Early Bronze Age metallurgy: a newly discovered copper manufactory in southern Jordan

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Recent excavations in southern Jordan have revealed the largest Early Bronze Age (c. 3600–2000 BC) metal manufactory in the ancient Near East. On-site Geographic Information Systems (GIS) analyses of the finds provide new evidence concerning the scale and organization of metal production at a time when the first cities emerged in this part of the Near East. Materials and lead isotope analyses of the metallurgical finds provide important data for reconstructing ancient metal processing and for identifying trade networks.

Key-words: archaeometallurgy, Early Bronze Age, Jordan, Khirbat Hamra Ifdan, GIS

The Early Bronze Age (EBA, *c*. 3600–2000 BC) represents a time of fundamental social change in the southern Levant when the first fortified towns and urban centres evolved. Since the 1930s, scholars have linked advances in metallurgy with the emergence of urbanism and the rise of some of the earliest civilizations (Childe 1930). Recent excavations at the site Khirbat Hamra Ifdan (KHI) in the copper–ore-rich Faynan district of southern Jordan have revealed the largest Early Bronze Age metal workshop in the Middle East, and have yielded thousands of finds related to ancient copper processing. This unique assemblage of archaeometallurgical remains includes crucible fragments, prills and lumps of copper, slags, ores, copper tools (e.g. axes, chisels, pins), copper ingots, a few furnace remains and an extensive collection of ceramic casting moulds for ingots and tools. The archaeometallurgical data from this site provides vital information for accurately reconstructing EBA metal processing as well as some of the dimensions of trade relations that were linked to significant changes in social evolution in that period. The 'manufactory' (Costin 1991) complex at KHI survived in a remarkable state of preservation due to the structures being sealed by wall collapse as a result of earthquake activity at the end of the Early Bronze III (*c*. 2700–2200 BC). Thanks in part to this 'Pompeii effect', KHI represents the first near-complete EBA metal workshop in the ancient Near East. Use of on-site Geographic Information Systems (GIS) data recording has greatly streamlined and facilitated the recognition of activity areas linked to ancient metal production at the site (Levy *et al*. 2001). The analysis of the metallurgical data from KHI will enhance our understanding of the copper production processes and provides an important analytical lens for monitoring the oscillations in social change in a region traditionally viewed as a periphery to the ancient EBA centres of civilization — namely Egypt and Mesopotamia.

The Faynan district, ~50 km southeast of the Dead Sea, was the most important resource area for copper in the southern Levant (FIGURE 1). The Jabal Hamrat Fidan (JHF) represents the western 'Gateway' to Faynan, a region which contains evidence for numerous single and multiple occupation sites dating to the entire span of the EBA and was the largest source of copper ore during this period in the southern Levant. Sites such as KHI provide ideal 'open-air laboratories' for investigating the social dimensions of these ancient production centres.

The Faynan district is best known from biblical texts as the location of Punon, one of the

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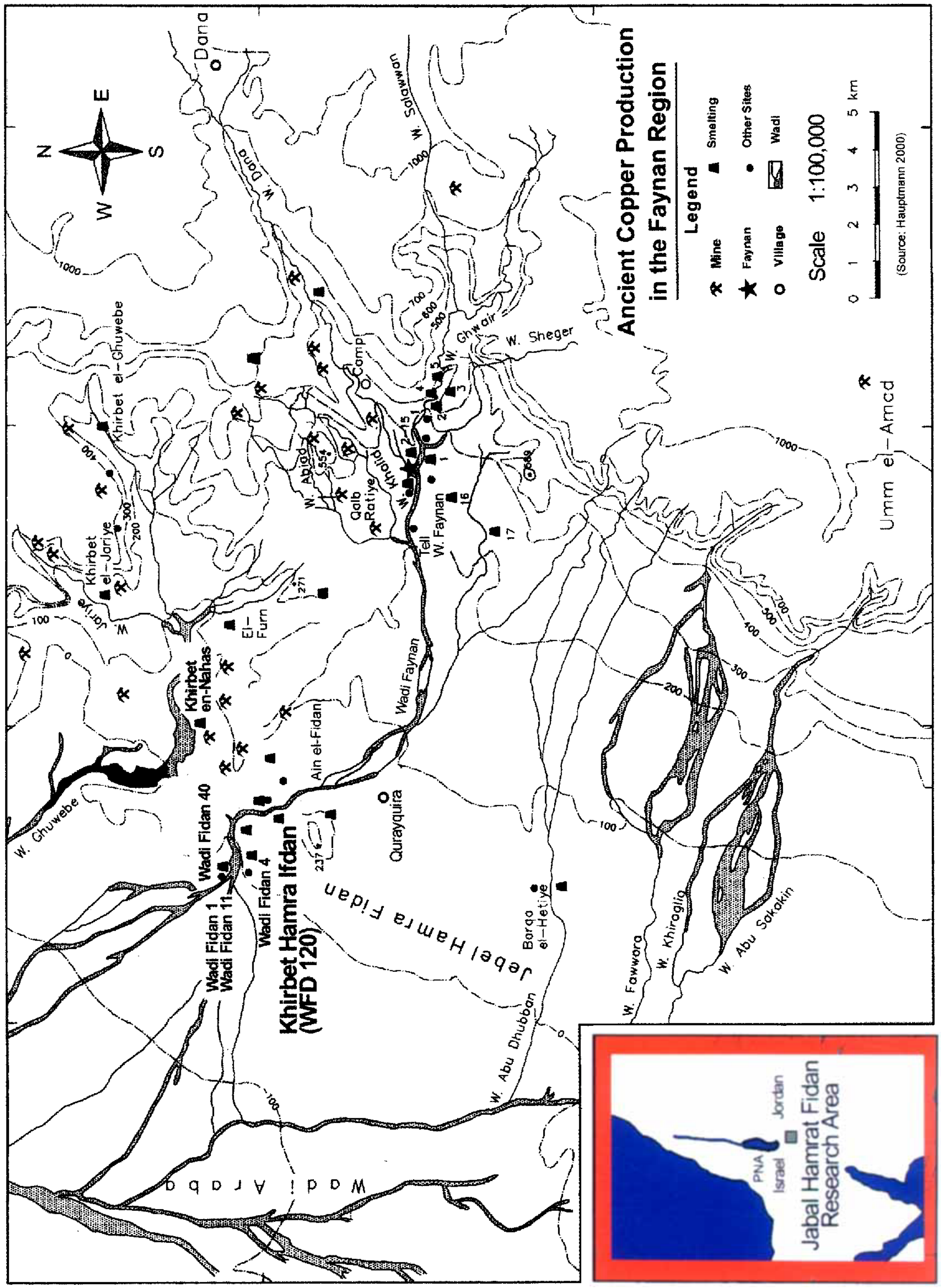
Ancient Copper Production in the Faynan Region
Legend
Mine
Faynan
Village
Smelting
Other Sites
Wadi
Scale 1:100,000
0 1 2 3 4 5 km
(Source: Hauptmann 2000)
Jabal Hamrat Fidan Research Area
PNA
Israel
Jordan
Khirbet Hamra Ifdan (WFD 120)
Wadi Fidan 1
Wadi Fidan 11
Wadi Fidan 4
Wadi Fidan 40
Khirbet en-Nahas
Ain el-Fidan
Wadi Faynan
Qurayquira
Jebel Hamra Fidan
Barqa el-Hetiye
El-Furn
Khirbet el-Jariye
Khirbet el-Ghuwebe
W. Ghuwebe
W. Jariye
Dana
W. Dana
W. Salawwan
W. Ghwair
W. Sheger
W. Abiad
W. Khalid
Qalb Ratiye
Tell W. Faynan
Camp
Umm el-Amad
W. Fawwara
W. Khiraglig
W. Abu Sakakin
W. Abu Dhubban
Wadi Arabah
30°40'
30°35'
35°20'
35°25'
35°30'
35°35'

