

PART FOUR

ARTIFACTS, ECOFACTS AND OTHER STUDIES

CHAPTER 22

METALWORKING IN AREA G

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INTRODUCTION

Metallurgical remains were found at Dor mainly in Phases 12–10 in Area G, spanning the Late Bronze Age IIB (LBIIB) and early Iron Age IA (Ir1a *early*). These remains consist of metallurgical debris, including greenish cuprous bits and chunks, bits of charcoal and fragments of crucibles, as well as metallurgical installations related to Phase 10c. An analytical and micromorphological study of sediments in the eastern section of the area by a team that included the authors of this chapter (Berna et al. 2007) detected significant amounts of copper in sediments from Phases 12, 11 and 10c, as well as temperatures up to 1300°. The following description is based on this prior study, supplemented by an attempt to reconstruct the metallurgical production processes, as reflected in the various components of production that were uncovered.¹

METALWORKING IN PHASES 12–11 (LBIIB)

Phases 12–11 (dated, respectively, to the first and second halves of the 13th century BCE) are known only from a very limited exposure (see Plan 1 in Volume IIA or IIC; Chapters 2, 8 and 9). Phase 12 is a deep, undifferentiated fill with metallurgical waste products exposed in two small test probes, mainly in Loci 18401 and 18414 (Phase 12b). Phase 11 exhibited several surfaces or tip-lines consisting of closely laminated and overlapping lenses of sand containing mudbrick material, ash, bits of charcoal and tabun (or furnace) material. Metallurgical waste products were exposed mainly in Loci 18399, 18483 and 18494 (Table 22.1). In Phase 11, the debris sloped downwards from north to south and east to west, suggesting that it was poured or dumped from a point northeast of the excavated area. The latter was verified by Berna et al. (2007) based on sediment morphology. Apart from a single installation of unclear function (“Shell-Floor Installation”; Chapters 2 and 14) in the western part of the excavated area, no architecture is associated with either of these phases. It is not known whether this is because this area was not built up or if this is merely the result of limited exposure.

EVIDENCE FOR A BRONZE WORKSHOP IN PHASES 10B–C (IR1A EARLY)

In Phase 10c, a building was constructed which formed at least part of the basis for the better-preserved structure of Phase 9,

which lasted through many changes and one destruction event, until the end of the Iron Age sequence (Fig. 22.1; see Chapter 2). The rich evidence for the existence of a copper/bronze workshop in this building includes numerous ash lenses, shallow, charcoal-rich melting pits, a tabun-like installation termed a “furnace” (L18308), a pot bellows, crucible fragments and waste products, as well as concentrations of bones that might have served as fuel. Two shallow basins lined with thick clay (L18082 and L18298) might also have been related to the metalworking activity. Most of these production paraphernalia came from Courtyard 18333, which measures ca. 4.5 m north to south and at least 7.5 m from east to west. See Chapter 2, Fig. 2.17 for a suggested reconstruction of the Phase 10c workshop and Fig. 2.1 for the location of the pot bellows and furnace.

Ash Lenses and Melting Pits

Courtyard 18333 contained a series of superimposed sloping surfaces which were built up from the dumping of ashy debris created during the course of the bronzeworking activity, typically manifested as alternating layers of white ash and sand, mixed with bits of mudbrick debris and charcoal. These lenses never extended far and, at first, were thought to be simply ashy patches on a single, more-or-less continuous white floor surface. However, this was not the case and, in fact, it was impossible to isolate discrete floors in this courtyard because of these overlapping, discontinuous ashy accumulations. Approximately 30 such lenses were counted in a single, ca. 40 cm-deep section, along with two distinct shallow ashy pits (Square AI/I32; Chapter 9, Figs. 9.70–9.71). Although these ashy lenses were mostly limited to the courtyard, several of them, including some clearly identified as melting pits, were also found south of W18296 in Room 18330, a space measuring 4.0 m from north to south (L18290, L18312, L18322, L18323, L18325, L18328, L18329, L18333, L18336, L18345, L18348, L18374, L18385).

A detailed analysis of one of the pits exposed in the eastern balk of the area (Fig. 22.2; see Fig. 22.1 for the location of this balk) showed the presence of high concentrations of copper and sediments that were heated to very high temperatures (Berna et al. 2007: 370). However, whether this pit is representative of the others is questionable and raises questions of how, within the framework of the metallurgical activity, were the ashy lenses formed, what was the purpose of the pits and how did they function in conjunction with the crucibles? Melting



Fig. 22.2. A melting pit identified in the eastern section. (p10Z3-1029)

pits are not meant to contain fire and therefore, are almost never vitrified. As a result, they leave little or no evidence of their existence and are not easily identified during excavation. Melting pits are reported from various sites, such as Dan (Ilan 1999: 34), Hazor (Yadin et al. 1958: 105–106) and the City of David in Jerusalem (Mazar 2009: 53–54).

