:

1. The bulk of the Jericho material comes from tombs containing multiple, successive interments rendering difficult any attempt to detect patterning among the mixed-up artefacts.
2. As far as Tall aḍ-Ḍab'a is concerned, an explication of patterns of artefact deposition, and age-sex associations of the metalwork from graves at this site is scheduled to appear elsewhere (Philip, in press). As a result, I have decided not to repeat this information in the present study.

Recent work (Philip 1989: 169-172) has shown that the metalwork of the southern Levant and the eastern Nile Delta shows a remarkable degree of stylistic homogeneity during the MB II period. However, it has not been possible to establish whether this material represents the widely traded products of a single centre, or whether similar artefacts were being made over a wide geographical area. Each solution to this problem has its own implications for the socio-economic organization of the region during the Middle Bronze Age. While such material has been recovered from numerous sites, only two, Jericho and Tall aḍ-Ḍab'a, have produced sufficiently large bodies of chemical analyses to permit us to move beyond the obvious typological resemblances, and to consider the comparative technology of the two groups of material. This aspect of the material may have important implications for the organization of production and distribution of metalwork during the Middle Bronze Age.

Typology

One group comes from Tall aḍ-Ḍab'a in the eastern Nile Delta, a site which has produced much MB II metalwork in Syro-Palestinian style, much of this from graves. The site is probably to be identified with Avaris, capital of the Hyksos (Bietak 1991: 28). This material is currently being prepared for publication by the present writer. The other comes from the Middle Bronze Age tombs at Jericho, excavated by Kenyon (1960; 1965). Metallurgical work was carried out by Khalil (1980), whose invaluable study of the Jericho metalwork remains the only substantial body of such analyses from a site in the southern Levant. It is a great pity that more information of this kind is not presently available.

Extant Middle Bronze Age metal objects from Jordan are few, but those reported resemble closely their Palestinian counterparts: e.g. material from graves on the 'Ammān Citadel (Najjar 1991: 110, and unpublished material seen courtesy of the Department of Antiquities of Jordan) or Pella (McNicoll *et al.* 1982: 39, PL. 111: 6-8; 42, PL. 111: 20; Smith and Potts 1992: 81, PL. 61: 16-20). Additional examples will doubtless be found as more Middle Bronze Age cemeteries are excavated. Unfortunately, with the exception of Khalil's (1980) pioneering work, little Middle Bronze Age metalwork from the region has been analysed.

Typologically, the Middle Bronze Age metal repertoires of Jericho and Tall aḍ-Ḍab'a are very similar. Both sites produce axes, daggers, curved knives, metal belts, toggle-pins, and other material typical for the south Levantine Middle Bronze Age. Compare for example the published material from Jericho (Kenyon 1960: FIGS. 117, 128, 177; 1965: FIGS. 111, 114, 174) with a selection of that from Tall aḍ-Ḍab'a (Bietak 1979: PL. 36; 1985: Abb. 12). In the case of the Tall aḍ-Ḍab'a metal-

work some types do show stronger Levantine parallels than others. Weapons in particular exhibit a high degree of stylistic conformity throughout the southern Levant and the Delta during the later Middle Bronze Age (Philip 1989: 168-72). The wide spatial distribution of metal objects in what are intrinsically unusual styles, indicates that the homogeneity of metal artefacts is deliberate. A case in point is provided by those daggers with broad, flat midribs (Philip 1989, Type 17) where it is doubtful if objects from the two sites could be distinguished by eye if mixed together.

All of the metalwork from Jericho comes from tombs dated to the MB IIB/C period, a period of no more than 200 years. That from Tall aḍ-Ḍab'a covers the later part of the MB IIA period and all of MB IIB/C, perhaps nearer 250 years in all. Given the size of the samples, and the mixing of material within the Jericho tombs, no attempt has been made to provide more refined chronological sub-divisions.

There must have been a reason for the employment of standard designs throughout the southern Levant and eastern Delta during this time. Fashion provides only a superficial explanation as we might reasonably ask by what mechanism these fashions spread so successfully. Jericho is a long way from the Nile Delta, and the two sites were located within very different physical and cultural settings. There is a noticeable difference between the ceramic assemblages from the two sites: compare the range of MB IIB/C vessels from Jericho (Kenyon 1960; 1965) with those from Tall aḍ-Ḍab'a (Bietak 1991: FIGS. 10, 11). However, there is a significantly closer resemblance between their metal repertoires. The reason for this may lie in the symbolic meaning of certain metal artefacts, and their social contexts of production and use.

Limits of the Typological Approach

While typological comparisons show that both Jericho and Tall aḍ-Ḍab'a (and a number of other sites for which, alas, no archaeometallurgical data are available) have very similar metal repertoires, this approach can take us little further. We cannot for example tell if the archaeological distribution owes to the widespread trading of goods manufactured at a single centre, or whether artefacts were being produced to highly standardized designs at two (or more) centres. In order to pursue this aspect of the material further, archaeometallurgical work is required.