40 stations mentioned in the book of Numbers (*Numbers* 33: 42–43; generally identified with the Greek *Phaino*, the present Khirbet Faynan, Jordan) and in the archaeological literature for extensive evidence concerning ancient mining and smelting sites spanning the Chalcolithic (*c.* 4500–3600 BC) through the Islamic periods (Hauptmann 1989; 2000; Hauptmann *et al.* 1992).

KHI is situated on a naturally defended mesa-top plateau or 'inselberg' aproximately 25 m above the wadi channel, and located in the middle of a seasonal drainage known as the Wadi Fidan. The area was first visited by Frank (1934), in part by Glueck (Glueck 1935; Adams 1992), and reported on by several other survey projects (Knauf & Lenzen 1987; MacDonald 1992). The site was first probed by Adams (1999; 2000), whose early excavations demonstrated the rich potential of the site for examining the technological and scalar changes in copper production during the EBA. In 1999–2000, the first large-scale excavation work was carried out at the site under the direction of T.E. Levy and R.B. Adams aimed at providing a foundation for examining the social context of EBA metallurgy (Levy *et al.* 1999).

FIGURE 2. *Overview of the Early Bronze Age excavations at Khirbet Hamra Ifdan (KHI), Jordan, highlights courtyard where main casting activities took place.*

EBA metallurgy in context and at KHI

The earliest metal production sites in the southern Levant date to the Chalcolithic period (*c.* 4500–3600 BC), when production was carried out near large corporate buildings within village settlements found primarily in Israel's northern Negev desert far away from the source areas of copper in the Arabah valley and Sinai Peninsula (Levy & Shalev 1989). Chalcolithic metallurgy was linked to the emergence of the first chiefdom organizations in this part of the Near East and seems to have been controlled by social élites (Levy 1998). By the beginning of the EBA I (*c.* 3600–3300 BC), with the collapse of Chalcolithic settlement over much of Palestine, for the first time, metal production took place near the ore sources of Faynan in Jordan. With the rise of fortified towns in the southern Levant during the EB II–III (*c.* 2900–2200 BC), and within the contexts of developing complexity in the Levant and surrounding cultures (i.e. Old Kingdom Egypt, see below), metal production increased dramatically in scale. In the copper district of Faynan, for the first time large-scale EB II–III mining activities were carried out in galleries and shafts. To smelt the ore, 13 contemporary smelting sites were discovered where some 5000 tons of slag reveal a metal production of perhaps several hundred tons of copper during the EBA (Hauptmann 2000). This is by far the largest evidence of copper production during this period in the ancient Near East. The recent excavations at KHI provide a powerful lens for examining the more general processes of social evolution seen through the development of craft specialization in ancient metallurgy. Scalar differences in metal production between the Chalcolithic period and the EB III are marked and point to significant differences between metal production for chiefdom elites in the