Furnace 18308

Furnace 18308 is a circular, oven-like feature, ca. 1.1 m in diameter (Fig. 22.3; see Fig. 22.1 for its location in the courtyard; also Chapter 9, Figs. 9.73, 9.75). It was set into a pit and lined with large storage-jar sherds and mudbricks near its bottom. The walls of the furnace, built on top of a single course of fist-sized stones, were composed of coarse, 3 cm-thick fired clay, blackened on the interior. The upper fill inside the furnace was brown sand and mudbrick debris, while the base contained burnt organic material, red, brown and grey sediments and white sand. In the southern wall was an aperture, ca. 10 cm high and 5 cm wide. This opening likely served to feed air into the furnace. A channel leading from this opening to the adjoining surface was found blocked by a juglet (Chapter 9, Fig. 9.73). The sloping channel, reflecting the accumulation of ashy-surface debris, possibly indicates a prolonged use of this installation. Although no metallurgical debris was found inside, its location among the melting pits suggests its association with the metallurgical activity.

Pot Bellows

The role of the pot bellows in the melting process is to provide a flow of air that will enable combustion inside the crucible. An efficient pot bellows requires that the rim diameter be wide, so that the hide covering it will transmit a maximum amount of air when pumped. The covering is fastened to the pot with a cord under an out-turned rim or in a groove just below the rim exterior. An opening near the base serves to insert a pipe of perishable material whose purpose is to direct the air blast to the furnace/crucible, done through the mediation of a tuyère.

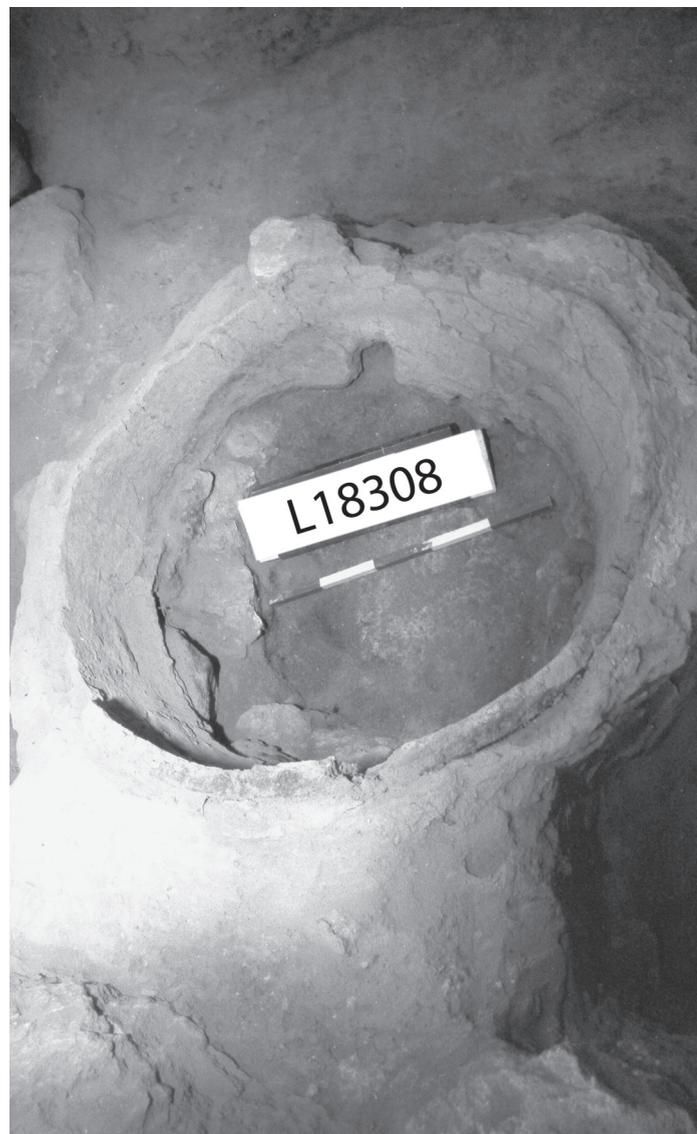


Fig. 22.3. Phase 10c Furnace 18308. Note aperture in southern wall. (p08Z3-1277)

The base of the pot bellows is normally wide and flat (Davey 1979).