Archaeometallurgy

In the process of investigating the problems outlined above, new data relevant to archaeometallurgical studies will be produced. These will have considerable intrinsic interest as our analytical database is still very limited. In addition they should shed additional light on patterns of production and distribution of metalwork. These results will be discussed below.

Attempts to trace metal artefacts to specific ore sources through study of their trace element patterns are fraught with problems as Craddock (1976) has pointed out. More sophisticated techniques such as lead isotope analysis may offer more hope in this direction (Sayre *et al.* 1992). However, researchers advocating this method of analysis have still to acknowledge fully both the scale of the problem presented by the recycling of scrap metal, and that posed by the deliberate addition of lead to tin-bronzes. The subsequent re-introduction of this lead to the metal pool, through the recycling of leaded, copper-alloy scrap could have potentially serious implications for the validity of lead isotope measurements taken from finished artefacts. The data from Jericho and Tall aḍ-Ḍab'a suggest that these are real problems and requiring serious consideration. Useful information relevant to matters of production and distribution, however, should be obtainable from an examination of the nature of the alloys employed at the two sites.

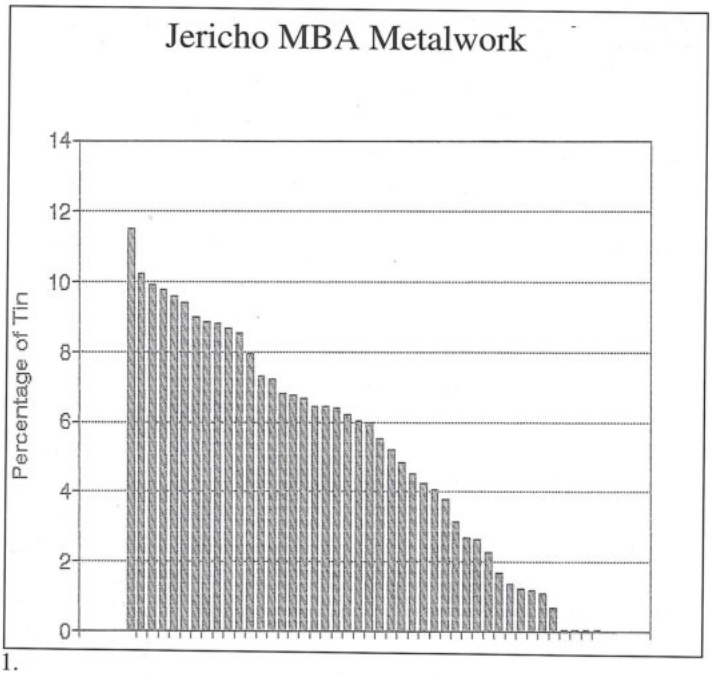
Discussion of Analytical Results

All objects discussed below were analysed by the same method: Atomic Absorption Spectrophotometry (AAS) on drilled samples. The analytical methods employed on the Tall aḍ-Ḍab'a material are those described by Hughes *et al.* (1976). Included are 44 objects from Jericho analysed by Dr Lutfi Khalil (Khalil 1980) and 41 objects from Tall aḍ-Ḍab'a analysed by Mr Mike Cowell of the British Museum Research Laboratory in preparation for the final publication of the metalwork from the latter site.

In the case of the Tall aḍ-Ḍab'a samples, the precision of the AAS technique is typically about 1-2% relative for most major and minor components and 10-50% relative for trace components, this depending on how closely the measured concentration approaches the detection limit. A description of the procedures employed on the material from Jericho is provided elsewhere (Khalil 1980: 55-57).

The data-sets described above are compared by means of a series of simple statistical methods, namely histograms for the display of single variables, and scatter plots where it is desired to explicate the relationship between two alloying elements.

Tin (Sn): Histograms showing the percentage of tin indicate that the material from both sites includes a number of good tin-bronzes. However, while the material from Jericho (FIG. 1) shows a relatively wide spread of tin contents, with few objects containing less than 2% Sn, and a median value of around 6% Sn, that from Tall aḍ-Ḍab'a (FIG. 2) shows a more marked division into tin-copper alloys, and a second group containing very low