FIGURE 1 (opposite). *General map of the Faynan (Jordan) research area.*

lab no.	period	site	^{14}C date BP	^{14}C dates cal BC (1σ)	provenance	publication
HD-12337	Chalcolithic	Tell Wadi Faynan	5740±35	4675–4575	Square A, L 23, −1·4 m	Najjar *et al.* 1990
HD-12336	Chalcolithic	Tell Wadi Faynan	5375±30	4330–4165	Square A, L 8, −1·05 m	Najjar *et al.* 1990
HD-16380	EBA I	Wadi Fidan 4	4702±37	3610–3375	Area D, L 4-14	Adams & Genz 1995
HD-16327	EBA I	Wadi Fidan 4	4718±25	3615–3380	Area D, L 4-9	Adams & Genz 1995
HD-13776	EBA I	Wadi Fidan 4	4684±50	3610–3365	Area A, L 50	Adams & Genz 1995
HD-16379	EBA I	Wadi Fidan 4	4576±45	3360–3165	Area A, L 5	Adams & Genz 1995
HD-16378	EBA I	Wadi Fidan 4	4422±51	3255–2920	Area A, L 22	Adams & Genz 1995
HD-13975	EBA II	Barqa el-Hetiye	4376±57	3080–2910	House 1, 27/91 L 13	Fritz 1994
HD-10577	EBA II–III	Faynan 9	4140±109	2880–2500	smelting site	Hauptmann 1989
HD-10573	EBA II–III	Wadi Gwair 4	4059±55	2840–2490	smelting site	Hauptmann 2000
Beta-143811	EBA III	JHF 120 (KHI)	4020±70	2605–2465	L 1236	this article
HD-16533	EBA III	JHF 120 (KHI)	4044±40	2585–2490	Trench 1, L 114	Adams 1999
HD-10994	EBA III	Faynan 9	3973±85	2575–2345	smelting site	Hauptmann 1989
HD-10574	EBA III	Ras en-Naqb 1	3971±67	2565–2400	smelting site	Hauptmann 2000
HD-10993	EBA III	Faynan 9	3981±50	2560–2455	smelting site	Hauptmann 1989
Beta-143813	EBA III	JHF 120 (KHI)	3960±50	2555–2535 2490–2445	L 1602	this article
HD-10579	EBA III	Faynan 16	3923±61	2465–2315	smelting site	Hauptmann 2000
Beta-143810	EBA III	JHF 120 (KHI)	3870±40	2465–2205	L 1010-14758	this article
HD-16529	EBA III	Wadi Gwair 3	3919±26	2460–2345	smelting site	Hauptmann 2000
HD-16534	EBA III	JHF 120 (KHI)	3914±45	2460–2320	Trench 2, L 209	Adams 1999
HD-10584	EBA III–IV	Faynan 9	3812±77	2395–2135	smelting site	Hauptmann 1989
Beta-143812	EBA IV	JHF 120 (KHI)	3650±60	2125–2075 2055–1935	L 1010-14208	this article

TABLE 1. *Radiocarbon determinations for JHF research area, during the Chalcolithic–Early Bronze Age.*

former period, and more 'commodity driven' production in the latter (Adams 1999).

Three main occupation phases have been identified at KHI. Stratum I represents later occupations from the Islamic, Byzantine and Iron Age periods. Stratum II dates to the EB IV occupation and Stratum III to the EB III period when the site was occupied most extensively. There are indications of an EB II occupation in Stratum IV; however, the excavation sample size is too small to make meaningful observations. Radiocarbon dates from the region, coupled with ceramic and stratigraphic data provide a solid chronological framework for evaluating changes in metal production during the last phases of the EBA at Faynan (TABLE 1).

The main occupation phases at KHI are Stratum III (EBA III, *c.* 2700–2200 BC) that coincides with the consolidation of the earliest fortified sites throughout the Levant and Stratum II (EB IV, *c.* 2200–2000 BC) that is often linked to a period of social collapse. The reasons posited for the collapse of EBA urbanism are varied and include: general climatic deterioration in the 3rd millennium Near East (Weiss *et al.* 1993), Egyptian conquests during the Old Kingdom Fifth Dynasty (Redford 1992), invasions of West Semitic 'Amorite' tribes from Syria, internal social upheaval and other factors. It is against these formative processes of social change that EBA metallurgy evolved.

Early Bronze Age metal workshops have been found across the Near East in Oman at Maysar 1 (Weisgerber 1981); in Iran at Shahr-i Sokhta (Heskel 1982), Tepe Hissar (Pigott *et al.* 1982), and Shahdad (Pigott 1989; 1999); in Anatolia at Arslantepe (Palmieri *et al.* 1993), Kestel (and Göltepe) (Yener 2000), Norşuntepe (level VIII — Müller-Karpe 1994), Tepecik, Cudeyde (Goldman 1956), Gözlu Kule/Tarsus (Goldman 1956), Değirmentepe (Esin 1988), Hisarlik (Level II, Troy — Schliemann 1881). Interestingly, the nearby (*c.* 100 km south) copper mines at Timna in southern Israel have produced little evidence of EBA metal processing and the island of Cyprus, the most important source of eastern Mediterranean metal during the Middle and Late Bronze Age (*c.* 2000–1300 BC), has virtually no evidence of contemporary EBA metal production or processing. More significant is the relatively small scale of production and treatment of raw metal reflected at these other Near Eastern EBA metal production sites noted here. Until the recent excavations at KHI, the largest assemblage of metallurgical remains of that period came from Schliemann's excavations at Troy (Hisarlik) where 70 crucible fragments, 70 casting moulds and some other metal production remains were found. In addition to the small sample sizes from these sites, little data has been quantified, making comparative studies difficult.

The recent excavations at KHI (FIGURE 2) shed new light on the scale and organization of Near Eastern EBA metal processing due to the unusually large sample of artefacts related to production activities. The excellent preservation of these materials at the site and the relatively undisturbed contextual data of these finds point to 'factory-like' production technologies. A total of 3782 archaeometallurgical finds were recovered from the EBA strata at the site in an excavation exposure of *c.* 977 sq. m. The total volume of deposits excavated for the two main EBA strata are Stratum II — EB IV = (160·58 cu. m) and Stratum III — EB III (405·91 cu. m). The finds can be divided (TABLE 2, FIGURE 3) into:

a copper metal objects (axes, chisels, pins, ingots)
b copper ores (most identified with specific source areas in Faynan)
c copper prills (droplets of metal obtained through smelting) and copper lumps (produced by re-melting smaller batches of raw copper)
d slag (extremely metal-rich slags transported as an intermediate product from smelting sites in the Faynan area to KHI for further metal extraction, and slag from remelting in crucibles)
e casting moulds (for axes, chisels, pins, blades, and ingots)
f remains of pyrotechnical facilities (small crucibles for melting copper-rich slag, batches of copper, partly for smelting ore; some clay rods or 'Lady Fingers' that functioned in smelting furnaces) and
g spherical and elliptical grooved stone hammers used for further treatment of metal objects or breaking up casting moulds.