A near-complete ceramic pot bellows, measuring 35 cm in diameter and 21 cm in height, was found in the southwestern corner of Room 18286 in Phase 10c, north of W18229 (Fig. 22.4; see Fig. 22.1 for its location in the room). Since it was located close to and facing the wall, it was definitely not found where it was operated and was likely part of the metallurgical activity evidenced in the courtyard immediately to the south. The temperature of sediments in the eastern balk related to Phase 10, measured by Berna et al. (2007: 369) and found to reach as much as 1300°, is in accordance with this find since such a temperature could not have been obtained without the use of a bellows.

Tuyères used in conjunction with the pot bellows in order to protect the ends of perishable tubes leading from the pot into the fire must have been collected and deposited elsewhere, since only a single fragment of such a tuyère was found in this area.

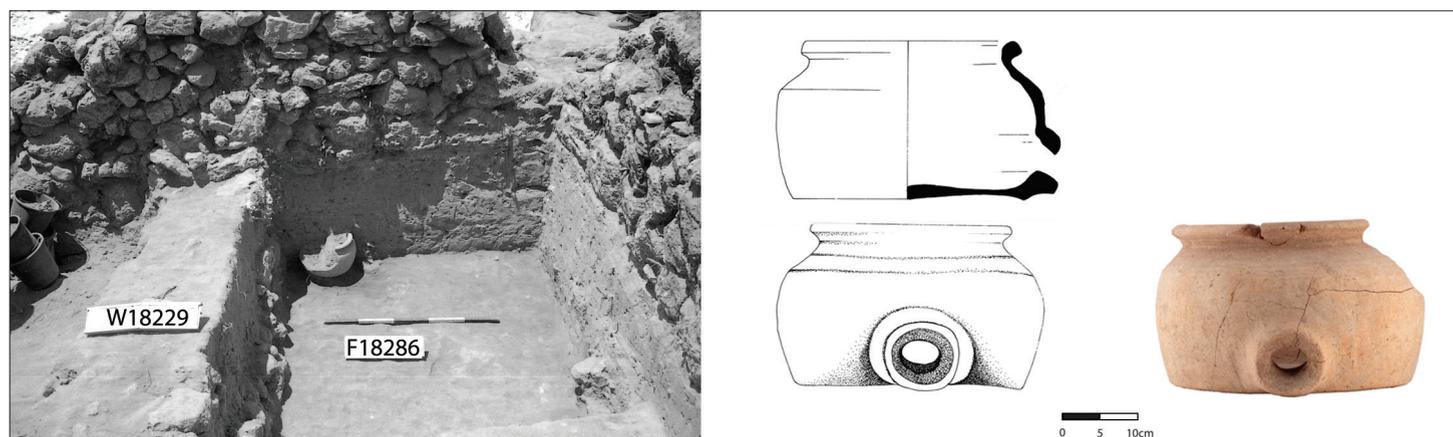


Fig. 22.4. Pot bellows *in situ*, looking west; photograph and drawing of the restored pot. (p05Z3-0635)

Crucibles

Crucibles are generally relatively shallow clay vessels with a wide rim diameter and thick walls, rich in organic temper and heavily vitrified and slagged on their interiors (to the extent of bloating and melting), while the core is less vitrified and the exterior is only slightly baked (Martinón-Torres and Rehren 2014: 113–114). Several crucible fragments have been preserved in Area G, mostly crucible-slugging, which is the interaction between the ceramic of the crucible and the hot melt inside. Although the best-preserved crucible (Reg. No. 184033, L18313) is missing its rim (Fig. 22.7a), based on its thick base, it appears to be shaped like a flower-pot which is the most common type of crucible at Iron Age I sites, e.g., Tell Qasile (Tylecote 1992: Fig. 13:B4), Megiddo (Gadot et al. 2006: Fig. 18.31) and Dan (Ilan 1999: Pl. 79:1–2; Ben-Dov 2011).

Waste Products

Some 187 waste products from Phases 12, 11, 10c and 9 were recovered, although the distribution of these materials across the different phases (Table 22.1) indicates that the bulk of metallurgical activity occurred in Phase 10c, in which 93 prills, 36 chunks, four crucible slag fragments and one nearly complete crucible were found. No waste products were attributed to Phase 10a and only very few to Phases 10b and 9 (the latter probably residual); no crucible fragments were found in the latter two.

The waste products include prills (spherical copper pellets, e.g., Fig. 22.5), irregularly shaped copper chunks and crucible fragments, as well as complete and fragmentary objects which could have been scrap earmarked for recycling or end products that remained in the workshop; all were highly corroded due to the humid climatic conditions at the site.

