Beyond smelting: New insights on Iron Age (10th c. BCE) metalworkers community from excavations at a gatehouse and associated livestock pens in Timna, Israel

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ABSTRACT

This paper presents results of excavations at an Iron Age (~10th c. BCE) gatehouse and associated livestock pens in one of the largest copper smelting camps in Timna Valley – Site 34 (“Slaves’ Hill”). The extraordinary preservation of organic materials allowed for in depth investigations of animal bones as well as seeds and pollen found in dung piles. The results demonstrate that the gatehouse area was used for keeping donkeys (or mules), which were the common draught animal at the time, together with other livestock (probably goats). The donkeys were fed with grape pomace and hay (rather than straw) that originated from the Mediterranean regions, >100 km to the northeast (Edom) and 200 km to the north (Philistia/Judea). This food reflects special treatment and care, in accordance with the key role of the donkeys in the success of copper production and trade in a logistically challenging region. Furthermore, the excavations revealed a deliberate piling of the dung against the inner face of the site’s wall, most probably in order to use it as fuel in the copper smelting process (the initial heating of the furnaces). In addition, the excavations yielded insights on the metalworkers themselves, including their rich diet (as reflected by animal bones and seeds) and activities at the gatehouse area. The latter includes secondary metallurgical processes such as refining/melting in crucibles and probably casting of ingots. Lastly, the results of this study shed new light on the Iron Age society engaged in copper production in Timna (probably early Edom), further stressing its complexity and centralized organization, as well as its involvement in inter-regional trade. The gatehouse and walls also indicate substantial investment in deterrence and defense, reflecting a period of instability and military threat in 10th c. BCE Timna.

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1. Introduction

The Timna Valley (Fig. 1), one of the best-preserved ancient copper ore districts in the world, constitutes a “field laboratory” for the study of early copper extraction technologies and associated social organizations (e.g., Rothenberg, 1999a; Rothenberg, 1999c). In contrast to many other regions rich in copper ore deposits, most of the ancient mining and smelting sites in Timna were unharmmed by modern prospection and exploitation activities. In addition, the extremely dry climate minimized the effect of erosional processes, while also leaving the sites bare of vegetation, and thus easy to find, access, and research. The climate conditions are also responsible for the extraordinary preservation of organic materials, which provide a unique opportunity to explore various aspects of ancient human activities that are usually transparent in the archaeological record. Such well-preserved organic remains were uncovered recently as part of the Central Timna Valley Project (CTV) of Tel Aviv University (Ben-Yosef, in press), and are the focus of the current study.

The CTV 2014 excavations at Site 34, one of the largest copper smelting camps in Timna dated to the Iron Age (late 11th–10th c. BCE), unearthed the entrance complex to the fortified site, including a gatehouse and adjacent areas that were found to be extremely rich in dung and other organic remains. The latter is interpreted by us as evidence of donkey “stables” or pens, which also included other livestock related to the maintenance of the industrial activities conducted at the site. This paper presents the results of the excavations, together with radiocarbon dating and analysis of the faunal finds (mammalian bones) and botanical remains (seeds and pollen). The synthesis of these varied studies shed new light on the society of Iron Age Timna and its metalworkers, the organization of production, copper extraction technologies and inter-regional trade.

2. Site 34 (“Slaves’ Hill”) and the excavations at the gatehouse complex (Area G)

Site 34 (“Slaves’ Hill”, Khirbet Meneiyyeh) is an extensive (ca. 3 ha.) copper smelting camp located on a sandstone mesa surrounded by cliffs
at the center of the Timna Valley (Fig. 2). The site was surveyed by Glueck (1935) and Rothenberg (1962), both emphasizing the abundance of slag mounds (estimated at ~1000 tons) and the remains of a wall along parts of the cliffs. Rothenberg (1962) also identified the ruins of a gatehouse at the end of the only access path to the hill on its northwestern side. Site 34 was not excavated by Rothenberg and the Arabah Expedition, who conducted substantial and important excavations in several smelting and mining sites in Timna from 1964 to 2002. Excavations at the site started in 2013 under the CTV Project (Fig. 3, Ben-Yosef, 2016), focusing on large slag mounds (Area 19A), metallurgical and other installations (Areas 13, 21), and the entrance complex to the site (Area G). The excavations of the latter are the basis for the current study.

The Excavations at Area G were conducted during the season of 2014 and aimed at investigating the entrance complex to the site and to better understand the site’s fortification system. The excavations resulted in exposing a two-room well-designed gatehouse, and the discovery of two areas for keeping donkeys and other livestock with extraordinarily well-preserved organic remains (Figs. 4, 5). For documentation and recording purposes, Area G was divided into two sections, Area GN (“Gate-North”) and Area GS (“Gate-South”) (Fig. 5). The stratigraphy and main features, including locus designations and spatial layout are summarized in Fig. 6 as a Harris Matrix (Harris, 1977).

The main features exposed during excavations include, in addition to the two rooms and livestock pens, the passageway of the gatehouse, the upper section of the access path to the site, several sections of the site’s wall and two massive platforms (or tower bases, cf. Rothenberg, 1962:21) between the wall and the rooms. Following are the descriptions of these features and the main finds.