artefact category	Stratum II	Stratum III	Stratum IV
metal objects			
axes	0	3	0
chisels	0	0	0
pins	12	47	0
ingots	2	58	0
lumps	15	169	3
copper ores			
OE (ore)	62	230	4
OE-DLS (dolomite-limestone-shale)	10	35	0
OE-PR (ore and prill)	0	3	2
OE-PSO (ore mixed with prill and slag)	52	216	3
OE-PSO/DLS (combination of both)	24	80	1
OE-SL (ore and slag)	7	37	0
prills			
PR (prill)	21	280	1
PR-PSO (prill, mixed with slag and ore)	1	29	0
slag			
SL (slag)	8	32	0
SL-SMS (shiny, glass-like black slag)	19	82	1
casting moulds			
axes	1	25	0
chisels	0	58	0
chisel w/butt	0	29	0
pins	1	25	0
small ingots	0	3	0
ingots	16	345	0
indeterminate	51	366	1
blade	0	15	0
smelting facility remains			
crucible fragments	40	625	6
Lady Fingers	2	117	0
furnace fragments	8	44	0
stone tools			
hammerstones	45	342	0
grooved 'mining or metalwork' hammer	7	61	0
total	*404*	*3356*	*22*

TABLE 2. *Summary of Early Bronze Age metallurgical finds from Khirbet Hamra Ifdan, Jordan.*

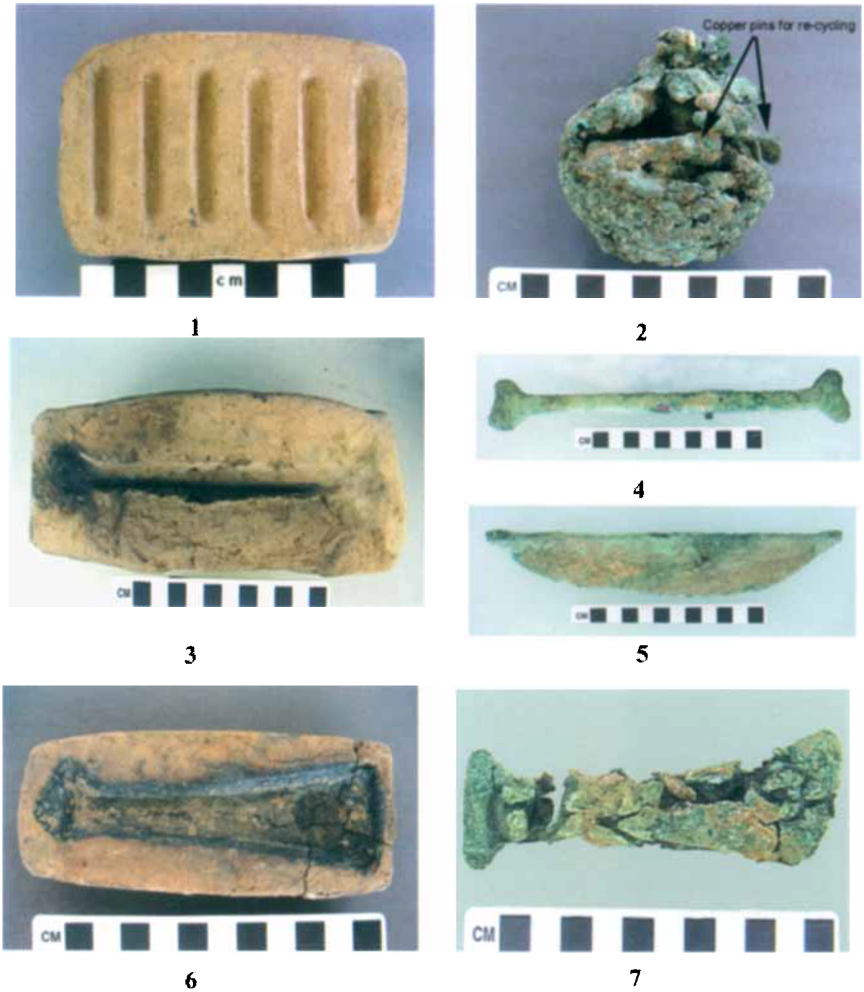

FIGURE 3. *Casting moulds, melted copper from crucible and metal tools from KHI.*
1 *multiple pin casting mould*
2 *recycled metal remains with evidence of corrosion*
3 *ingot casting mould*
4–5 *copper ingot (top and side view)*
6 *axe casting mould*
7 *copper axe*

The organization and scale of metal production

Identification of the distribution patterns of the thousands of metallurgical remains discovered at KHI was facilitated through GIS and the ArcView 3.2 program. As highlighted in the flow chart (FIGURE 4) and the graphic presentation of data through GIS maps (FIGUREs 5A, 5B), by identifying clusters of archaeometallurgical data across the site in courtyards, rooms and other architectural features, it is possible to reconstruct all of the stages in metal processing at this site. Accordingly, ore extracted through mining activities was mostly smelted near source; however, the distribution of small quantities of ores and slag at KHI points to some on-site smelting of ore in crucibles. The bulk of pre-cast metal arrived in the form of prills (droplets of smelted metal), small metal batches and copper-rich slag from the specialized smelting sites (Hauptmann 2000) (FIGURE 1). In terms of pyro-techniques, the concentrations of metal prills and metal lumps across the site, and evidence of re-cycling based on clusters of re-melted copper prills, ingots, and tools 'frozen' in the negative impression of a crucible base (referred to as the KHI 'cupcake'; FIGURE 3:2), point to the centrality of melting and re-melting activities for casting at KHI.