Bones

Accumulations of bones found in the vicinity of the metallurgical installations may have been related to the production process.



Fig. 22.5. Bronze prills from Phase 10c L18312. (p10Z3-0089)

Bones were found in association with metalworking at Dan (Ilan 1999: 55), Tel Rehov (Yahalom-Mack forthcoming), Megiddo (Gadot et al. 2006: 91–92) and the City of David, Jerusalem (Mazar 2009: 53–54). The possible use of bones in metal production has been discussed in relation to the finds from Kition, where considerable amounts of bone-ash were found at the Northern Workshop, apparently resulting from the bones of animals scarified in the temple. It has been suggested that this bone-ash was subsequently used as fuel or flux in secondary smelting operations (Tylecote 1982: 82; Zwicker 1985), as a deoxidizer (Karageorghis and Kassianidou 1999: 182) or in the production of refractories, such as furnaces or crucibles (Zwicker 1985: 415). In the case of bronze smithies, the use of bones as fuel seems the simplest and likeliest explanation.

METALWORKING IN AREA G

Table 22.1. Metal-waste products, objects and crucibles in Phases 12–9

Locus	Phase	Prills	Chunks	Objects	Crucibles (mainly crucible slag fragments)
9881	9	1			
18033	9	1		1	
18050	9	1			
18265	9	1			
18570	9			2	
18344	10	1			
18285	10			1	
18078	10a			1	
18070	10a/10b??			1	
18086	10a/10b??			2	
18316	10b	1	2		
18317	10b	2		1	
18310	10b			Iron fragments	
18273	10b+c	1			
18311	10c	1			
18312	10c	33	13		
18322	10c		1		
18323	10c	2			
18325	10c	1			
18328	10c	11			
18329	10c	1			
18330	10c	1	2		
18333	10c	10	10		2
18336	10c	9	2		
18345	10c				2?
18348	10c	1			
18313	10c/10b?	20	6	1	1 (large base fragment (Fig. 22.7a))
18320	10c?/11?		2		
18337	10c?/11?	2			
18365	11			1	
18405	11		1	1	
18421	11			1	
18444	11			2	
18469	11			1	
18483	11		2		
18487	11		1		
18489	11			1	
18494	11				2
18496	11			1	
18446	11?			1(?)	
18334	11a				1
18399	11a	1	1		
18484	12				?
18382	12a	1			
18401	12b	3	4		
18414	12b	1	5	1	1

ANALYSES CONDUCTED ON THE METALLURGICAL REMAINS

In addition to the analysis of the sediments in the field (Berna et al. 2007), a selection of waste products from Phases 12 to 10 and the crucible from Phase 10c with adhering slag were analysed.

Waste Products

In order to determine the overall composition of the highly corroded byproducts, the surfaces of prills, chunks and fragments of crucible slag were examined using an X-Ray Fluorescence (XRF) analyzer. A bench-top model EX-310LC (Jordan Valley Co), with a rhodium target X-ray tube running at 35 kV was used. An additional filter of 0.2-mm-thick aluminum foil was placed above the detector window to optimize the analytical conditions. Two to four measurements with a 2-mm beam were carried out on the surface of each artifact and the average result was calculated.

The results showed that tin was present in 99% of the items from Phases 11–10, while only five out of the nine items from Phase 12 contained tin. Fe/Cu ratio calculated for 72 prills and chunks from Phases 12–10 (Fig. 22.6) showed an average value of 0.03 ± 0.05 , which appears to be characteristic of the remelting of refined copper, either copper ingots or bronze scrap.² The Fe/Cu ratio in five crucible slag fragments was higher, measuring 0.98 ± 0.6 . Since this type of slag forms as a result of the reaction between copper and iron oxides in the melt and the constituents of the crucible which include iron, it does not seem to be indicative of the purity of the melt.

It thus appears that waste products from Area G at Dor are basically oxidation products, which precipitated from a homogeneous, fully liquefied melt during or at the end of the melting process using open crucibles (e.g., Klein and Hauptmann 1999: 1080). Such products are produced mainly along the rim of the crucibles, as access of oxygen occurs by intermittent charcoal additions or hyperfunction of the bellows (Klein and Hauptmann 1999: 1080).

