

# Copper Among the Nomads: Early Bronze Age Copper Objects from the Camel Site, Central Negev, Israel

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## Introduction

The origins and development of copper metallurgy in the Southern Levant have been the subject of intensive research for several decades. Focusing on Chalcolithic and Early Bronze Age copper metallurgy, researchers have conducted a range of analyses designed to address issues as diverse as technology and its evolution (e.g., Golden 1998; Merkel & Rothenberg 1999; Shalev 1994; Shalev & Northover 1987; Rothenberg & Glass 1992; Rothenberg & Merkel 1998; Key 1980; Potazkin & Bar-Avi 1980), sources of raw materials (Shalev *et al.* 1992; Tadmor *et al.* 1995; Shugar 2001), utilitarian function (Moorey 1988), ideological aspects (e.g., Levy 1995), and socio-economic role (Shugar 2001; Levy & Shalev 1989; Golden 1998). Although obviously, and of necessity given the peripheral source areas, a significant trade good, little attention has been directed toward the systematic reconstruction of trade systems for early copper (but see Tadmor *et al.* 1995). The underlying assumption of most studies has been that copper was the focus of directed trade originating in early market or redistributive centres (e.g., Kempinski 1989; Ilan & Sebbane 1989).

The discovery and analysis of seven small copper objects from the Early Bronze I-II Camel Site, in Mitzpe Ramon in the Central Negev, adds a new perspective to our understanding of early copper production, distribution and consumption systems. The Camel site materials represent a pastoral nomadic complement to the centralized system based in the large sedentary settlements of the agricultural heartland. Beyond the simple presence of copper, and its obvious implications in terms of nomad participation in the copper trade, composition analysis of the objects also reveals a far more complex system than might have been expected. In general, the Camel materials suggest that the copper trade encompassed a range of trade systems beyond the focused and directed exchange usually assumed.

## The Camel Site

The Camel Site (Rosen 2003) is a small encampment, ca. 400 sqm in area, situated some 200 m north of the Makhtesh Ramon (Crater), the largest of the three erosional cirques in the Central Negev (Fig. 1). Architecturally the site is comprised of two irregularly shaped enclosures abutting one another with smaller rooms attached to the periphery (Fig. 2). This general pattern of enclosure and attached rooms, reflecting pastoral pen and hut compounds, is typical of the Early Bronze Age in the southern Levantine deserts (e.g., Rosen 2002; Haiman 1992; Henry 1992; Kozloff 1981; Beit Arieh 1986). Four cairns are located just outside the building remains and a fifth is integrated into the compound structures.

The material culture assemblage recovered from the Camel Site is varied, including a large lithic assemblage of waste and formal tools (greater than 25,000 artefacts), ceramics, copper items, haematite, quartz crystals, seashells and

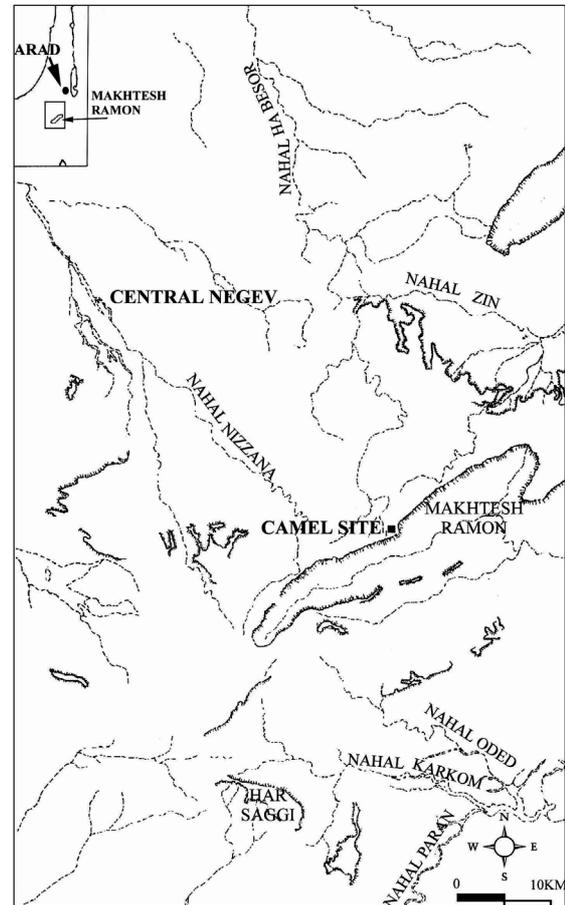


Fig. 1. Map of region showing location of Camel Site.