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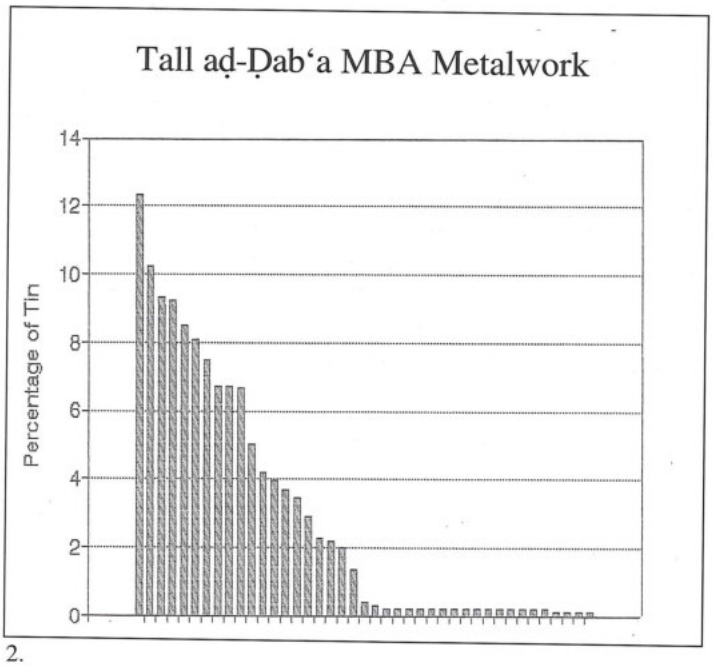

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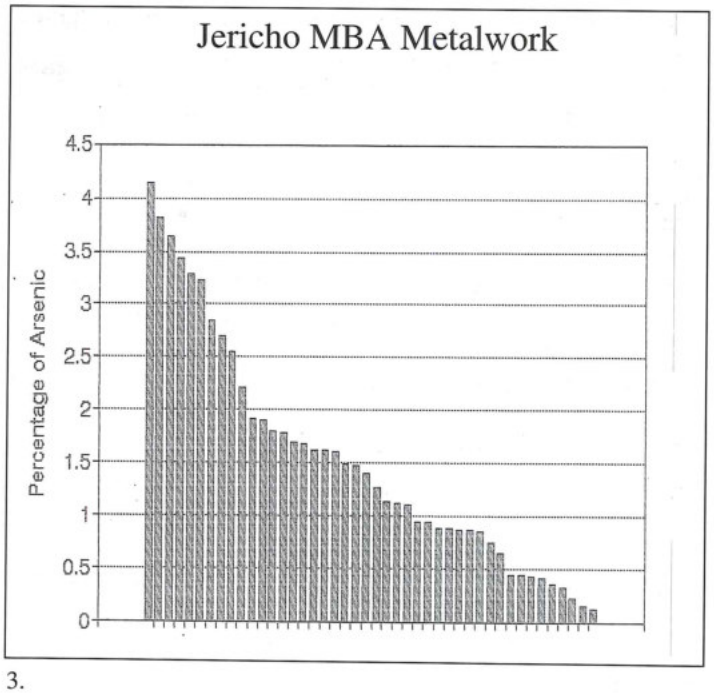

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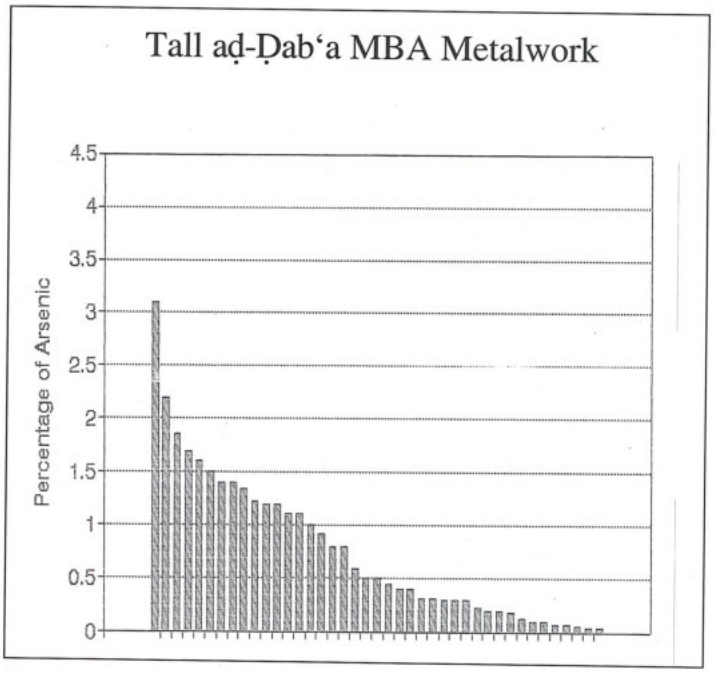

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quantities of tin. Here the median value is c. 0.2% Sn.