Crucible

Other than the slagging observed inside the crucible with the preserved base mentioned above (Fig. 22.7a), the fact that the

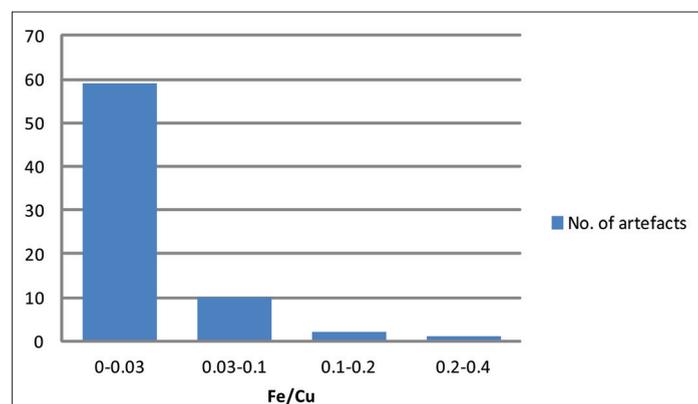


Fig. 22.6. Fe/Cu ratio measured in the prills and chunks. (d10Z1-1106)

crucible was heated from the inside was confirmed using Fourier Transform Infrared Spectroscopy (FTIR), based on the alteration of clay minerals due to exposure to heat. Representative spectra were obtained by grinding a few tens of micrograms of samples taken from across the section of the crucible, using an agate mortar and pestle. The ground sample was then mixed with KBr (IR-grade) to produce a 5 mm diameter pellet using a press. Spectra were collected between 4000 and 400 cm^{-1} at 4 cm^{-1} resolution for 32 scans using a Thermo Nicolet IR-200 spectrometer. A thermal gradient, with the inside far hotter than the outside, was observed (Fig. 22.7b).

A small sample (METB37, ca. 3 X 3 cm in size) was cut off the slag adhering to the interior of the crucible (Fig. 22.8). The sample was mounted in Epoxy resin, polished and then examined using a Nikon Eclipse E-600 polarized microscope in reflected light mode. Various oxidation phases (SnO_2 , Cu_2O and CuO), typically produced during the remelting of bronze, were observed. The shape of the tin oxide (SnO_2) crystals clearly point to high-temperature formation. Some of them contain copper or bronze (as seen in their centers), indicating that they were formed by preferential oxidation of tin from a liquid melt (see examples and additional references in Rademakers, Rehren and Pusch 2018). Tin burning out of bronze in this way is indicative of locally oxidizing conditions in certain areas of the crucible. Tin oxide could form directly

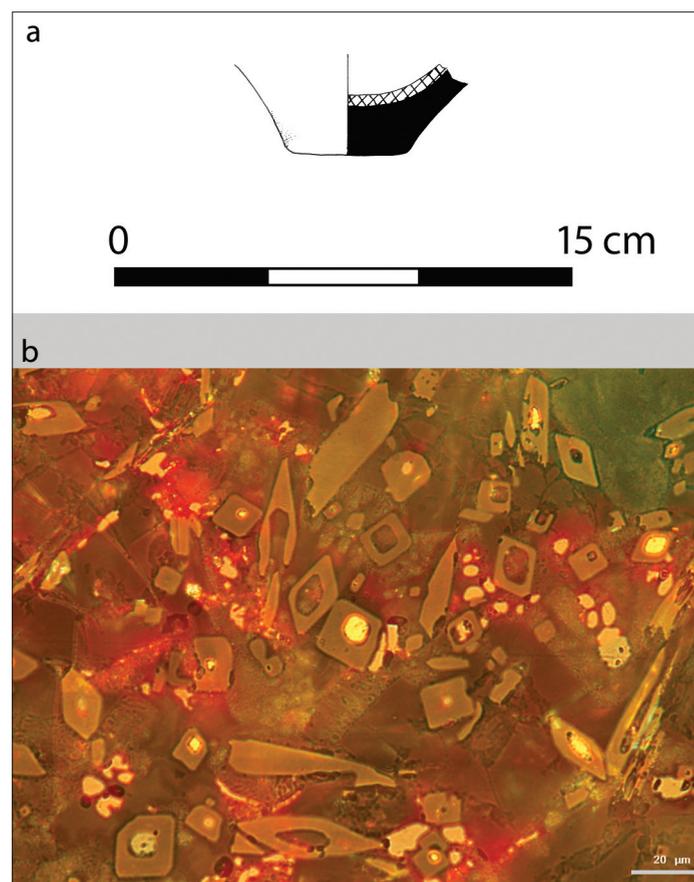


Fig. 22.7. a: Crucible base with slagged interior; b: Image of crucible slag taken using an optical microscope with polarized light at X500, showing various oxidation phases (SnO_2 , Cu_2O and CuO), typically produced during the remelting of bronze. (p16Z3-1023)