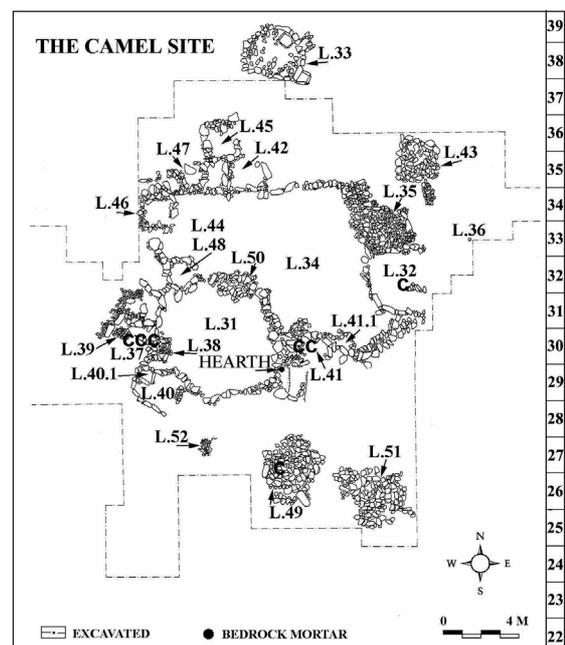


Fig. 2. Plan of Camel site showing find locations of copper artifacts. C=copper artifact.

seashell beads, three obsidian flakes, originating in eastern Turkey (Rosen *et al.* 2005), ostrich eggshell fragments and beads, and millstones with debris from their manufacture (Rosen 2003; Abadi 2003). The ceramic assemblage included primarily holemouth cooking and storage wares, and the lithic tool assemblage most notably included microlithic drills, microlithic lunates (= transverse arrowheads), tabular and other scrapers, blade tools including a few rare sickles, and *ad hoc* elements. With the exception of a few sherds attributable to the Intermediate Bronze Age (= Early Bronze IV = Middle Bronze I, c. 2000-2200 BC), the entire material culture assemblage accords well with an Early Bronze Age I-II attribution. This matches radiocarbon determinations of  $4115 \pm 50$  BP (RT-2043) calibrated (1 sigma) to 2860-2580 BC (with a higher probability of the date falling in the earlier part of the span) and  $4345 \pm 65$  BP (RT-3083) calibrated (1 sigma) to 3080-2880 BC. Two additional dates were aberrant.

As indicated by the material culture and the radiocarbon dates, the site is basically a single period occupation with later ephemeral presence at the end of the 3rd millennium BC. Stratigraphically it was excavated in three units, the surface layer, an upper yellow loess, and a lower organic horizon consisting of a mixture of the yellow loess and grey ashy matrix. The lower horizon was found only in the enclosures and has been interpreted to be a degraded dung layer. The large size of the material culture assemblage, and the consensus view that the Negev Early Bronze Age is a pastoral nomadic society, suggests that the site formed over the course of seasonally repeated occupations.

## The Objects

Seven copper objects were recovered all from around the periphery of the central pens of the site (Fig. 2). Two were awls, one (P30a) with a square section (Fig. 3C), and the second (Q30b-1) strongly corroded with only a small core preserved (Fig. 3A). The remaining pieces were small lumps,

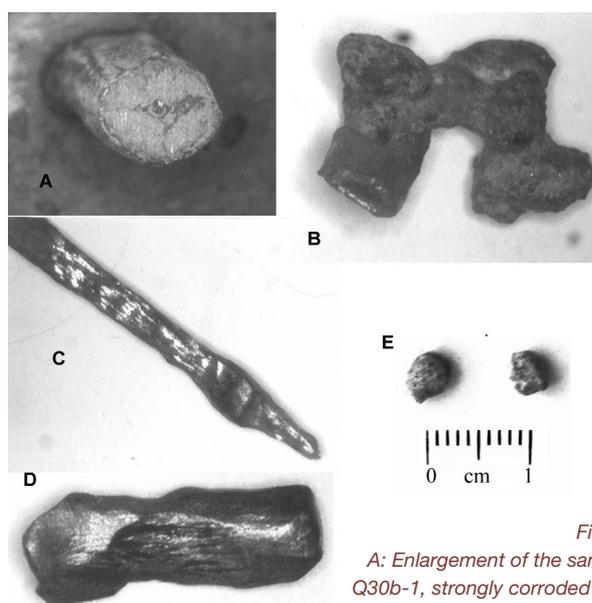


Fig. 3.