2.1. Access path and perimeter wall

The only access path to the site climbs comfortably from the northwestern corner of the hill to the gatehouse with only one switchback (Fig. 2). The path, in places carved into the sandstone bedrock, had been wide enough to accommodate two loaded pack animals walking side by side (or crossing each other), before it was covered by stones from the wall’s collapse. The steepest portion of the path, just before it makes a sharp 90° turn and enters the gatehouse, also includes wide steps carved into the soft sandstone, with flagstones placed on top of some or all of them. This segment was found tilted and separated from the original cliff by a major fissure, probably a result of one of the earthquakes that frequent the area (cf., Matmon et al., 2005).
The gate provided entrance to the site through a relatively massive outer perimeter wall. This wall, made of the fragile local sandstone, is poorly preserved and most of its outer face collapsed onto the slopes. However, in the excavations at Area G5 we were able to expose a section across the entire width of the wall and estimate its construction technique. The original wall’s width is around 1.7 m. It was constructed by building two wall lines and rubble fill in the middle. The wall lines are made of partially dressed, relatively large (20–40 cm) fieldstones that were stabilized with smaller stones of irregular shapes placed in between (dry construction). The few preserved segments of the outer face indicate that this part was better constructed (larger stones than the inner face and better placement) and that efforts were invested in carefully adjusting the wall to the hill’s contours, making it a direct continuation of the sheer cliffs (Fig. 7).
2.2. The gatehouse structure

The gate is made of three main elements: the central passageway, two platforms and two gate rooms (Figs. 4, 5). The passageway was 2.90 m in width and paved by sandstone flagstone (average size 25 × 20 × 5 cm), including massive threshold stones one of which was found in situ (110 × 40 × 25 cm, Fig. 8). A large, flat-topped stone block (50 × 30 × 25 cm) found in situ in the middle of the passageway attached to the northern room's wall (Figs. 5, 8) might have been a “seat” with administrative and/or cultic purposes (on “seats”, administration and cult in gates, see e.g., Blomquist, 1999). The straight entrance passage is flanked by platforms, each found between the site’s wall and the gatehouse rooms (abutting both, Figs. 5, 9). They were built on deliberately levelled surfaces from massive, partially dressed sandstones, and demonstrate the most concern with construction techniques in the gatehouse complex. The platforms are about 1 m in height and are made of at least five courses of rectangular flat stones (northern: 60–70 × 30–40 × 10–20 cm; southern: 100 × 60–70 × 30–50 cm). The northern platform was constructed by laying down two to three slabs side by side and then alternating the orientation of the slabs 90° in

Fig. 4. Site 34, Area G at the end of the 2014 excavations: The entrance complex to Site 34 with a two-room gatehouse flanked by animal pens and piles of dung.

Fig. 5. Site 34, Area G – Map of the entrance complex; reconstruction of the wall is based on the excavations of its foundations and measurements of its width in the few locations were its outer face has been preserved.
Fig. 6. Main stratigraphic units and locus distribution ("Harris Matrix") of the 2014 excavations in Area G, Site 34.
each successive layer, and the southern by placing massive stones at the
bottom (without alternating direction). These platforms probably rep-
resent the bases of towers or watch posts that protected the entrance
to the site.

The two rooms flanking the gate’s passageway have different di-
mensions, the northern is rectangular (1.4 × 2.8 m) and the southern
is roughly square (1.1 × 1.4 m) (Fig. 5). While the walls of the northern
room were preserved to a maximum of one course of heavily eroded
elongated large sandstone slabs (some parts of the walls were
completely eroded), the walls of the southern room were preserved to
at least two courses. Except some wall segments of the southern
room, the first course of stones was placed directly on bedrock. The east-
ern wall of the southern gate is made of two rows of stones and may in-
dicate the original construction technique of some of the other
walls, which now have only one surviving row. The large amount of col-
lapsed field stones removed during excavations suggests original con-
struction of at least five more courses. An entrance is clear only in the
southern room, where it is located in the eastern end of its northern
wall and indicated by a door lintel; assuming a roughly symmetrical
plan the entrance to the northern room should be located in the eastern
end of the southern wall, where the walls did not survive. The small
finds within the rooms indicate various types of activities, including ev-
idence for cooking and storing in both rooms. A rich assemblage of tex-
tile, rope and cord fragments was unearthed only in the southern room
(similar fragments were found also in the southern pen, see details in
Workman, 2016), which also had larger amount of seeds (below). On
the other hand, the northern room yielded various materials related to
metallurgical activities, including two rare crucible fragments with cop-
per prills (Fig. 10) and an in-tact tuyère fragment (Fig. 11). The meta-
lurgical evidence within this room should probably be associated with
other metallurgical finds from the northern dung (and other waste)
pile, including copper ore fragments, pieces of slag, prills and a relatively
large flat piece of copper metal (ca. 5 cm in diameter, possibly a frag-
ment of an ingot).

There are no exact parallels to the gatehouse structure at Site 34 in
other sites from the Iron Age Levant (cf., Frese, 2012). The other exca-
vated gates, which are predominantly city gates, are considerably larger
(although varied in sizes) and typically have rooms with three walls
rather than four. The closest parallel is possibly the gate of the Stratum
X fortress at Arad (late 10th/early 9th c. BCE, Herzog, 2002:29), which
has two gate chambers and thickening of the walls (towers?) flanking

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Fig. 7. Two of the best preserved segments of Site 34’s perimeter wall (outer faces), located
north (A) and south (B) of the gatehouse complex.

Fig. 8. General view (looking west) of the gatehouse passageway (A), in situ threshold
stone (B and left arrow in A) and a “seat” (C and right arrow in A).

Fig. 9. Aerial view of Area GN (cf. Fig. 5); the exposed bedrock to the north of the gate room
were covered by organic rich layers of dung and other materials (removed during the
2014 excavations) indicating that the area was used for keeping donkeys and other
livestock. The pen extended further to the north and beyond the excavated area as
indicated by the greyish sediments on the surface of the site and shallow probing.