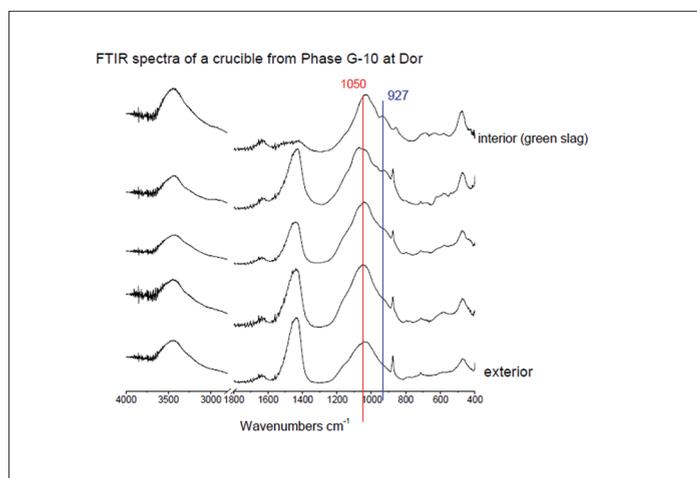


Fig. 22.8. FTIR spectra of the crucible's section (see Fig. 22.7a). (d10Z1-1108)

from the oxidation of metallic tin, from the re-crystallization of mineral cassiterite or as a result of bronze remelting. In the sample at hand, there is no evidence for the presence of metallic tin or cassiterite (mineral tin), which are indicative of alloying activity and access to fresh raw materials. However, even though the crucible slag microstructure in this case appears to provide evidence for bronze remelting, it is not necessarily so, as it has been shown that crucible slag is highly heterogeneous and our sample represents only one area of a single crucible (e.g., Rademakers and Rehren 2016).

Lead Isotope Analysis

Lead Isotope Analysis (LIA) was conducted on 10 items from Phases 12–10 in order to determine the provenience of the copper used in the metallurgical activity at Dor. The results are presented and discussed in Chapter 23.

RECONSTRUCTING THE REMELTING PROCESS IN PHASES 10B–C

The metallurgical activity in these phases appears to have involved the remelting of copper and bronze in open crucibles. The temperature necessary for remelting was most likely achieved by directing the tip of the tuyère downwards into the crucible which was filled with metal and charcoal. This is evident by the formation of the slag-like layer inside the crucible, which is the result of the reaction between the clay and the hot melt. The tuyères most likely received air from the pot bellows at ground level. Even though none of the tuyeres were found (aside from one small fragment), the complete ceramic pot bellows located in one of the rooms surrounding the courtyard is evidence of their existence.

It is suggested that metallurgical activity did not take place in the melting pits, but rather that these were merely designed to hold a crucible or a mold. The latter would have been positioned very close to the melting pits since, while casting, the smith often has only a few seconds to pour the metal before it solidifies (Tylecote 1992: 136). The only pit

that was vitrified, described above (and reported in Berna et al. 2007), appears to have been an exception rather than the rule. It may, in fact, be the result of copper/bronze spilled into it from a mold or crucible. As noted above, in some cases, it was possible to differentiate between these shallow pits and the many ash lenses, although how exactly the latter were formed remains unclear.

Also unclear is the purpose of the tabun-like installation, designated a “furnace”. Since, for the purpose of melting copper or bronze in a crucible, a shallow pit is all that would have been required, the purpose of the tabun-like installation/furnace in designated bronzeworking areas in conjunction with the melting pits, is unknown. Furnaces which are similar in shape, size and, probably, manner of construction were found in conjunction with metalworking at Dan (Biran 1989: Fig.72), Tel Zeror (Ohata 1967: Pl. XXVI) and in Room 12 of the Northern Workshops at Kition (Karageorghis and Kassianidou 1999: 174, Furnace J, 0.95 m in diameter). Their size differentiates them from smelting furnaces, which are usually much smaller, measuring only 30–50 cm in diameter (Jones 2007: 135, 216).³

At Qantir in the Nile Delta, a systematic melting operation was carried out during the reign of the 19th Dynasty. Instead of pits, the crucibles were positioned in parallel canals. At the end of every pair of canals was a huge cross-shaped furnace, likely used to hold a large mold and to maintain it heated while it was gradually filled with liquid bronze (Pusch 1990; 1996; Rehren and Pusch 2012). Although the furnace at Tel Dor could have had the same purpose, this is unlikely, as the objects dated to this period (early Iron I) are generally small and were probably cast in open molds.