It is possible to identify an EBA 'factory-line'-like operation for the production of copper tools and ingots at the KHI settlement. As seen in the GIS map for the EB III period (FIGURE 5A), specialized metal-processing activities were concentrated in a variety of the more than 80 rooms, courtyards and other spaces excavated

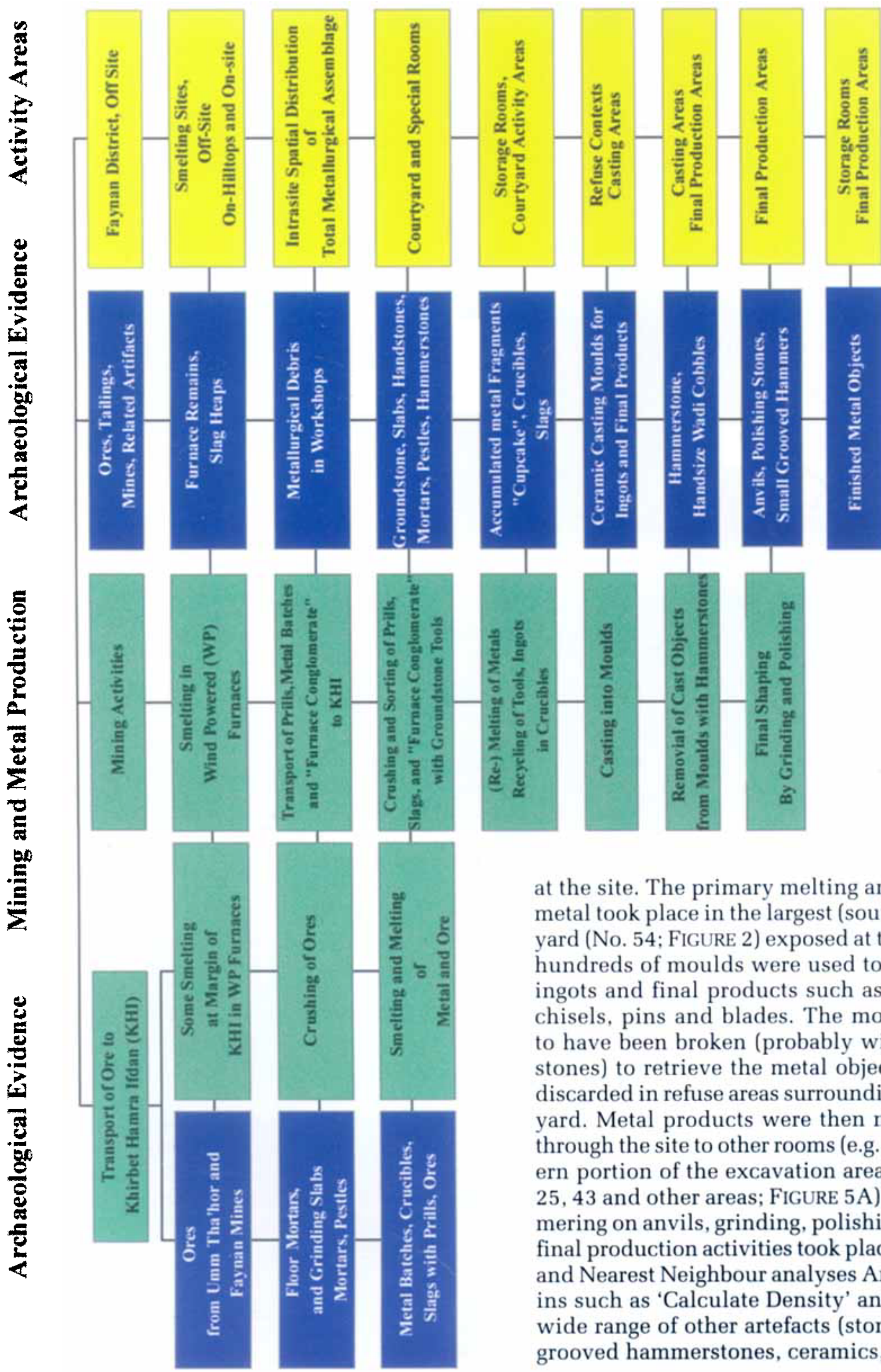

FIGURE 4. *Flow chart — the Early Bronze Age III 'Metallurgical Chain' of mining and metal production at KHI, Jordan.*

at the site. The primary melting and casting of metal took place in the largest (southern) courtyard (No. 54; FIGURE 2) exposed at the site. Here hundreds of moulds were used to cast copper ingots and final products such as metal axes, chisels, pins and blades. The moulds appear to have been broken (probably with hammerstones) to retrieve the metal objects and then discarded in refuse areas surrounding the courtyard. Metal products were then moved north through the site to other rooms (e.g. in the northern portion of the excavation area and Rooms 25, 43 and other areas; FIGURE 5A) where hammering on anvils, grinding, polishing and other final production activities took place. Using GIS and Nearest Neighbour analyses ArcView plug-ins such as 'Calculate Density' and 'Kernel', a wide range of other artefacts (stone hammers, grooved hammerstones, ceramics, etc.) linked to metal production have also been analysed to clarify the 'Metallurgical Chain' at KHI. Although lack of space precludes including all these studies here, the full range of metal production activities is highlighted in the flowchart (FIGURE 4).