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the entrance. However, also here the dimensions are significantly larger (4.5 m width of the passageway and 3.3 × 8.0–9.0 m chambers). It is worth noting that the contemporary smelting camp Site 30, which is located in close proximity to Site 34 (<400 m), is also enclosed by a wall (Ben-Yosef et al., 2012; Rothenberg, 1980). This wall is now reconstructed, without any detailed report on its survey (and possible excavations) during the Arabah Expedition campaigns in the 1970s and the later reconstruction process. However, the site’s plan (Rothenberg, 1980) indicates that the width of the wall and gate’s passageway (ca. 1.4 and 2 m respectively) are similar to these features at Site 34. The plan also indicates the presence of two robust platforms flanking the gate (ca. 5.5 × 3 m, also here probably tower bases), but without gate rooms. At the site itself, the reconstructed gate includes the two massive platforms and a large pillar-like standing stone (“massebah”), which is placed against the platform situated on the left at the direction of entering. This standing stone was interpreted as part of the cultic activity conducted at the entrance to the site (Avner, pers. comm. 2009, and see discussion on their role in desert societies in Avner, 2001, 2002), and is possibly paralleled by the “seat” unearthed at Site 34 presented above, which is located on the same side of the gate passageway.

2.3. Livestock pens

The entire excavated areas north and south of the gatehouse structure (in the inner side of the wall) are composed of organic-rich sediments (Figs. 5, 9), which accumulated right on top of the bedrock, and are considerably thicker closer to the wall (up to 1 m high, Fig. 12). Based on the indicative greyish color of the surface prior to excavations, it is evident that these areas extend at least 15 m to the north and 10 m to the south of the excavations, and that all together the organic-rich sediments cover a stretch of >30 m along the wall. These sediments are predominantly composed of decomposed dung of large and medium mammals (Fig. 13a), mixed with intact dung of sheep/goat (Caprines) (Fig. 13b), animal bones (including horns, Fig. 13c), hundreds of seeds and animal hair. Other finds include some metallurgical remains, textiles (some are probably pieces of sacks and saddles, Workman, 2016), and more (Table 1 and Section 2.4 below). Except for a small patch in the northern excavation areas (GN), the organic materials are uncharred and extraordinarily well-preserved, providing an unprecedented opportunity to glean new insights on various aspects of the Iron Age metalworkers’ society at Timna.

The organic-rich sediments indicate that the areas flanking the gate were used for keeping donkeys (or mules) and other livestock, serving as pens that were probably enclosed by an impermanent wooden fence. The dung was deliberately piled against the inner face of the perimeter wall, probably on a constant basis and in order to use this material as fuel (see discussion in Section 6 below). The pens and dung piles include remains of insects typical to such contexts, including thousands of pupae belonging to Musca sp., a species of house fly (identified by A. Freidberg), several husks of Trachyschema hispida, a species of the Darkling Beetle family noted for their diet of decomposing organic matter. Fig. 10. One of two crucible fragments excavated at the northern room of the gatehouse (L. 414).

Fig. 11. An intact outer part of a used tuyère found at the northern room of the gatehouse (Area GS, L. 408, B. 5356).

Fig. 12. The inner face of Site 34’s perimeter wall exposed after excavations just north of the gatehouse structure; a thick accumulation of dung mixed with small field stones was found, indicating a deliberate piling of this material against the wall (visible on the right side of the photograph); some of the massive stones of the northern platform are visible on the left side (cf. Figs. 4, 9).
2.4. Small finds

In addition to mammalian bone fragments and seeds (presented and analyzed in Sections 4 and 5 below), hundreds of various artifacts from many different categories were excavated at Area G (Table 1). These include ground stones (grinding and pounding, see Greener and Ben-Yosef, 2016 for an overview of the ground stone assemblage at the entire site), dozens of pottery fragments, metallurgical related artifacts (mostly concentrated in the northern room and nearby dung pile, see Section 2.2 above), charcoal, wood (small branches and twigs), ostrich eggshells, fish bones, molluscan shells (including cowrie [Cypraea sp.] and a few fossils), and a rich assemblage of textiles (Fig. 14) and cordage.

Other noteworthy artifacts include a complete copper-based metallic ring (16.3 mm in diameter) found in the southern pen (L. 456), seven beads (five of which came from the southern room, L. 460, B. 5388), a human molar (northern room, L. 408, B. 5373), and a well-preserved small wooden bowl made of tamarisk (62 × 34.5 × 18.8 mm, northern room (L. 408, B. 5168). In addition, dozens of rounded stones and pebbles of various types (not local to the hill) were found, probably placed at the gatehouse to be used as projectiles (possibly sling stones). These stones are varied in rock types and diameters (from 20.5 to 95 mm, most averaging at 45–60 mm) and emphasize the defensive purpose of the gate.

3. Dating

Two short-lived organic samples from the gatehouse complex were dated by radiocarbon at the Oxford Radiocarbon Accelerator Unit (ORAU) (Table 2). The samples, which represent the main activity phase in the rooms (#OxA-30698, Locus 460) and pens (#OxA-30932, Locus 410), yielded similar ages that constrain the time of activity at the gatehouse complex predominantly to the 10th century BCE (1006–917 BCE 1 sigma). These results are in agreement with the dating suggested for the entire occupation span of Site 34, namely late 11th century to around 925 BCE, when the smelting camp was abandoned probably as a consequence of Pharaoh Shoshenq I campaign to the region and re-organization of the copper production industry in the Arubah Valley (Ben-Yosef, 2016). Furthermore, it seems that the gatehouse complex was built alongside or very soon after the beginning of copper production at the site, in accordance with the assumption that the site’s location on a hill surrounded by sheer cliffs was chosen in an effort to provide defense.

4. Faunal remains (mammals)

Recording and analysis of animal remains followed the protocol outlined in Sapir-Hen and Ben-Yosef (2014). The sample was retrieved by dry and wet sieving with a 1 mm mesh. The analysis focused on taxonomic and skeletal elements abundance, both calculated as the number of identified specimens (NISP), assuming interdependence (Grayson, 1984). This quantification method was chosen as it allows for statistical manipulation. Age estimation of the faunal remains was based on epiphyseal closure stages following Zeder (2006), and was based on minimum number of elements (MNE). Species and skeletal elements frequencies were compared with the fauna from Area 19, which is dated to the same time-span as Area G. The data from Area 19 include published results from season 2013 (Area 19A, Sapir-Hen and Ben-Yosef, 2014) and new data from season 2014 (Area 19B–C) published here for the first time.