A: Enlargement of the sample Q30b-1, strongly corroded awl.

B: Enlargement of the sample Q30b-2, copper lump/prill.

C: Enlargement of the square section awl, P30a.

D: Enlargement of the copper lump, I32c.

E: Prills, L30c-1, M26b.

three classifiable as prills (Q30b-2 (Fig. 3B), L30c-1 [black, very porous] (Fig. 3E), M26b [reddish yellow] (Fig. 3E), one a fragment of a manufactured item (I32c) (Fig. 3D), and the final piece, a discard from casting (L30c-2 [black, very porous]). The goals of the physical analysis were to define the metallurgical composition, the technological processes, and, if possible on the basis of the chemical and metallurgical study, to define the objects functionally/topologically.

## Analytic Procedure and Sample Preparation

Major, minor, and trace elements were determined by Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES). Drillings from each cleaned sample were removed for chemical analysis. After acid dissolution, fifteen elements were determined using the procedure described in Segal *et al.* (1994). The elements determined and their limits of detection are listed in Table 1.

Table 1: Limits of detection (LOD) of determined by ICP-AES elements. The sample size was 25 mg dissolved in 25 mL, so dilution factor was 1000.

Element	Wavelength, nm	LOD, ppm
Sn	189.980	349.0
As	193.699	31.0
Mo	202.030	10.0
Zn	206.200	2.6
Pb	220.353	22.0
Co	228.616	5.7
Cd	226.502	1.7
Ni	231.604	11.0
Au	242.795	3.5
Mn	257.610	0.7
Fe	259.940	8.3
Cr	267.716	2.0
V	310.230	3.5
Cu	324.754	0.7
Ag	338.289	1.2
Sb	206.833	17.0

The samples were then sectioned, mounted in resin, and polished. The structure of polished and etched sections from the objects was studied using a metallurgical microscope. Microstructure and composition of local inclusions were analyzed by SEM-EDS with Back Scattered Electron Detector (BSE). The etching solution consisted of 120 ml H<sub>2</sub>O, 50 ml HCl and 5 g FeCl<sub>3</sub>.

## Chemical composition

The chemical composition of the samples is given in Table 2. The data indicate that all the objects except awl P30a are made of more or less pure unalloyed copper. Samples Q30b-2 and M26b are similar by their relatively high iron content (1-1.5% Fe), samples Q30b-2, M26b and L30c-2 by their sulphur content (0.6-1% S), and samples P30a and I32c by their nickel content (0.024-0.026% Ni).

Table 2: Chemical Composition of Cu-objects from Camel Site, in wt %. Sn, Mo, Au, V were not detected (nd).

Description	Cu	Fe	As	Sb	Zn	Pb	Co	Ni	Cd	Mn	Cr	Ag	S
Q30b-1,awl corroded	85.5	0.06	nd	nd	nd	nd	nd	0.004	nd	0.001	0.010	0.01	nd
Q30b-2 copper lump	94.0	1.42	0.01	nd	0.38	0.08	0.022	0.062	nd	0.049	0.015	0.13	1.0
P30a awl	86.6	0.48	3.44	0.2	nd	0.06	0.007	0.026	nd	nd	0.002	0.02	2.5
I32c copper lump	95.7	0.07	0.02	nd	nd	0.10	0.005	0.026	nd	0.001	0.015	nd	nd
M26b copper lump	97.0	1.5	0.01	nd	nd	0.04	nd	0.004	nd	0.008	nd	0.02	1.0
L30c-1 copper sulphide lump	68.0	1.0	0.02	nd	0.03	0.06	0.010	0.024	0.04	0.003	0.006	0.04	17
L30c-2 copper oxide lump	80.0	0.20	nd	nd	0.06	0.03	nd	0.004	nd	0.001	nd	nd	0.6

Sample L30c-1 stands out. Although similar to Q30b-2 and M26b by iron content and to samples P30a, I32c by nickel content, it contains 17% S, typical for copper sulphide prills in smelting slags. Thus, it is not a metal piece, but matte, an intermediate product of copper smelting.