The magnitude of the KHI metallurgical assemblage for the EB III (TABLE 2), its comparison with other contemporary Near Eastern production sites, and the highly specialized nature of KHI during this period point to a 'quantum leap' in the scale of early metal production at a time when the earliest Levantine urban centres were growing and solidifying their power. GIS plots comparing the EB III (Stratum III; FIGURE 5A) distribution of metallurgical remains and architecture with those of the EB IV (Stratum II; FIGURE 5B) highlight the nested and structured organization as well as scale of metal production in the EB III urban period. In the following (EB IV) period, a time of general social dissolution in the southern Levant, there is a distinct absence of architectural features and infrastructure associated with metal production. The quantity of metallurgical remains drops markedly from *c.* 3356 in the EB III to only *c.* 404 in the EB IV. Regional surveys in the research area show (with the exception of KHI) a paucity of EB IV sites that would have provided a local subsistence base for the inhabitants of the site. However, in the EB III there was a network of small hamlets, agricultural installations, cemeteries and other sites linked to KHI. Thus, the JHF settlement pattern data, coupled with on-site metallurgical production data at KHI indicate a much less intensive, periodic and unsystematic scale of production in the EB IV compared with the EB III. These results confirm the generally accepted view of a social 'collapse' in the EB IV; however, by focusing on craft production as an analytical lens for examining change, the foundations of a more quantitative method for measuring change has been achieved.

Processing and trade of copper at KHI

With the discovery and analyses of the metal workshop at KHI, for the first time in Old World archaeometallurgy research there is now strong evidence that provides better insight into the craftwork of copper processing during the 3rd millennium BC. Until now, reconstruction of these processes was based on simple speculative chemo-physical models of modern metal technology. Such models indicate a refining of raw copper, i.e. a deliberate purification from impurities such as lead, arsenic, iron or nickel by blowing air into the liquid metal bath. Accordingly, impurities get oxidized until the liquid copper itself is transformed to copper-oxide. Hence, a typical feature of refining is a surplus of cuprite (Cu_2O) in the crucible. The new discovery reported here changes this view by providing fresh empirical data from the Early Bronze Age. The finds from KHI show that a variety of metallurgical materials were delivered from outside to this EB settlement/manufactory. Among these were slags with copper contents up to 10% weight or more ('furnace conglomerate') and thousands of prills and small batches of copper with adhering slag. They are proof of the partially limited success of smelting processes carried out at the smelting sites in the Faynan area (FIGURE 1). In addition, high-grade pieces of malachite, chrysocolla and copper-chlorides were transported from the nearby Faynan mines to KHI. At the KHI processing centre, they were all repeatedly smelted and melted in crucibles in order to remove slag, and to gain larger lumps of metal of sufficient quantity to cast into an ingot or tool (FIGURE 3). The smelting of ores perhaps followed a traditional workshop recipe that goes back to the Chalcolithic period, when smelting activities were carried out inside the settlement. The hypothesis that ancient metal workshops had their own 'recipes' — which might have been characteristic for certain regions — has been suggested earlier (Junghans *et al.* 1960).

The multiple re-melting and re-cycling of copper lumps and prills into larger units are probably identical with the production of washed or purified copper as described in 3rd-millennium BC cuneiform tablets from Ebla in Syria (Reiter 1997). This was called 'urudu-luh-ha', in contrast to *urudu*, which means un-purified copper. Before a more in-depth knowledge on EBA copper processing was available, it was suggested that such purification would mean a deliberate refining of metal in the modern metallurgical sense (Waetzold & Bachmann 1984). As shown by the phase contents of slags and copper, this was not the case at KHI, and there is no evidence as yet for refining at any other of the ancient Near Eastern EBA workshops. The skill and expertise of the KHI metallurgists was remarkable as they produced high-quality copper perfectly suitable for a flawless casting and ready for export in the form of both ingots and finished tools (FIGURE 3). Alloying was not performed in the KHI manufactory. This is an important observation, as tin bronzes are extremely rare in the EBA II/III southern Levant. It seems that this metallurgical process was carried out at urban centres in the north and the northwest (Hauptmann 2000).

In addition to technological questions, archaeometallurgical studies concerning provenance provide insights on where the copper from Faynan was traded. Sourcing metal is based upon a chemical 'fingerprinting' of impurities in ore (the source) and a comparison of finished objects with this ore. Methods to determine these impurities comprise both chemical analyses of trace elements, and the analyses of lead isotope abundance ratios (LIA).

For Faynan, reference compositions of ores and (EB) raw copper were previously determined (Hauptmann *et al.* 1992). Similarities between the two were found (FIGURE 6), but a large range of trace element variation seems to be characteristic. The chemical composition of crescent-shaped bar ingots from KHI indicate a considerable bunching of trace elements that results from the metal processing as described above: i.e. re-melting and re-cycling led to a homogenization of varying compositions of copper that now may be seen as a representative average composition.

This chemical composition is also reflected in a number of late EBA crescent shaped bar ingots that were found at several localities in the southern Levant (FIGURE 7). These data point to the origin of the ingots in the area of Faynan, an observation that is also supported by the stylistic attributes of the ingots (Adams 1999; 2000). Unmistakable, however, are lead isotope abundance ratios, which do not change between ore and metal, no matter how many (s)melting processes the ore/metal was exposed to. These observations are based on the analyses of some 70 south Levantine crescent-shaped bar ingots at the Max-Planck-Institut für Chemie at Mainz, and at the Geochronological Laboratory, University of Münster. All compositions match exactly the range of ores and raw copper from Faynan. Admittedly, we cannot exclude that bar ingots derived from Timna copper, but such a suggestion lacks any archaeological evidence. The bar ingot trade from Faynan supports previous observations of a pronounced 'metallurgical drift' of Faynan copper to the north, northwest (Hauptmann 2000) and southwest since the Chalcolithic period. Finally, the new data from KHI in Jordan support hypotheses that relate the extensive 'EB IV' settlements in the Negev desert of Israel with an ancient copper trade network that ultimately reached Old Kingdom and Intermediate Period Egypt (Haiman 1996; Adams 1999). Recent petrographic analysis of ceramics from these EB IV sites in the Negev suggest the possibility that in fact some of these sites have a longer period of occupation and probably originated earlier during the EB III. This is confirmed by both typological and petrographic analysis of the KHI ceramics and comparison with the evidence from the Negev (Goren 1996; Adams 1999). The combination of the ceramic and metallurgical similarities make a compelling case for the re-dating of the some of these Negev sites.