The small sample of faunal remains include large livestock animals such as cattle (Bos taurus) and donkey (Equus asinus), in addition to Caprines, of which only goat (Capra hircus) was securely identified.
Table 1 (continued)

<table>
<thead>
<tr>
<th>Locus</th>
<th>Types of finds</th>
<th>Wet sieving (1 mm mesh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>450</td>
<td>Bone, copper ore, copper prills</td>
<td>charcoal, copper ore, copper prills, drilled stone, flint, hair, hammerstone, insect remains (husk), ostrich egg shell, pottery, rope, seeds (date, grain, grape, other), slag, soil sample, textile (including cords), tuyère fragments, wood</td>
</tr>
<tr>
<td>451</td>
<td>Bone, charcoal, copper prills, flint, grinding stone, pottery, projectile stone, seeds (date, other), slag, soil sample, stone vessel (handle?), textile, tuyère, wood</td>
<td></td>
</tr>
<tr>
<td>452</td>
<td>-Feature-</td>
<td>Bones (including fish), disk bead, copper prills, seeds</td>
</tr>
<tr>
<td>453</td>
<td>Flint, pottery</td>
<td>-Wall-</td>
</tr>
<tr>
<td>454</td>
<td>Hammer stone, pottery</td>
<td>-Wall-</td>
</tr>
<tr>
<td>455</td>
<td>Wall, wall</td>
<td>-Wall-</td>
</tr>
<tr>
<td>456</td>
<td>Bone, charcoal, pottery</td>
<td>Beads, bone (including horns, hoof),</td>
</tr>
</tbody>
</table>

The assemblage included also scarce wild game animals, with cape hare (Lepus capensis) and gazelle (Gazella sp.) (Table 3). The scarce gazelle bones do not allow identification to species – mountain gazelle (G. gazella) or dorcas gazelle (G. dorcas), both inhabiting the southern Ararabah Valley (Tchernov et al., 1986). The majority of the faunal remains were found in the pens, and a smaller sample in the rooms (Table 3). Still, both contexts included a representation of livestock animals.

The species frequencies in the gate house complex differ significantly from that found in Area 19 (χ² = 14.839, p < 0.001), as the former show higher frequencies of large livestock (17% vs. 6% of total NISP, Table 4). The donkeys and cattle in the gatehouse are all adults (all epiphyses are fully fused, except for one cattle bone which also fuses at a late age [proximal femur, 3.5 years]).

Differing from the large livestock age profile, the aging profile of the Caprines (based on the epiphyseal closure, Table 5) shows that both young and adult animals were present, implying at least part of the herd was consumed at a prime age. The relatively high frequency of unfused elements is surprising, as the small sample size and the high fragmentation of the assemblage is expected to produce a bias against the identification of unfused epiphyseal elements (Lyman, 1994).

Based on the skeletal elements frequency of caprines in the 2013 assemblage from Area 19A, Sapid-Hen and Ben-Yosef (2014) demonstrated that the metalworkers engaged in direct smelting were treated with better meat than workers engaged in auxiliary activities, including food preparation and other supporting tasks. It is worth noting that the Caprines in the new assemblage from the gatehouse complex (Area G, analyzed as a whole) were found to have skeletal elements frequency similar to the contexts representing the smelters in Area 19A (termed “industrial”, χ² = 0.47, p = 0.35) and distinct from the contexts

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Fig. 14. A large piece of linen textile as found at the southern room of the gatehouse (Area G3, L. 460, B. 5277).
representing the auxiliary activities there (termed “domestic”, $\chi^2 = 3.70, p = 0.03$) (Table 6, Fig. 15).

5. Botanical remains (seeds, grains and pollen)

The excellent preservation of organic remains enabled a detailed archaeobotanical study, which is based on seeds, grains and pollen sampled during the 2014 at the gatehouse complex.

5.1. Seeds and grains

A variety of seeds and grains were collected at the gatehouse complex, some in situ and others by dry (6 mm mesh) and wet (1 mm mesh) sieving of selected loci. The cultivated species dominating the assemblage include grape (Vitis vinifera), date (Phoenix dactylifera), olive (Olea europaea) and cereal that are yet to be identified to the species level (Fig. 16). In addition, fig (Ficus carica), pistachio, and fruits of the doom palm (Hyphaene thebaica) were identified in very small numbers, which in the case of figs might be a bias of the tiny size of the seeds (smaller than 1 mm). A small quantity of yet unidentified seeds, including those of wild plants, awaits future research.

The grape seeds (pips) were found in large quantities within the dung piles, in cases within intact dung pats (of large mammals, most probably donkeys). In February 2016, several field days devoted to retrieving more grape seeds from the piles at Area GN resulted in huge quantities NISP of yet unidentifiable seeds, including those of wild plants, awaits future research. The grape seeds (pips) were found in large quantities within the dung piles, in cases within intact dung pats (of large mammals, most probably donkeys). In February 2016, several field days devoted to retrieving more grape seeds from the piles at Area GN resulted in huge quantities of yet unidentifiable seeds, including those of wild plants, awaits future research.