Sample L30c-2 underwent refining, perhaps achieving a high level of purity during the casting process. The grain structure suggests casting without additional treatment. It may be a casting discard.

Two samples are made from more varied copper metal. Sample Q30b-2 contains some zinc, cobalt, nickel, manganese and silver, and the awl P30a is made of arsenical copper. It contains 3.44% As, 2.5% S and 0.2% Sb. These elements can be present together naturally, but may also reflect intentional alloying. Sample Q30b-1, the second awl, was strongly corroded, but seems to be made of pure copper.

## Metallography

Samples were studied both in a polished state and after etching. In general, two types of structures could be identified, cast objects and objects further worked after casting.

**Sample Q30b-1.** This awl was strongly corroded and it was impossible to see its structure.

**Samples Q30b-2, M-26b and L30c-1.** Equiaxial grain structure with  $\text{Cu}_2\text{O}$ -Cu eutectic can be seen in Figs. 5 and 6. There are no traces of grain deformation. Presence of copper-iron oxide and sulphide inclusions in two first samples and copper sulphide matrix with iron sulphide inclusions in the last sample suggests that these copper prills were collected during the smelting. Sample Q30b-2 reveals grain structure in polished state. It contains  $\text{Cu}_2\text{O}$ -Cu (eutectic areas) and round and elongated copper sulphide inclusions. In sample M-26b round copper sulphide and copper-iron sulphide inclusions were observed (Fig. 4).

**Sample P30a.** This square-sectioned awl reveals heavily deformed grains (see Fig. 7). It underwent numerous episodes of heating and hammering. Finally the metal was annealed. Straight annealing twins can be seen at higher magnification (Fig. 8). Grain size is 0.015 mm, suggesting an annealing temperature of not more than 400 °C.

**Sample I32c.** The structure of this sample indicates it to be a part of a manufactured object. The elongated form of copper-iron sulphide inclusions and corrosion cracks shown in

Figs. 9 and 10 is a result of the several episodes of heating and hammering. Equiaxial non-deformed grains with straight twin lines suggest full recrystallization with the final

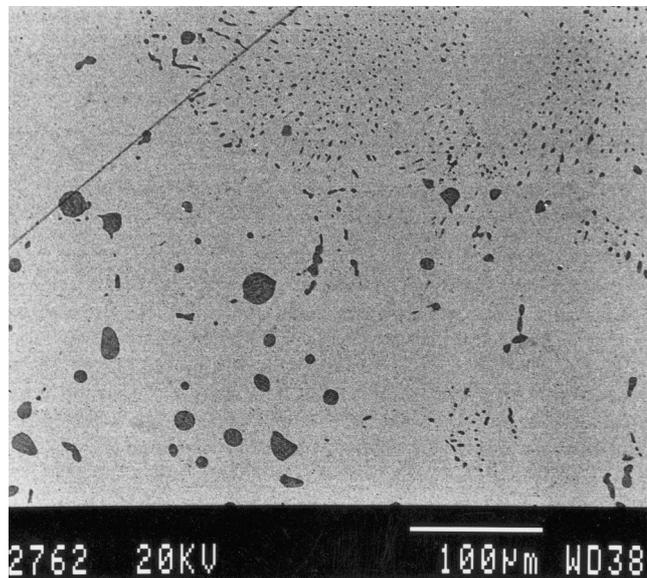


Fig. 4. BSE image of the sample M26b in polished state showing  $\text{Cu-Cu}_2\text{O}$  eutectic black spots and black copper-iron oxide and gray copper-iron sulfide inclusions.