Arsenic (As): When the content of arsenic is plotted in the same way, the objects from Jericho (FIG. 3) can be seen to contain generally higher levels of arsenic, median c. 1.3% As, than do objects from Tall aḍ-Ḍab'a (FIG. 4), median 0.5% As. Almost 50% of the objects from Jericho contain more than 1.5% As, while only 20% contain less than 0.5% As. The Tall aḍ-Ḍab'a material reveals a different picture (FIG. 4), with just under 15% containing more than 1.5% As and around 55% less than 0.5% As. This difference should be significant.

Recent work on the comparative properties of copper-tin and copper-arsenic alloys (Northover 1989: 113), suggests that the presence of around 2-4% arsenic is required to significantly improve the toughness and hardness of a worked copper object, although arsenic retains its effectiveness as a de-oxidant at lower levels. In the case of the Tall aḍ-Ḍab'a objects, only 5% lie within this range, although, around one quarter of those from Jericho do so.

Arsenic is volatile and can easily be removed from molten metal by heating under oxidizing conditions, dur-

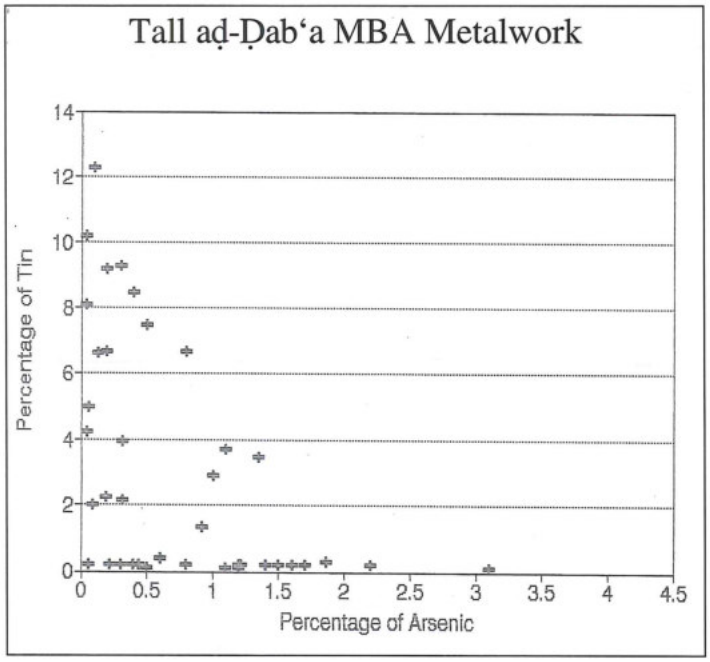
ing recycling or hot working for example (McKerrel and Tylecote 1972). As many of the Jericho objects contain arsenic at concentrations of less than between 1 and 2%, it seems likely on balance that the presence of arsenic in many of the objects from Jericho owes to its presence in the original copper ore, rather to deliberate addition. At Tall aḍ-Ḍab'a on the other hand, a good number of the objects seem to have been made from copper which was derived from a low-arsenic ore, or had been recycled so often as to have reduced significantly the original arsenic content. Other artefacts contain arsenic at levels more akin to those found at Jericho, perhaps indicating that copper from two different ore sources were in use at Tall aḍ-Ḍab'a, or that the metal employed for these had been subject to less extensive recycling.

A comparison of the pattern of co-occurrence of tin and arsenic in artefacts from the two sites is revealing. In the case of Tall aḍ-Ḍab'a (FIG. 5), objects containing tin at above 4% or so, nearly always contain arsenic at levels of 0.5% or less. Equally, those objects containing levels of arsenic over 1.5%, generally contain less than 0.5% tin. Pieces containing marked quantities of both tin and arsenic are relatively few, suggesting that a real distinction was made at the site between tin-bronzes and copper alloys containing arsenic above a certain level. Finally, the Tall aḍ-Ḍab'a plot shows a group of objects low in both tin and arsenic. These represent the objects made from low-arsenic copper discussed above.

Low-arsenic coppers are all but absent from the plot of the equivalent data from Jericho (FIG. 6), suggesting that much of the raw copper coming to Jericho may have originated from arsenical ores. A general trend is detectable. A good proportion of objects containing 6% or more tin show arsenic at less than 2.0%, while most of those containing arsenic at greater than 2.5% contain less than 3% tin. While a good proportion of the objects from Tall aḍ-Ḍab'a contain very low levels of tin (FIG. 2), these are relatively rare at Jericho, where all but four objects contain at least 1.0% tin. The bulk of objects from Jericho therefore contain some tin, a good number between 2 and 6% most of which also contain arsenic levels ranging between 1 and 2%. At Jericho then, there is rather more mixing of tin and arsenic in individual pieces than at Tall aḍ-Ḍab'a.