5.2. Pollen

Six samples were collected for palynological investigation: four were taken from the northern dung piles (Area GN, no. 1–4) and another sample was collected from the southern dung piles (Area GS, no. 5); in addition, a sample which represents the recent “pollen rain” in the studied area was taken from surface sediments of the site (no. 6 – a control sample). All ancient samples were taken only from the inner part of dung pats and decomposed dung material in order to prevent pollen contamination. Indicative dung pellets of Caprines were avoided. Sampling strategies and techniques followed the recommendations of Bryant (1974a, 1974b). Pollen extraction followed a physical-chemical preparation procedure: One Lycopodium spore tablet was added to each sample in order to calculate pollen concentrations (Stockmarr, 1971). Then, samples were immersed in HCl to remove the calcium carbonate, and then a density separation was carried out using a ZnBr2 solution (with a specific gravity of 1.95) in order to float the organic material, together with five minutes of sonication. After sieving (150 μm mesh screen) and short acetolysis, the unstained residues were homogenized and mounted onto microscopic slides using glycerin. In each sample, at least 500 pollen grains were counted and identified to the lowest possible systematic level. For pollen identification, a comparative reference collection of the Israeli pollen flora of Tel Aviv University (Steinhardt Museum of Natural History) was used, in addition to pollen atlases (e.g., Beug, 2004; Reille, 1995, 1998, 1999).

In general, pollen was well preserved in all samples from the dung material (no. 1–5), as evidenced by the relatively high pollen concentrations (ranging from 30,595 to 127,545 grains/g sediment) (Table 7). Yet, it seems that the samples from the northern dung piles (no. 1–4) are typified by higher pollen concentrations and a better state of preservation in comparison to the sample which was analyzed from the nearby Area GS (no. 5). This may explain the relatively high ratios of unidentifiable pollen grains in the latter sample (resulted mainly from degradation process). Another difference between the northern and southern assemblages is the high frequencies of spores which appear only in sample no. 5.

All archaeological samples (no. 1–5) are dominated by cereal pollen type (87.1–97.0%), which unfortunately was impossible to distinguish to the species level. The control sample, which represents the recent “pollen rain” (no. 6), includes, in addition to desert elements, neophytic trees (Eucalyptus spp. and Casuarina spp.), which were mainly introduced to this region during the previous century, as well as some planted trees such as Mediterranean cypress. This control sample is characterized by low pollen concentrations (1933 grains/g sediment) and very high ratios of unidentifiable pollen grains (52.8%), supporting...
our results that the samples from the archaeological context (no. 1–5) are very well preserved.

6. Discussion: a new dimension of Iron Age metalworkers community

While previous research in the Timna Valley focused predominantly on metallurgical technologies (e.g., Bachmann, 1980; Conrad and Rothenberg, 1980; Rothenberg, 1990) and on chronology (e.g., Ben-Yosef et al., 2012; Merkel and Rothenberg, 1999; Rothenberg and Glass, 1992; Rothenberg, 1999a, 1999c), many aspects of the societies operating the copper mining and smelting sites were little investigated and very few publications were dedicated to material culture that is not directly related to mine excavation and furnace operation (including pottery). The new excavations at Site 34 provide an opportunity to study various different aspects of the society operating one of the largest copper smelting camps in the region (Ben-Yosef, 2016). The results of the 2014 excavations in one of the main areas (Area G) are reported on here, and include substantial amount of new materials of various categories, most notably organic remains that are extraordinarily well preserved. The latter provide a rare window into different facets of past lives that are inconspicuous in most archaeological sites, including the extensively investigated copper production sites of Faynan in the northern Arabah Valley where only charred materials were found (Hauptmann, 2007; Levy et al., 2014a).

The organic remains, which provide insights into the diet of the site’s inhabitants and trade connections, should be examined against the extreme climate conditions that characterize Timna (Fig. 17). The region is inhospitable for human existence, with the closest permanent water source located >15 km away at the oasis of ‘Aid Ghadian (Yotvata). Receiving about 30 mm average annual rainfall (but erratic and unpredictable, Bruins, 2006) there is no possibility for any kind of agriculture or horticulture in the region. Its location deep within the Saharo-Arabian desert zone suggests that the Timna Valley was less susceptible to small scale climate changes, and our underlying assumption is that Iron Age environmental conditions were the same as of today (cf., Langgut et al., 2013).

The majority of the organic remains from Area G are associated with pens flanking a gatehouse structure at the entrance complex to the smelting camp. The identification of these areas as pens (or stables) for keeping donkeys and other livestock is supported by the massive amount of dung and the bone assemblage. Adult donkeys (or mules) and cattle (probably oxen) that were found in the pens were most

Table 5
Faunal remains: Fused and Unfused Caprine Bones from Area G; epiphyseal closure stages following Zeder (2006).

<table>
<thead>
<tr>
<th>Stage</th>
<th>Age (months)</th>
<th>Fused</th>
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<th>%f</th>
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<tr>
<td>a</td>
<td>0–6 m</td>
<td>Proximal radius</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>b</td>
<td>6–12 m</td>
<td>Dist humerus</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>b</td>
<td>6–12 m</td>
<td>Pelvis</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>b</td>
<td>6–12 m</td>
<td>Scapula</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Total 6–12 m</td>
<td></td>
<td></td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>c</td>
<td>12–18 m</td>
<td>1st phalanx</td>
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<td>1</td>
</tr>
<tr>
<td>c</td>
<td>12–18 m</td>
<td>2nd phalanx</td>
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<td>0</td>
</tr>
<tr>
<td>d</td>
<td>18–30 m</td>
<td>Distal tibia</td>
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</tr>
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<td>d</td>
<td>18–30 m</td>
<td>Distal mep</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total 12–30 m</td>
<td></td>
<td></td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>e</td>
<td>30–48 m</td>
<td>Calcaneus</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>e</td>
<td>30–48 m</td>
<td>Prox femur</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>e</td>
<td>30–48 m</td>
<td>Dist femur</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>e</td>
<td>30–48 m</td>
<td>Dist radius</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>e</td>
<td>30–48 m</td>
<td>Prox tibia</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>e</td>
<td>30–48 m</td>
<td>Prox ulna</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>f</td>
<td>48 m+</td>
<td>Prox humerus</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Total 30 m+</td>
<td></td>
<td></td>
<td>2</td>
<td>4</td>
</tr>
</tbody>
</table>

Table 6
Faunal remains: skeletal elements frequencies (NISP) of Caprines from Area G.