The critical role of the pot bellows in the metallurgical production process is clear, as described above. Generally, two types of pot bellows occur: squat with straight sides and tall with rounded or carinated sides. Pot bellows of the first type were found in many instances in pairs and were supposedly operated by foot (Davey 1979). Pot bellows of the second type were never found in pairs and were definitely operated manually. The pot bellows from Area G at Dor is clearly of the second type.

Parallels for the pot bellows from Dor are found mainly along the Lebanese and Syrian coasts, such as at Sarepta and Ugarit (Davey 1979), as well as in northern Israel in contexts dated to the LBII and Iron I (see below).

At Megiddo, two similar ceramic pot bellows were found, one each in Tombs 3 and 1145A (Guy and Engberg 1938: Pls. 37:7 and 49:22, respectively), located on the eastern slope of the tell. These tombs are not far from Area K, excavated by Tel Aviv University, where a sequence of courtyard houses contained evidence for near-continuous bronzeworking from the late MBII until the end of the of the Iron I. Based on the ceramic assemblages from the tombs, they are roughly contemporary with Levels K-9–K-7 (=Strata VIII–VIIB). Another pot bellows fragment was found in excavation of Level K-6 (Yahalom-Mack et al. 2017: 56). At Tel Abel Beth Maacah, a complete pot bellows was found in secondary use in an Iron IB public building, along with additional evidence of metalworking (Yahalom-Mack, Panitz-Cohen and Mullins 2018). Fragments of large handmade vessels found in Iron I

contexts at Dan may have been used as pot bellows as well (Ilan 1999: 127, Pls. 9:2, 28:4, 53:2; Ben-Dov 2011).

REGIONAL AND ECONOMIC IMPLICATIONS OF METALWORKING AT DOR

Metalworking at Dor is evidenced in two different periods: during the 13th century BCE and in Iron Age I (specifically in Ir1a *early* in Dor terminology, the horizon of Phase 10), dated to the late 12th–11th centuries BCE. Solid evidence in the form of the distribution of crucible fragments and waste products, as well as the location of the pot bellows and furnace, show that metalworking took place mainly in Phase 10c in a clear workshop context. As noted above, the metallurgical activity in this phase appears to have involved the remelting of copper and bronze in open crucibles. According to our XRF analyses, none of the waste products appear to be refining slag, but rather oxidation products of a melting process. While the analysis of ingots from different cargos found off the Carmel coast, not far from Dor, showed that they were made of refined copper (Yahalom-Mack et al. 2014), we cannot determine whether such refined copper, in the form of ingots or scrap metal, was remelted at Dor. Lead Isotope Analysis showed that copper from the Arabah was likely used in Phase 10c, suggesting the influx of fresh copper and, likely, tin during this time (Chapter 23).

Evidence for bronzeworking during the LBIIB in Canaan is scarce in relation to the Iron I. At Tel Rehov and Tel Zeror, there is evidence for Egyptian bronzeworking traditions (Yahalom-Mack 2015). The limited exposure of Phase 12 in Area G provided enough data to determine that bronzeworking did, in fact, take place at Dor during this time, as it did at Tel Nami and Tel Akko. At Tel Nami, metalworking was apparently practiced in association with an LBIIB sanctuary (Artzy 1995; 2000). Evidence includes scrap metal, copper-based tools and weapons (some possibly intended for recycling) and other remains, such as parts of crucibles with traces of metal on them (which were not illustrated in any of the preliminary publications of the site). The scrap metal, which included fragments of stands and two parts of the same figurine, is similar to some of that found among the cargo of the Cape Gelidonya shipwreck, dated to ca. 1200 BCE (Bass 1967: 107ff; Artzy 1995; 2000). In this regard, the numerous parallels in the Cape Gelidonya cargo (Bass 1967: 88–113) for a bronze hoe found in Phase 11 in Area G at Dor (Chapter 26, Table 26.16:11; see Chapter 23, sample Dor-8) should be noted.⁴ Remains of bronze remelting activities in Area AB at Akko were reported (Dothan 1992: 1228), but never published. These apparently included two crucibles with remains of metal adhering to their interior, parts of tuyères, slag and broken and distorted metal fragments.

The concentration of metalworking at LBII sites along the coast points to a connection between these settlements and the maritime trade with Cyprus. By the end of the 14th century BCE, Cyprus became the dominant source of copper for much of the eastern Mediterranean. Canaanite city-states, particularly Ugarit, seem to have played a major role in this stage of palace-controlled commerce, as both consumers and distributors of copper (Jones 2007:47–57, with references). A

Syro-Palestinian origin for the Uluburun ship has been argued by Bass (1991: 75) and Pulak (1997: 252).