The suggested use at Jericho of copper with a higher natural arsenic content than that employed in many of the artefacts from Tall aḍ-Ḍab'a, would explain the generally higher arsenic levels noted in objects from the former site. However, this does not account for the more frequent co-occurrence of tin and arsenic in copper alloys at Jericho. Perhaps the answer lies in the role of scrap at the two sites. Tin is far less volatile than arsenic. Because of this, scrap tin-bronze will pass most of its tin content directly into the new alloy (Cowell 1987: 98).

Perhaps the underlying pattern at Jericho is that of smiths employing copper derived from arsenical ores, with the addition of a certain amount of tin through the mixing of this material with recycled metal, including scrap tin-bronze. The metal used at Jericho seems to have undergone considerably more mixing than that employed at Tall aḍ-Ḍab'a, where a rather different alloying pattern can be observed, and where a significant number of objects are low in both arsenic and tin. This suggests that copper from a low-arsenic ore was in use alongside



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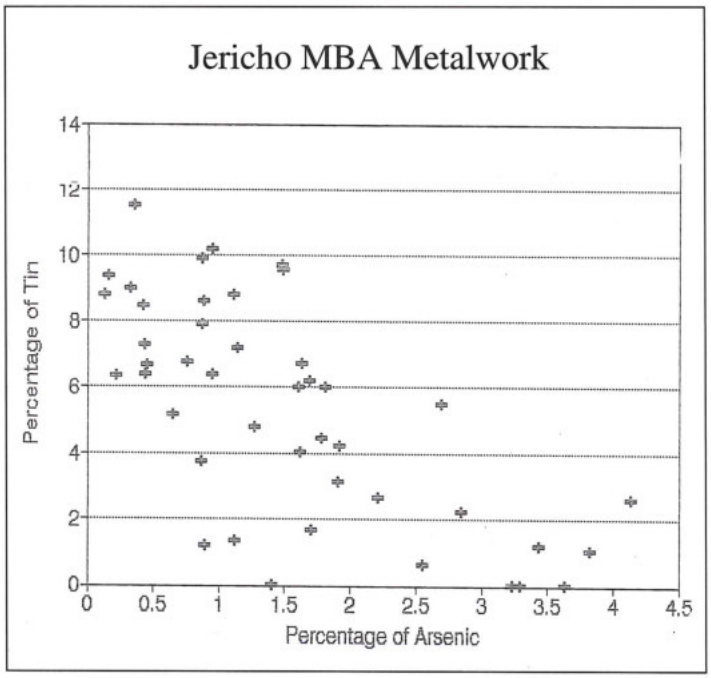

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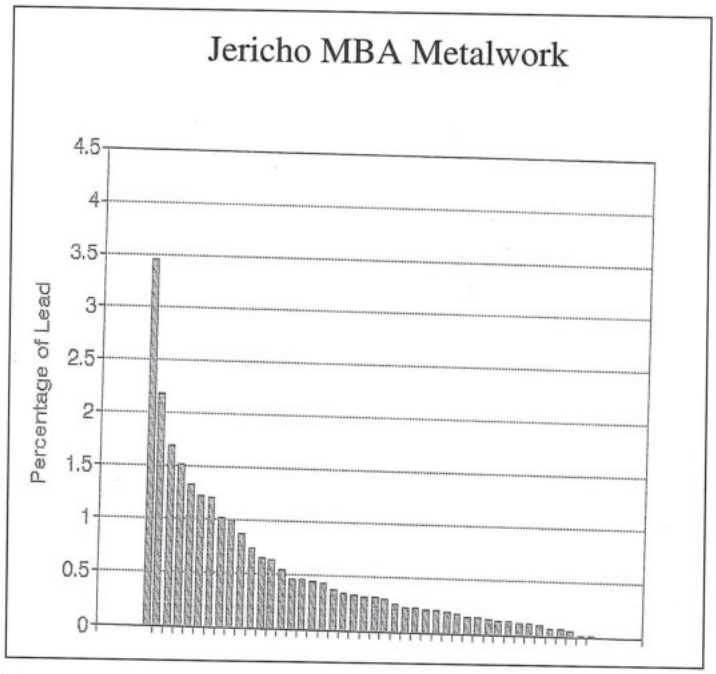
copper with a rather higher arsenic level. We might also argue that the relatively low tin levels of most unalloyed and arsenical copper objects from Tall aḍ-Ḍab'a indicate that scrap tin bronze was re-used in a more systematic manner than at Jericho. Perhaps there was a greater use of new metal at Tall aḍ-Ḍab'a, or perhaps scrap tin bronze was often kept aside, for use as an ingredient in new batches of tin-bronze, rather than being added to a common pool of scrap.

The evidence then suggests that more recycling of scrap took place at Jericho. Of course, we do not know the origin of the metal used at Jericho. Some of it may have arrived at the site as brought-in scrap, originating elsewhere, perhaps already a mixture of new and recycled metal. Whatever the exact mechanism, the general distribution of alloy types at the two sites suggests that we do indeed have two distinct industries, producing artefacts to highly standardized designs.