<table>
<thead>
<tr>
<th>Element</th>
<th>NISP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carpal - magnum</td>
<td>1</td>
</tr>
<tr>
<td>Femur</td>
<td>5</td>
</tr>
<tr>
<td>Horn</td>
<td>3</td>
</tr>
<tr>
<td>Humerus</td>
<td>6</td>
</tr>
<tr>
<td>Mandible</td>
<td>3</td>
</tr>
<tr>
<td>Mandibular tooth</td>
<td>5</td>
</tr>
<tr>
<td>Metacarpal</td>
<td>4</td>
</tr>
<tr>
<td>Metapod</td>
<td>1</td>
</tr>
<tr>
<td>Metatarsal</td>
<td>4</td>
</tr>
<tr>
<td>Pelvis</td>
<td>5</td>
</tr>
<tr>
<td>1st phalanx</td>
<td>4</td>
</tr>
<tr>
<td>2nd phalanx</td>
<td>3</td>
</tr>
<tr>
<td>3rd phalanx</td>
<td>1</td>
</tr>
<tr>
<td>Radius</td>
<td>2</td>
</tr>
<tr>
<td>Rib</td>
<td>19</td>
</tr>
<tr>
<td>Scapula</td>
<td>3</td>
</tr>
<tr>
<td>Skull fragment</td>
<td>1</td>
</tr>
<tr>
<td>Tarsal - astragal</td>
<td>2</td>
</tr>
<tr>
<td>Tarsal-calcanus</td>
<td>1</td>
</tr>
<tr>
<td>Tarsal - external cuneiform</td>
<td>1</td>
</tr>
<tr>
<td>Tarsal - internal cuneiform</td>
<td>1</td>
</tr>
<tr>
<td>Thoracic vertebra</td>
<td>4</td>
</tr>
<tr>
<td>Tibia</td>
<td>7</td>
</tr>
<tr>
<td>Lower limb shaft</td>
<td>1</td>
</tr>
<tr>
<td>Vertebral</td>
<td>3</td>
</tr>
</tbody>
</table>
probably used as beasts of burden. It is reasonable to assume that these animals, which were a key component in the operation of the copper production system, were not allowed to wonder around the smelting camp and thus were kept in close proximity to the gate. Furthermore, the analysis of the bone assemblage demonstrates that the frequency of large livestock (donkeys and cattle) at the pens is considerably higher than the late 10th century BCE.

Keeping in mind the unique characteristics of Site 34, which is an industrial site devoted to copper smelting (Ben-Yosef, 2016), the identification of the pens/stables is reinforced and their location is better understood: while the site has abundant metallurgical remains, including furnaces and designated places for ore and slag processing, there is very little evidence of domestic activities such as dwelling and cooking. This and other evidence at the site suggests that the metalworkers dwelled in tents below the hill, and that the hilltop was kept for the various activities related to smelting (cf., Ben-Yosef, 2010). Fundamental component of the site maintenance was the constant transportation of copper ore and other numerous supplies needed for the successful production (including materials such as charcoal, clay, water, food, and large quantities of heavy ground stones; for the latter see Greener and Ben-Yosef, 2016; and see general experimental data in Merkel, 1990). It is therefore clear that draught animals played a major role in the operation of the site, and that contra to agrarian villages where livestock were stored in domestic units, here the preferred location for their stables would have been near the gate to the complex (above). Furthermore, although other waste materials are mixed within the dung piles (such as ground stones and textile fragments), their amount is negligible in relation to the dung and they do not allow an interpretation of a garbage disposal area for the entire site; rather, these artifacts should be interpreted as directly related to the activity at the gatehouse and its rooms, of which the dung piles served as a midden. Moreover, some of the textile fragments from this context are possibly related to the draught animals themselves, including remains of saddles and even adornments (this intriguing interpretation awaits further research on the textile assemblage).

For the Iron Age southern Levant, the pens (or donkey stables) at Site 34 are first direct evidence of keeping draught animals and other livestock in a gatehouse complex. This is probably the result of preservation, as their identification is based on organic remains that are rarely found. The pens were probably fenced by an impermanent wooden construction where they were not bordered by the site's perimeter wall and the gatehouse structure. They required regular maintenance, which in addition to feeding the animals – for the latter see Greener and Ben-Yosef, 2016; and see general experimental data in Merkel, 1990). It is therefore clear that draught animals played a major role in the operation of the site, and that contra to agrarian villages where livestock were stored in domestic units, here the preferred location for their stables would have been near the gate to the complex (above). Furthermore, although other waste materials are mixed within the dung piles (such as ground stones and textile fragments), their amount is negligible in relation to the dung and they do not allow an interpretation of a garbage disposal area for the entire site; rather, these artifacts should be interpreted as directly related to the activity at the gatehouse and its rooms, of which the dung piles served as a midden. Moreover, some of the textile fragments from this context are possibly related to the draught animals themselves, including remains of saddles and even adornments (this intriguing interpretation awaits further research on the textile assemblage).

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cooking ovens is known from ethnography (e.g., Gur-Arieh et al., 2013; Portillo et al., 2016) and the archaeological record (Gur-Arieh et al., 2014); at Site 34 it is likely that the dung was used predominantly as part of the metallurgical industry. This included the preliminary heating of smelting furnaces, a process that could take up to an hour during which a temperature of at least 1200 °C was reached (the main smelting phase required charcoal, e.g., Rehder, 2000), the firing of clay-based installations and artifacts (e.g., tuyères) and secondary metallurgical activities such as refining and melting of raw copper.