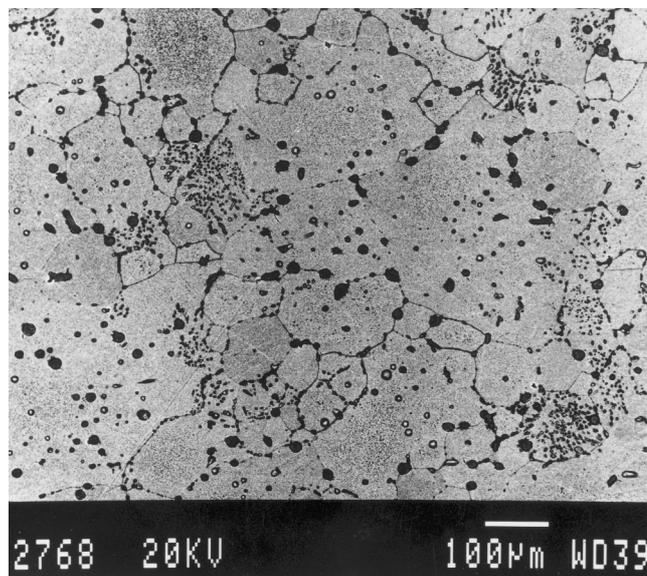


Fig. 5. Etched surface of the M26b sample showing equiaxial grain structure with numerous copper-iron oxide and sulfide inclusions (black spots).

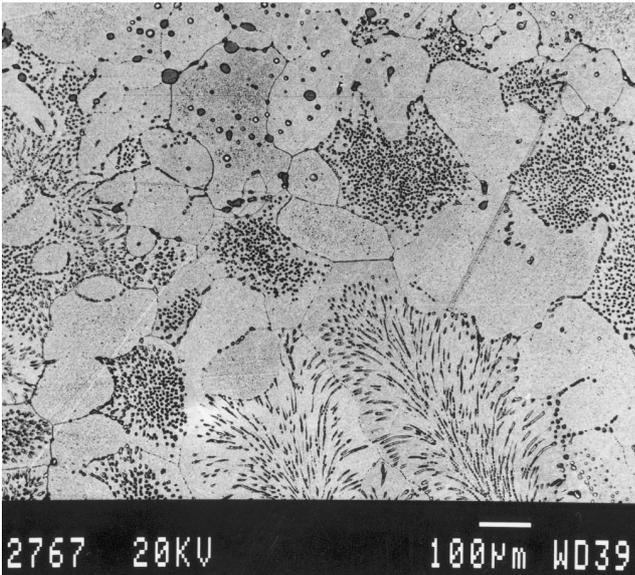


Fig. 6. Enlargement of Fig. 5.

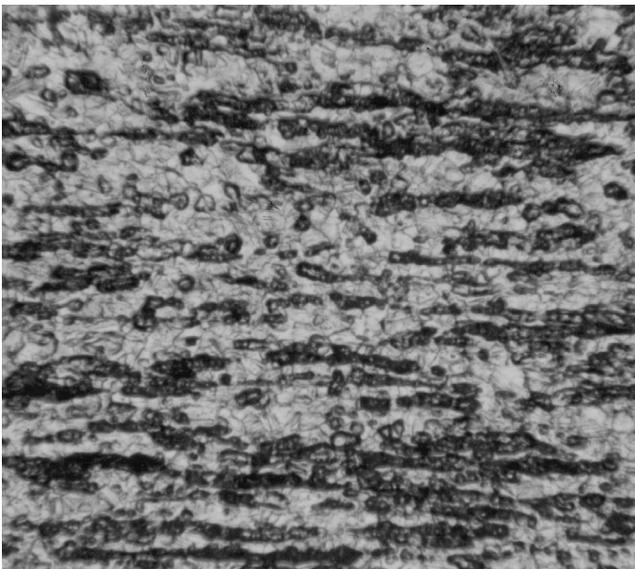


Fig. 7. Etched surface of the awl P30a showing strongly deformed structure. Elongated form of inclusions is result of hammering, x250.