Lead (Pb): Recent work (Philip 1991: 101) has argued that there is evidence that lead was, on occasion, deliberately added to copper alloys at least as early as the Middle Bronze IIA period. While the addition of around 2% Pb to bronze both improves the fluidity of the cast metal and lowers the melting point, the presence of lead in greater quantities, however, adds little to the properties of the final product (Craddock and Giumlia-Mare 1988: 319). Although advantageous in cast metalwork, lead is not normally added to metal intended for sheet working, as it is insoluble in copper and the resulting globules of lead will form lines of weakness when hammered (Giumlia-Mare 1992: 108). In the majority of cases, the lead contents of the artefacts from both Jericho (FIG. 7) and Tall aḍ-Ḍab'a (FIG. 8) are low, typical of the trace amounts normally associated with copper ores.

However, there is one dagger from Jericho containing almost 3.5% Pb. It is of an unusual design (Philip 1989, Type 19: the only parallel is from al-Jib near Jerusalem [Pritchard 1963: 138, FIG. 51.39]). Furthermore, one axe from Tall aḍ-Ḍab'a contains more than 4% Pb. Both are tin-bronzes and may well represent genuine leaded bronzes. In addition to these clear examples, each site produced several artefacts containing lead at a level of around 1%. Cowell (1987: 98) has suggested that concentrations of lead above 1% found in analysed artefacts from ancient Egypt indicate its deliberate addition to alloy; levels below this represent its presence in the original copper-ore. The extension of this 'rule of thumb' to the material discussed here would indicate that the deliberate addition of lead was practiced, on occasion, at Jericho and Tall aḍ-Ḍab'a during the Middle Bronze Age.

In his study of Egyptian metalwork, Cowell (1987: 98, FIGS. 3 and 4) observed that lead contents of over 1% are associated exclusively with tin-bronze, rather than arsenical copper. When the lead content of our artefacts is plotted against those of tin and arsenic, a similar situation emerges. In the case of Jericho (FIG. 9), the few objects containing more than 1.5% lead, all contain at least 4% tin. The same picture exists among the Tall aḍ-Ḍab'a material (FIG. 10). At neither site were examples found of leaded high arsenic-copper alloys (FIGS. 11 and 12). In fact at Jericho, those objects containing 2% or more arsenic, contain lead levels of 0.5% or less (FIG. 11). At



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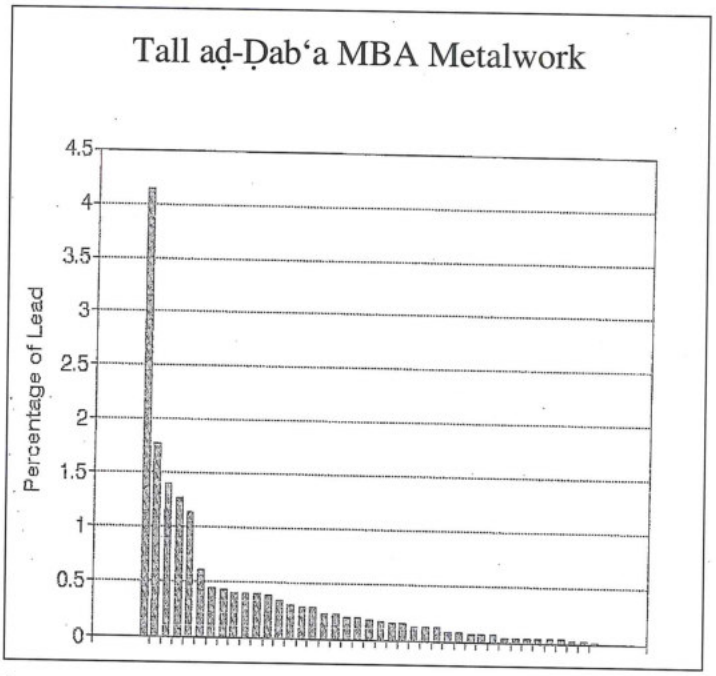