Conclusion

The evidence for large-scale and multi-phased manufacture in copper production at KHI during the later phase of the EBA presents a unique opportunity to examine the evolution of a highly specialized craft at a time when the Levant 'periphery' and neighbouring 'core' civilizations such as Egypt were undergoing major socio-political changes. In particular the rise of fortified Early Bronze Age towns in the Levant suggests developing complexity in social organization, which parallels the rise of Pharaonic Egypt during the Old Kingdom, albeit on a smaller scale. In the Levant, a part of these social changes were the development of élites and corporate authorities in the new urban centres that controlled specialized craft and subsistence production (Costin 1991). The recent excavations reported here are different from the normative EBA fortified town pattern in that KHI is

a a naturally fortified, non-urban site that lacks evidence of palatial and large scale architecture (FIGURE 5A)

b located in the desert periphery rather than the Mediterranean 'centre' of EBA urban settlement, and

c contains evidence for highly organized craft

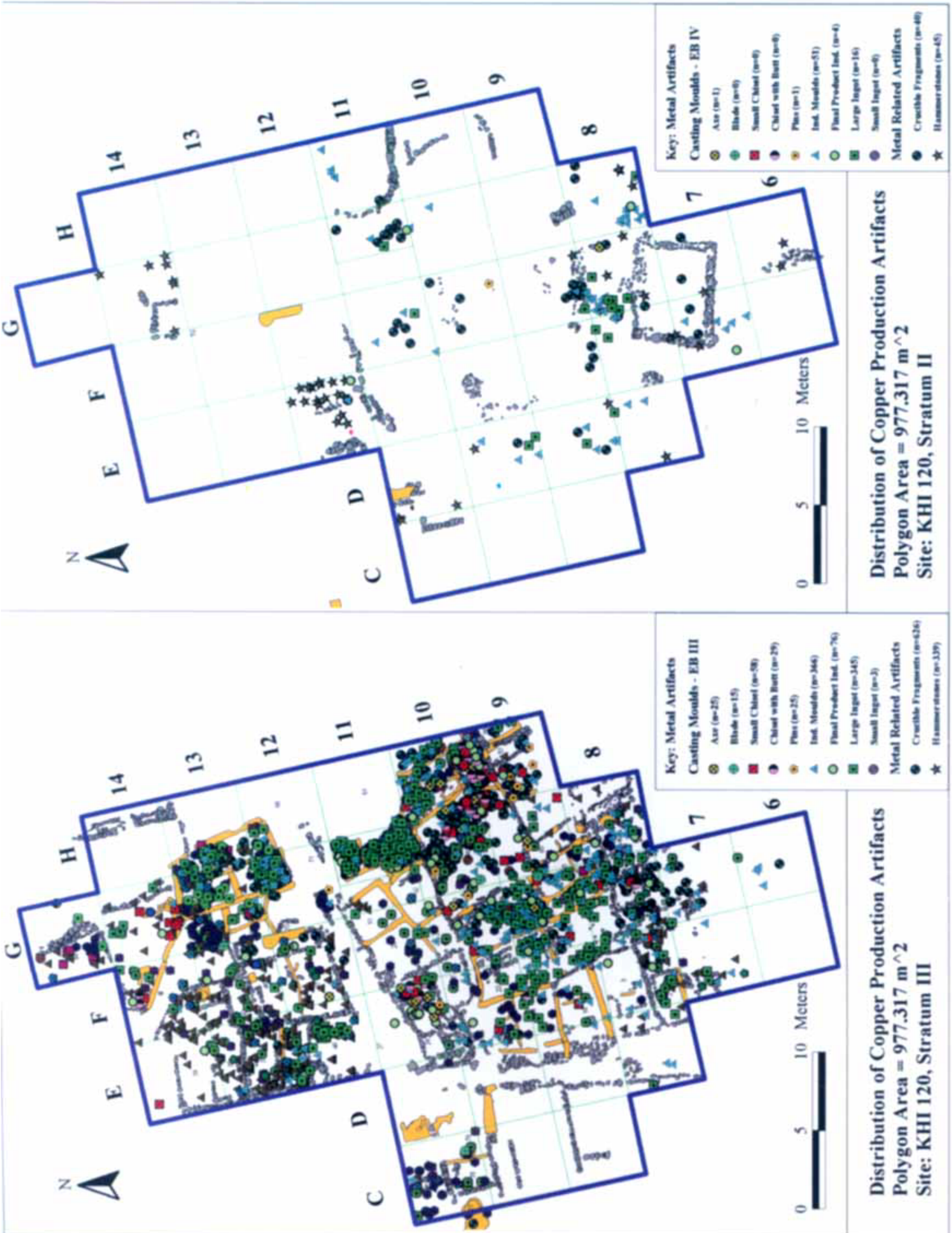

FIGURE 5A. *GIS map of EB III (Stratum III) archaeometallurgical remains.* 5B *GIS map of EB IV (Stratum II) archaeometallurgical remains at KHI, Jordan.*