Fig. 8. Enlargement of Fig. 7, showing grain structure with annealing twins, x625. ↓

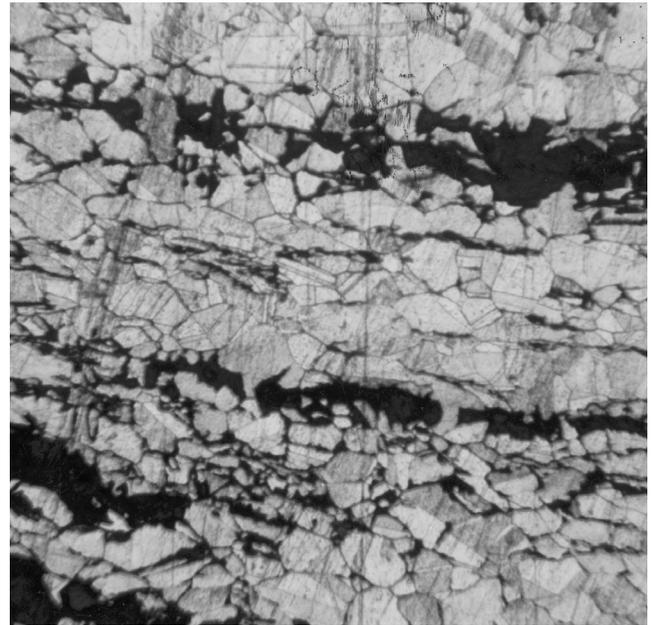
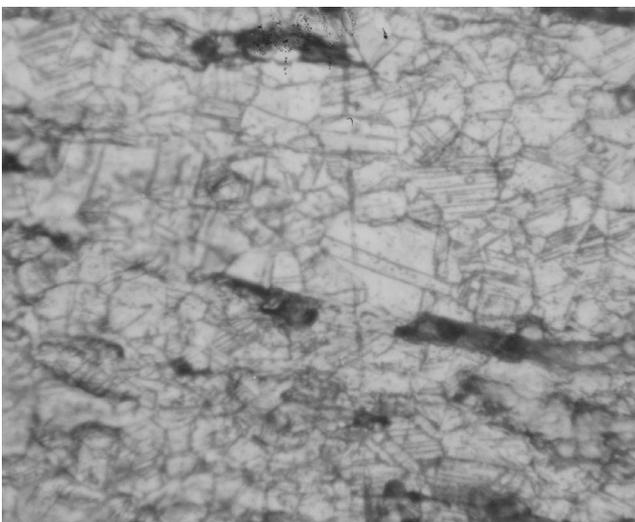


Fig. 9. Etched surface of the copper lump I32c. Elongated form of copper-iron inclusions and corrosion cracks suggests hammering, straight twins on the grains show final annealing, x125.

annealing procedure. Grain size is 0.06 mm, indicating that annealing temperature was about 500 °C. The sample contains copper chloride inclusions (result of corrosion) along the grain boundaries.

**Sample L30c-2.** The grain structure and rather pure copper (oxidized probably due to corrosion over time) suggest that it was collected as a casting discard and transported to the site.

## Discussion

The variability in composition and structure of the seven copper objects from the Camel Site reflects a surprising

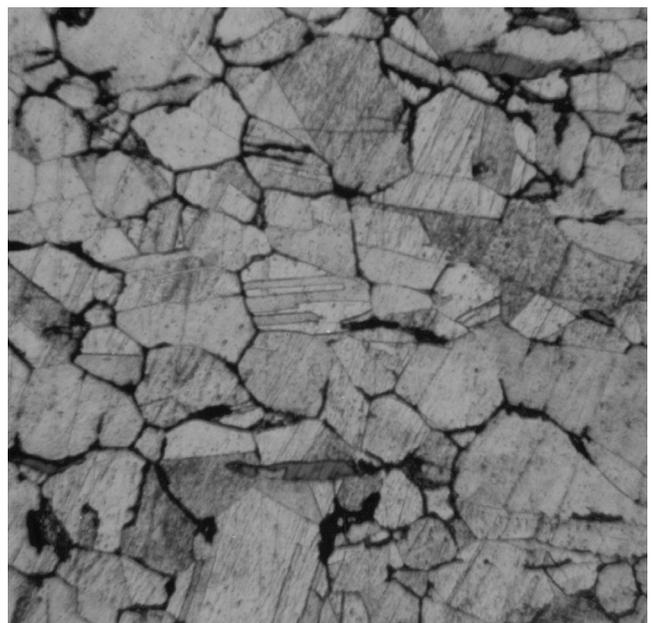


Fig. 10. Same as Fig. 9 with large magnification, showing equiaxial grains with twins and elongated intergranular copper sulfide inclusions, x250.

breadth in the technological range and configuration of the desert copper system. This can be summarized as follows:

The arsenical copper awl P30a reflects either the deliberate alloying of copper with sulfidic ores containing arsenic (e.g., Lechtman & Klein 1999), or the selection of copper-arsenical sulfidic ores. This either suggests two production processes, one with alloying and one without, or two separate sources of copper (or both). Significantly, it contrasts with the second awl (Q30b-1), of pure copper and clearly not alloyed, and differing typologically as well.