The analysis of pollen from the dung piles provides information on the food of the livestock. The pollen assemblage, which came from within the animal dung, has a dominance of cereals which strengthens the notion that the pollen spectrum represents the diet of animals which were fed (a typical palynological spectra which derive from human feces are much more diverse, see e.g. Deforce, 2010; Langgut et al., 2016). The frequencies of cereal pollen in all ancient samples (#1–5, Table 7) was high (87.1–97.0%). Most cereals are self-pollinated, thus a large number of pollen grains are found in the hulls (Deforce, 2010 and references therein). Therefore, high values of cereal pollen are common in cess deposits and are explained by the consumption of cereal-based food (Deforce, 2010; Langgut et al., 2016). Within the Timna dung deposits, the high ratios of cereal pollen most probably indicates that the donkeys (and/or other livestock) were fed with hay rather than straw. The former is considered as a superior animal food since it involves most of the cereal organs including the inflorescences and the grains which have high nutrition values, and not only the stems,
as in the case of straw. The occurrence of a cereal pollen clump which is composed of 20 grains (in sample no. 1), also suggests that the entire inflorescence was eaten (pollen grains are attached to one another in the flower source). The cereals were most probably cultivated in the Mediterranean regions, demonstrating the complexity of the production system and the invested efforts in long distance transportation and probably trade.

The other components within the palynological assemblage seem to originate from two different regions: (i) pollen which originated in the Mediterranean zone and penetrated into the assemblages probably from the nearby vegetation which surrounded the fields where the cereals were cultivated (e.g. *Pinus*), or from other diet components which also originated from Mediterranean regions (e.g. *Vitis*); (ii) pollen which represents the plants that grew in the vicinity of Timna. These types of pollen grains could have settled on the hay during the feeding process, accidentally been inhaled, or been trapped in drinking water sources (e.g., Langgut et al., 2016). This group therefore represents a natural “background” spectrum. The presence of desert elements within this group (e.g. *Acacia*, different types of chenopods, *Artemisia, Helianthemum*) supports our assumption that during the early Iron Age an arid environment – similar to today’s – characterized the immediate vicinity of Timna.

The hundreds of seeds found within the dung in the pen areas also provide insight into the livestock feed. In particular, we suggest that the large amount of densely scattered grape seeds (pips) within the decomposed dung indicates that the large livestocks were fed with grape pomace. The use of wine production’s waste as livestock feed is a well-known practice today (e.g., Famuyiwa and Ough, 1982; Riedel et al., 2012). Many modern wineries supply grape pomace to animal farms (the Agur Winery in the Judean Mountains is an example from one of the possible regions from which grape pomace was transported to Timna) and even specifically to caravans of donkeys (e.g., in the Swiss Alps, A. Nushaum, pers. comm. 2016). This practice also has some evidence in historical sources, most notably in Columella’s writings on the agriculture of the Roman Empire (1st c. CE). In his book *On Husbandry (De Re Rustica)* Columella describes the diet of oxen, which

“is regulated according to the time of year […] Mix with their chaff grape skins taken from the after-wine which have been washed and dried; but there is no doubt that it is far better to give them the grapemash, skins and all, before they have been washed, for they contain the strength both of food and of wine and make the cattle sleek and of good cheer and plump” (Book VI, Chapter III; we thank C. White for this reference).

In the archaeological record, direct evidence for grape pomace as livestock feed is extremely rare, probably as a result of preservation rather than the frequency of the practice. Early evidence from the southern Levant possibly comes from the Early Bronze Age III (3rd millennium BCE) site of Numayra on the eastern coast of the Dead Sea, where goat’s dung mixed with (carbonized) grape seeds was found (M. Chesson, pers. comm. 2016).

The substantial investment in the donkey feed is not surprising given the major role of this draught animal in the logistically challenging production system. Based on his research at the turquoise mines of Serabit el-Hadim in the Sinai Peninsula, Petrie (1906:119) provides an insightful reconstruction of the role of donkeys in a similar setting of mining activities in a remote desert location. According to him, each of the Egyptian expeditions to the mines included a “full train of 500 asses […] each carrying its own food and water and supplies for one man for three days”, and that the maintenance of the mining camps also required constant use of donkeys. This maintenance was calculated for 500 men and 500 donkeys (a reasonable number also for the operation of Site 34) as following:

“Each man requiring 3 lb. of supplies and each ass 15 lb. daily […] thus nearly 5 tons a day of food. Such would form 50 ass-loads; and as the round journey from the coast to Serabit and back would take five days, this would mean that 250 asses would keep up the whole food supply from the coast. Water might be put at 4 gallons each, but a larger allowance is more likely. Thus and ass would carry enough for three men; and so, if a single round to water was made each day, then 200 asses would be required to keep up the water-supply. This leaves 50 out of 500 as a margin of sickness and delays” (Petrie, 1906:119).

Petrie’s estimates are based on Egyptian inscriptions and on his own experience with donkey caravans. The operation of Site 34 probably kept up much on these lines, although necessarily with additional water supply for the maintenance of the smelting operation, which requires water for (constant) construction of metallurgical installations, including furnace walls and tuyères. The nearest water source to Timna, the ‘Aid Ghadian oasis (Fig. 17), also requires a (long) day of round trip (ca. 30 km), unless the caravans camped there.

Other supplies for Timna had to be transported from much longer distances. The hay and grape pomace, as well as all of the fruits and grains identified at Area G (except dates, which grow at the Oases of the Arabah Valley) point to regions of Mediterranean climate (Fig. 17). The nearest such areas are located ~100 km to the northeast (Edom) and 200 km to the north (Philistia-Judea). Based on evidence that connects the Iron Age society in Timna to the early Edomite polity which developed around Faynan (Levy et al., 2014b), it is possible that many of the supplies came from the Mediterranean strip of the northern Edomite Mountains, including the fruits and grains, the livestock and more. However, other evidence, including a Mediterranean fish bones assemblage (Sapir-Hen et al., in press) and high quality textiles (including linen, Workman, 2016), demonstrates that the supply for Timna was based on a more complex trade system that necessarily involved (direct or indirect) connections with the Mediterranean coast and probably with other regions as well.