It has been suggested that the increase in scrap-metal finds at sites in the eastern Mediterranean around 1200 BCE was due to an increase in the scope of circulation of bronze scrap, alongside products of added-value, that was conducted at an informal level by non-elite traders bypassing the palace-controlled trade (Sherratt and Sherratt 1991; Sherratt 1998; 2000). Independent metalworkers situated at sites along the northern coastal strip may have been particularly engaged in this type of informal commerce, which developed during the 13th century and continued into the 12th century BCE. The link between Tel Nami and the Cape Gelidonya shipwreck also seems to suggest this (Artzy 2000). These conclusions well fit the general reconstruction of the economic and cultural activities along the southern Phoenician coast during this time period (Gilboa 2005). Notably, LIA conducted on a small number of bronze artifacts from Dor (Chapter 23), including two objects from Phase 12, a single object from Phase 11 and five objects from Phase 10, indicate that while most of the objects from Phases 11 and 10 were likely made of copper from the Arabah, the two objects from Phase 12 were not. One of the latter (sample Dor-5) has lead isotope ratios which are roughly consistent with ores from Cyprus, as well as with a bun-shaped ingot from the Cape Gelidonya shipwreck.

Metalworking at Dor during the late 12th and 11th centuries BCE (Ir1a *early* in Dor terminology) appears to be related to a more extensive phenomenon. During this period, bronze remelting activity is known from fourteen sites in Israel, eleven of which have no prior LBIIB evidence for metalworking (details in Ilan 1999 and Yahalom-Mack 2009): Abel Beth Maacah and Dan in the upper Hula Valley, Tel Harashim in the Galilee, Beth Shean, Megiddo and Yoqne'am in the northern valleys, Dor on the northern coastal plain, Tell Qasile and Aphek in the Yarkon basin, Beth Shemesh in the Shephelah, Khirbet Raddana and the City of David in the central mountain range and Tel Masos in the Beer Sheba Valley. In the Jordan Valley, metallurgical activity was reported from Tell Deir 'Alla.

The especially large number of Iron I sites with evidence of bronzeworking appears to be related to the decentralized political structure which followed the withdrawal of the New Kingdom Egyptians towards the end of the 12th century BCE and to the availability of copper resulting from major mining and smelting activities in the Arabah that began during this time (Levy et al. 2004; 2008; Ben-Yosef et al. 2012). Fifty-four copper ingots were found near Neve Yam in underwater surveys off the Carmel coast, less than 7 km away from Tel Dor (Galili and Sharvit 1999; Galili, Gale and Rosen 2011). Nine out of the 54 ingots were analyzed and found to be chemically and isotopically consistent with the DLS ores from Faynan in the Arabah (Yahalom-Mack et al. 2014). LIA (Chapter 23) showed that six out of the seven analyzed objects from Phase 10 in Area G were also consistent with ores from the Arabah. This raises the question of the possible involvement of the Phoenicians, and the inhabitants of Tel Dor in particular, in the Arabah copper trade via the Mediterranean during the Iron Age I.

NOTES

- ¹ This chapter discusses the metal-production remains. Bronze and iron objects recovered from the entire stratigraphic sequence in Area G are presented in Chapter 26 (Tables 26.16–26.17).
- ² For comparison, the Fe/Cu ratio of five objects, two chunks and one prill from Area G, analyzed using ICP-AES, was calculated (for details of method and results see Chapter 23), showing a ratio of 0.003 ± 0.004 . This ratio is lower in a single order of magnitude than that measured using the XRF. This could be the result of the difference between the two methods, in which the surface of the waste products was measured using XRF, whereas for ICP-AES, the artifacts were drilled.
- ³ Smelting furnaces at Timna' were larger than usual, measuring up to 60 cm in diameter and in height (Tylecote 1992: 35, Fig. 16).
- ⁴ Although found extensively in Cyprus (e.g., Knapp, Muhly and Muhly 1988), Deshayes (1960: 139) and Catling (1964: 80–81) point to the Near East as the origin of this tool type. Similar bronze hoes were found at Ugarit in a 14th century BCE foundation deposit (Schaeffer 1956: 254–255, Pl. 232.6). In Canaan, they appear mostly at northern sites during the LBIIB and later, during the early Iron Age, also elsewhere, e.g., Beth Shean Levels VII and VI (Bonn, Moyer and Notis 1993: 205–206, Fig. 151:2; James 1966: Fig. 103:3, respectively), Megiddo Stratum VIII (Loud 1948: Pl. 185:2).

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