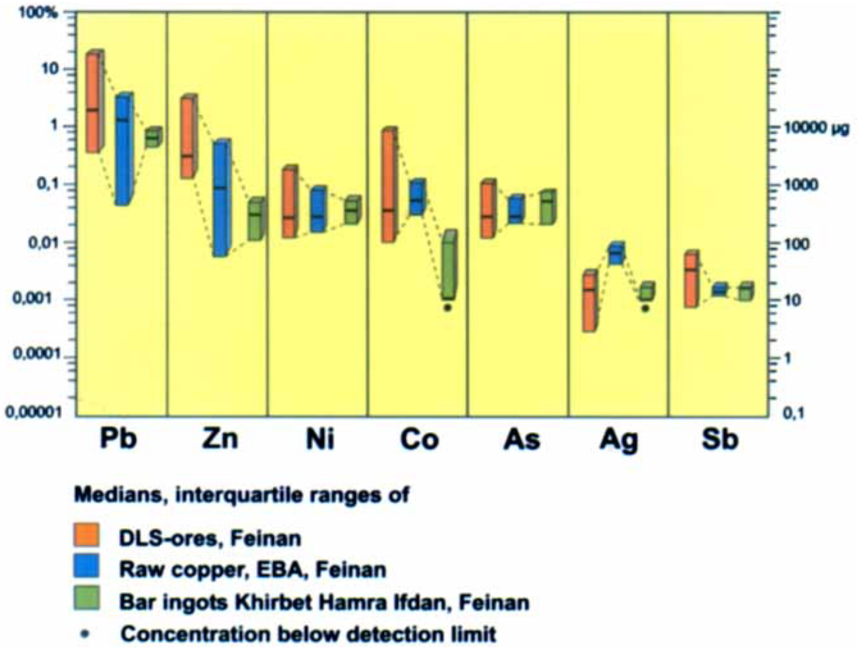

FIGURE 6. *Trace elements (medians and interquartile ranges) of ores and copper of the Early Bronze Age III metal production at Faynan (Feinan), Jordan. Note the decrease of trace elements from ore (panel 1) to raw copper (panel 2) which still shows a large range of concentrations. Metal 'ready to export' (crescent-shaped bar ingots, panel 3) provides a tight composition that results from repeated re-melting processes. It probably represents at best 'Copper from Faynan' during the EBA.*

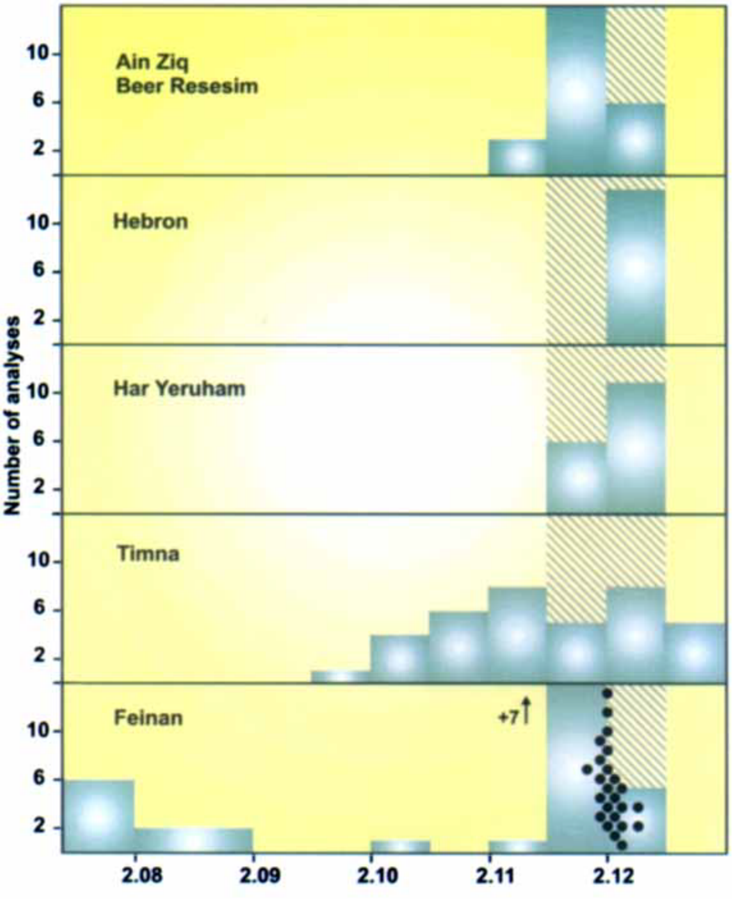

FIGURE 7. *Histogram of $^{208}Pb/^{206}Pb$-ratios in ores and raw copper from Faynan (Feinan), in ores from Timna (Hauptmann 2000), and crescent-shaped bar ingots from several localities in the southern Negev. Dots indicate first results of ingots from KHI; those from Ein Ziq and Beer Ressisim are taken from Segal* et al. *(1999). Principally, the ingots' origin could be from Timna too, but the overwhelming compositions point to Faynan (Feinan) — and are supported by the archaeological evidence of mining and smelting in this area.*

production from an as yet to be determined organizing body.

Current models for understanding the role of pre-industrial élites suggest they manipulated production and distribution of staples (e.g. cereals and other commodities) and/or wealth objects (craft products) as a mechanism to enhance and consolidate their social status (Johnson & Earle 1987). It is against this background that our assessment of the implications of the large-scale production of copper at KHI can be made. Three primary factors are key to understanding the development of the metal trade in the region during the EBA: production, distribution (trade) and consumption (Costin 1991). Since our site at KHI is the key EBA site in the largest Levantine copper resource zone, we will have, perhaps for the first time, a fuller picture of the socio-economic processes, which until now have been dominated by assessments based upon the archaeological view as seen from evidence for end-of-the-line trade and consumption. Forthcoming in-depth research on the EBA metallurgical remains from KHI will provide the first comprehensive assessment of the role of metal production on the emergence, maintenance and collapse of the earliest urban phenomenon in the Levant from one of the region's major ore resource zones in this part of the ancient Near East.

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