The presence of two different levels of iron in the artefacts may reflect differences in purity resulting from differences in the stage of manufacture, that is, initial smelting and later re-melting for casting. Thus, both of the awls show low iron content (less than 0.5%), whereas three of the copper lumps show greater than 1.0% iron.

No production artefacts - crucibles, furnace fragments, hammer stones, slags, etc. - were recovered. With the absence of ores, the fact that the Camel Site is not located near any known copper sources, and given the complete excavation of the site with 100% sieving, we can assume that no production took place at the Camel Site; it is likely that all of the copper found on site was transported there. That is, both finished tools (the awls) and prills and other copper scraps were trade items. The presence of matte (L30c-1) probably reflects rather indiscriminate collection of such scraps. This implies that reworking of copper, re-melting, was probably carried out at some consumption sites, like Arad (Ilan & Sebbane 1989). On the other hand, the nature of the artefacts - finished objects, prills, and casting discards - indicates that the inhabitants of the Camel Site were trading in a range of copper products, including production waste. Either they were middlemen trading in every scrap they could lay their hands on, or alternatively, they were themselves active in production at smelting sites near source areas. Such activities have been documented ethnographically, as for example among the Solubba (Betts 1989). Either way, we have a clear example of production and trade independent of some centralized system.

Finally, the repeated episodes of heating and hammering of the awl, indicating the need for reworking, also suggest it was used. In fact, the location of the two awls in Locus 37 coincides with the centre of bead manufacturing on the site, as indicated by a concentration of microlithic flint drills, ostrich eggshell fragments, and beads in various states of completion. The awls may well have been used in this context. The Camel Site inhabitants were consumers of as well as traders in copper.

It is difficult to evaluate the role of nomads in early metal production in the Levant. Although a major Early Bronze Age III copper production centre clearly tied to the urban society of the Levantine core zone has been documented at Feinan, no similar evidence for intensive exploitation has been found for earlier periods, either at Feinan or at other source areas for copper, such as Timna and South Sinai. Even with the evidence for Early Bronze Age II Aradian trade missions in South Sinai (e.g., Amiran *et al.* 1973; Beit Arieh 1981; Stager 1992), the actual evidence for copper production is rather limited. The materials from the Camel Site, as

minimal as they are, add an important quantity to the early metallurgy equation. Even a tiny nomad site in the middle of the desert, removed from the source areas and not even significant in terms of nomadic sites, shows evidence of being engaged in the copper trade. There are hundreds of sites surveyed similar to the Camel Site. Few have been excavated, and significantly, few excavations have employed sieving for the recovery of material culture. It seems likely that nomads played a role in the development of early Levantine metallurgy, even though at present we can not quantify this role any further.

It is also difficult to evaluate the role that metallurgy played in Early Bronze Age pastoral nomadic society. Previous studies of materials from the Camel Site (Rosen 2003 and references) have established the diverse range of economic activities represented on the site, including milling stone production and exchange, bead production and exchange, trade in other trinkets, and of course herding and hunting. The non-subsistence production activities have been characterized as cottage industries, extensive and opportunistic rather than intensive. In general, the economy has been characterized as multi-resource (cf. Salzman 1972). The metallurgical activities are similar. There is no evidence for intense industrial production. Rather, the Camel Site metallurgy seems to fit well into a general pastoral nomadic adaptation.

### Acknowledgments

We are grateful to Aaron Shugar and John Merkel for making valuable comments on this manuscript and to Beno Rothenberg for his discussions and encouragement. The Camel Site excavations were supported by grants from Wenner-Gren (to Benjamin Saidel, as part of his PhD dissertation research), the Jo Alon Center for Bedouin Research, and the Ben-Gurion University Department of Research Contracts. We also thank Stuart Laidlaw, of the Institute of Archaeology, University College London, for his help with the graphics files.

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