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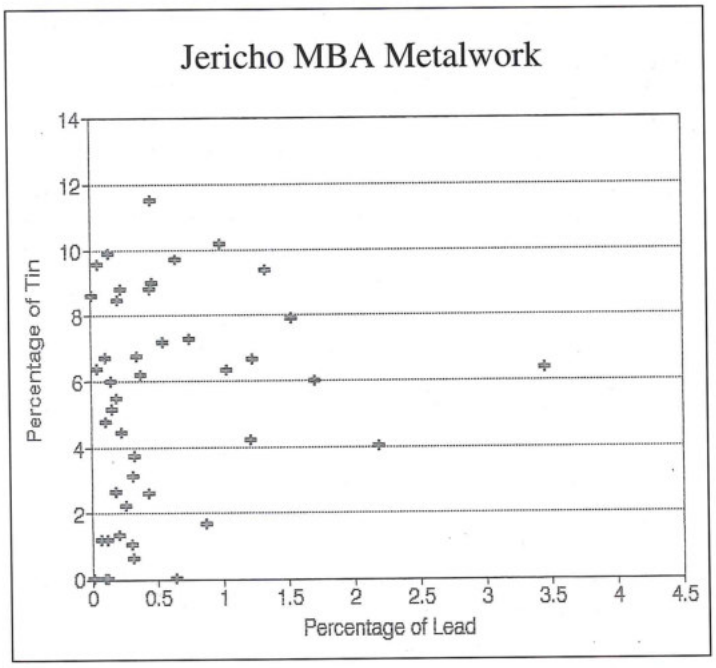

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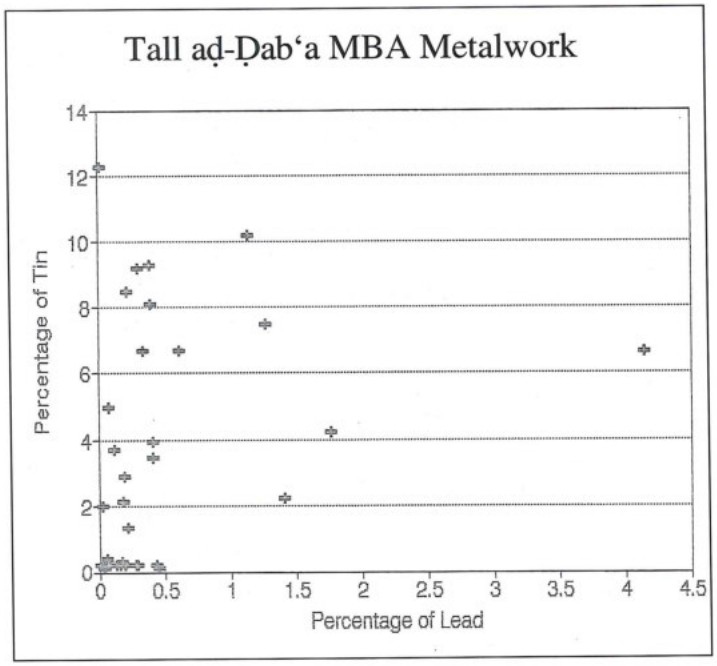

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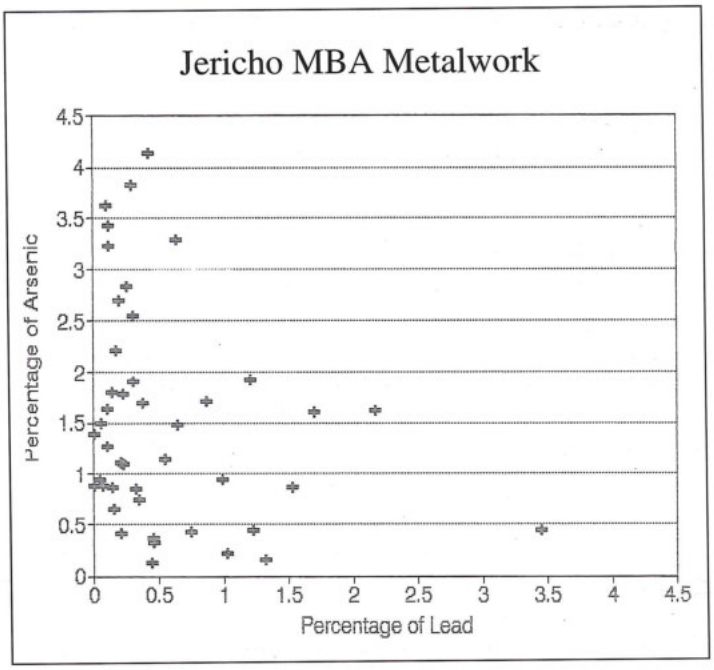