The results of the excavations at the gatehouse complex of Site 34 also provide insights into the role of the gatehouse in the operation of the smelting camp. There is no doubt that the gatehouse was part of a defensive system of the site (contra Glueck (1935) who considered these elements as means to enclose forced laborers), as is also evidenced by the site’s location on top of an almost inaccessible mesa and its substantial perimeter wall. The contemporary wall at Site 30 in Timna and the massive fortress at Khirbat en-Nahas in Faynan (73 × 73 m, Levy et al., 2014b) further demonstrate the need for defense in the Arabah’s mines during the 10th c. BCE. While there is no direct evidence for an active battle at the site (except possibly the projectile stones uncovered at the gatehouse), nearby polities most probably posed a serious threat to the copper production enterprise, which was one of the most lucrative industries of the time with a highly desired product (at the 10th BCE bronze was still the dominant metal for weapons and agricultural tools, Gottlieb, 2010; Yahalom-Mack and Elyahu-Behar 2015). One of these polities might have been the Kingdom of Israel at the days of the United Monarchy. The Old Testament describes a battle between the army of King David (early 10th century BCE) and the Edomites in the Arabah Valley, and the establishment of Israelite garrisons there (2 Samuel 8: 13–14). Although the historicity of this description is highly debated (e.g., Levy and Higham, 2005 and references therein), if the story is based on historical events it should be understood in light of the new evidence from the region, including Site 34 and its defensive system presented here.

In relation to its role in the site’s defensive system, the prominent structure of the gatehouse had a deterrent function, as it was an impressive landmark visible to long distances within the Timna Valley. As mentioned above, the activities conducted at the site were primarily industrial, while domestic ones and the workers’ dwellings (including the miners and other people) were based in the wadis below the hill (Ben-Yosef, 2016). Therefore, the gatehouse was part of a segregation system within the society operating the copper production enterprise,
separating between the people working on the hill – which engaged in one of the most advanced technologies of the time and possessed the coveted technological know-how – and the rest of the population (probably excluding times of war). The metalworkers, and in particular the furnace operators, constituted the higher ranks of society together with the ruling elite (Sapir-Hen and Ben-Yosef, 2014), and were treated accordingly with best foods and high quality clothing (Workman, 2016). The occupants of the gatehouse itself seem to have enjoyed a similar high social status, as evidenced by the rich diet of fish, fruits and meat, the latter demonstrates high frequency of the best meat accordingly with best foods and high quality clothing (Workman, 2016).

The gatehouse complex also had an important administrative function regulating traffic at the entrance to the site, including tracking incoming supplies and outgoing final products (i.e., copper ingots). Furthermore, in many contemporary gatehouse structures the administrative activities were accompanied by symbolic and cultic ones (Blomquist, 1999; Frese, 2012). At the gatehouse of Site 34, this aspect might be evidenced by the “seat” unearthed at the passageway (Section 2.2 above), and also by the metallurgical remains unearthed at the northern room. The latter include rare fragments of crucibles that indicate secondary metallurgical activities, probably refining (by melting) of raw copper, and production of final metal ingots (or possibly artifacts). The location within a small room at the very entrance to the site suggests that this was a cultic metallurgical activity, done on a small scale, rather than an integral component in the large scale production of ingots at the site (and see Rothenberg, 1999b for similar finds at the Hatzor Temple in Timna and discussion on cultic metallurgy). This interpretation is strengthened when taking into account the symbolic and cultic meaning attested to engagement with molten metals in various archaeological, historical and ethnoarchitectural records (e.g., Eliade, 1978).

7. Conclusions

The results of excavations in the gatehouse complex of one of the largest smelting camps in Timna Valley provide various new insights on the early Iron Age (10th c. BCE) copper production system and the society behind it. The two-room gatehouse was a prominent landmark and used for defense and deterrence, indicating a period of instability and military threats. The gatehouse complex included pens (or donkey stables) for keeping draught animals and other livestock, which were fed with hay and grape pomace, high quality foods that had to be brought from the Mediterranean region at a distance of >100 km. Other finds from the gatehouse excavations, such as fruits and cereal, fish bones, textile (linen) and more, indicate a complex long-distance trade system that probably included the northern Edomite plateau, the Mediterranean coastal plain (Philistia) and Judea (with no decisive evidence for connections with Egypt).

Some of the finds at the gatehouse suggest that it had cultic or symbolic function in addition to its defensive and administrative roles. These include metallurgical activities such as small scale copper melting and casting conducted at the northern room, and possibly the worshiping of standing stones (massaboth). These activities are in accordance with the high social status of the gatehouse occupants, as evidenced by the high quality of their diet and clothing.

In summary, the synthesis of results from several research avenues (field archaeology, faunal and botanical) widens our understanding of copper production in Timna beyond issues of chronology and technology, which were the focus of most previous studies. The newly excavated materials from the region (Ben-Yosef, in press) provide a basis for other studies of the society(-)es of Timna; furthermore, the extraordinary preservation of organic finds provide a unique window into aspects of the past that are typically inconspicuous in common archaeological practice, and call for exploration of innovative research methods, such as ancient DNA (cf., Baciери et al. 2016) and more.

Acknowledgments

We wish to thank the field supervisors of Area G, William Ondricek and Ilana Peters, for their devoted work during the 2014 season. We also thank the CTV staff and volunteers and the Timna Park management for their invaluable help during excavations. We thank in particular U. Avner for the help with aerial photography, V. Epstein for her technical help in the palynology laboratory, M. Cavanagh for his assistance to the field supervisors and the preliminary documentation of the seed assemblage and M. Cheson and C. White for sharing their knowledge on ancient use of pomace as livestock feed. The excavations at Timna Site 34 were supported by the Marie Curie FP7-PEOPLE-2012-CIG grant #334274 to E. Ben-Yosef. D. Langgut acknowledges the support of the Israel Science Foundation grant no. 2141/15.

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