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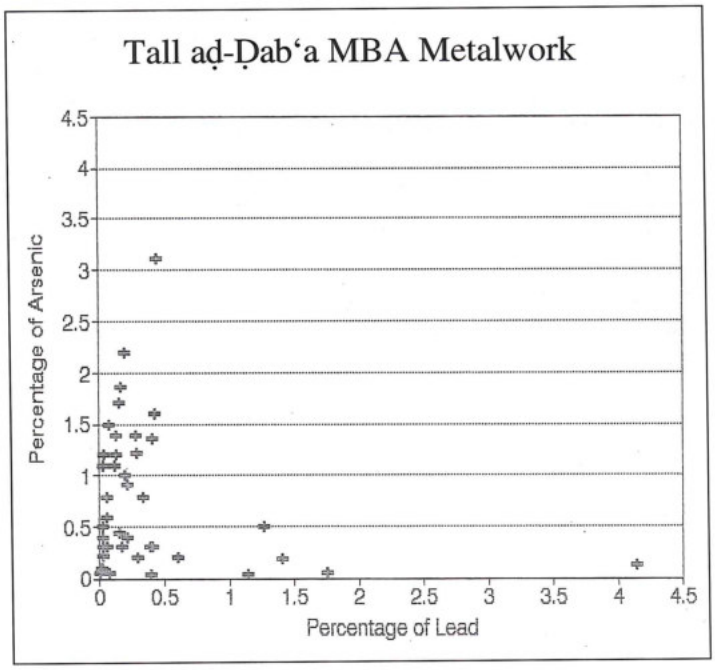

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Tall aḍ-Ḍab'a as well (FIG. 12), those objects which are high in lead are low in arsenic.

Although the data are limited, I suspect that we have at least a strong hint that increased levels of lead occur in association with the presence of significant amounts of tin. Therefore, the presence of lead in these artefacts cannot simply be explained away as owing to the presence of lead in the original copper ores. Rather, lead must have been added selectively to tin-bronzes. This picture holds for both sites, although the impression given by the data is that lead use in MB IIB/C artefacts was erratic. A similar pattern was suggested for the MB IIA period (Philip 1991). No clear correlation between the addition of lead and specific artefact types can be observed. This rather erratic occurrence is exactly the situation described by Craddock and Giumlia-Mare (1988: 319) as a consistent feature of the use of leaded bronzes in the Mediterranean region from the second millennium until the end of the Roman period. Returning to chronology, it is of interest to note that Cowell (1987: 98) observes that the majority of Egyptian leaded alloys are of Middle Kingdom or later date, and so begin to appear

contemporaneously with the Levantine Middle Bronze Age.

Conclusions

What conclusions can be drawn from the comparison of these two bodies of data? The relatively low level of mixing of tin and arsenic at Tall aḍ-Ḍab'a suggests that much of this material was made from new metal, perhaps of two different 'kinds' or from two separate sources, or at least that scrap was recycled systematically. Jericho on the other hand, shows a greater co-occurence of tin and arsenic, suggesting an industry based on copper derived from arsenical ores. The frequent occurrence of low levels of tin suggests the widespread mixing of scrap tin bronze with new metal, or other forms of scrap.

The data from both sites add additional weight to the view (Cowell 1987; Philip 1991) that lead was added to copper-alloys as early as the Middle Bronze Age, albeit in a rather erratic fashion. Furthermore, there is a correlation between the use of lead and copper-tin alloys. Lead was not added to all types of copper-alloy. This association between lead and tin further reinforces the argument that the addition of lead was deliberate. The presence of lead cannot be dismissed simply as representing an impurity in the copper-ore. When due allowance is made for likelihood of scrap recycling on a substantial scale, as the evidence from Jericho would seem to imply, this fact has serious implications for the applicability of lead-isotope techniques as a means of relating copper-alloy artefacts to their source.

The integration of the typological and metallurgical data provides important evidence for the reconstruction of socio-economic developments in the Middle Bronze Age of the region. Perhaps smiths at smaller sites such as Jericho relied on the recycling of scrap to a greater extent than did those at the large, rich site of Tall aḍ-Ḍab'a. Such a place may well have had a more reliable supply, and higher quality, of raw materials. In fact, the pattern of alloy selectivity, and the likely degree of recycling at any one site, might, when more data is available, form a useful indicator of that site's access to raw materials, and its relative position vis-a-vis inter-regional trade systems generally.

The different alloying patterns confirm that (at least) two separate metal industries were producing stylistically similar objects. Moulds for certain types are already known from Tall aḍ-Ḍab'a (Bietak 1985: Abb. 10 and additional unpublished examples). Jericho has not produced such moulds, leaving open the question of whether the metalwork from the tombs there was made at the site, at some larger Palestinian regional centre, or a combination of both.

We can now answer our original question. It is clear that smiths in Palestine and in the Delta were making items to the same designs. Elaborate metalwork was not being produced and traded from a single source, although a degree of trading cannot be ruled out. It is fairly certain then, that these artefacts, the weapons in particular, were made with special roles in mind. This in turn, implies a degree of common symbolic expression understood throughout a wide area, embracing the eastern Nile Delta, Palestine and Transjordan, during the later MB IIA and MB IIB/C periods. As much of this material comes from the richer male burials, it is not unlikely that we are seeing a system of expressing male high-status, that was common throughout the southern Levant and the eastern Delta. Elucidation of the exact relationship between these artefact style zones, and the political organization of the later Middle Bronze Age in this region is the next task.

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