Proceedings
of the
Seminar for Arabian Studies

Volume 39

2009

Papers from the forty-second meeting of the
Seminar for Arabian Studies
held in London, 24-26 July 2008

Seminar for Arabian Studies

Archaeopress
Oxford

Orders for copies of this volume of the *Proceedings* and of all back numbers should be sent to
Archaeopress, Gordon House, 276 Banbury Road, Oxford OX2 7ED, UK.
Tel/Fax +44-(0)1865-311914.
e-mail bar@archaeopress.com
http://www.archaeopress.com
For the availability of back issues see the Seminar's web site: www.arabianseminar.org.uk

Seminar for Arabian Studies
c/o the Department of the Middle East, The British Museum
London, WC1B 3DG, United Kingdom
e-mail seminar.arab@durham.ac.uk

Opinions expressed in papers published in the *Proceedings* are those of the authors and are not necessarily shared by the Editorial Committee.

Typesetting, Layout and Production: Dr. David Milson

The *Proceedings* is produced in the Times Semitic font, which was designed by Paul Bibire for the Seminar for Arabian Studies.

ISSN 0308-8421
ISBN 978-1-905739-23-3

Proceedings of the Seminar for Arabian Studies 39 (2009): 245–254

First report on the copper-smelting site HLO-1 in Wādī al-Ḥilo, UAE

Johannes Kutterer & Sabah A. Jasim

Summary

A preliminary report is given on the copper-smelting site HLO-1 of the Umm an-Nar (Umm al-Nār) period in upper Wādī al-Ḥilo in Sharjah, UAE. Two seasons of explorations by a joint team of the Sharjah Directorate of Antiquities and the University of Tübingen (Germany) in 2007 and 2008 yielded evidence for an Islamic settlement and graveyard at the site, as well as living structures, a fortified building (watchtower), and a copper-smelting workshop of the Early Bronze Age. A large hemispheric ingot of pure copper testifies to metal production at the site. From the amount of slag found during the explorations, a total of up to 56 t of locally produced copper could be estimated. The slag is of the Fayalite type and differs slightly from the slag analysed at the contemporary site of Maysar 1 (Oman). The difference may be due to the local ore, which was extracted from a vein situated at the slope above the site. The melting temperature of the slag from Wādī al-Ḥilo was determined to have been about 1200°C. Most of the prehistoric pottery found at the site is from the Umm an-Nar period. A few sherds and a radiocarbon date also indicate an occupation during the Wādī Sūq period.

Keywords: HLO-1, metallurgy, copper smelting, Wādī al-Ḥilo, Bronze Age

Introduction

The beginning of the Early Bronze Age marks a major step in the cultural development of south-east Arabia. In the area of the United Arab Emirates there are many important sites of this period, e.g. Umm an-Nar (Umm al-Nār), the site that gives its name to the main Early Bronze Age culture in south-east Arabia or Hili (Hilī), which is an anchor-point for the chronology of this time period. It is a general assumption that the rich metal sources of the Ḥajar Mountains are a basic geographic factor for the rapid changes which happened from the end of the fourth into the first half of the third millennium BC. This assumption is also based on early historic information from Mesopotamia: several cuneiform tablets from the late third millennium BC mention the land of Magan (which is identified as the Oman peninsula) as a source for copper (Potts 1990; 2001).

To date, no Bronze Age copper production site had been explored in the United Arab Emirates. This has now changed following discoveries in the upper Wādī al-Ḥilo. The Bronze Age smelting site is located in the northern Ḥajar Mountains only about 15 km from the east coast (Fig. 1). Nevertheless, the site is separated from the sea by major mountain ridges. The distance from the coast doubles if it is calculated along Wādī al-Ḥilo, which first flows south and then east in a narrow, winding valley towards the coast of the Gulf of Oman. The prehistoric site described here is situated at about 350 m above sea level on the left-side terrace of the wadi at the western foot of a mountain ridge, which has an altitude of *c.*1000 m in this area.

The site received archaeological attention after an exchange of territories between the Emirates of Sharjah and Fujayrah. Surveys of the Sharjah Directorate of Antiquities led to the discovery of dense slag concentrations and, more importantly, of a few pieces of Umm an-Nar pottery among the slag (Fig. 2). Excavations began in 2007 after recognition of the potential of the site for the *in situ* preservation of installations for Early Bronze Age metal production. Due to the presence of many Islamic burials in the area of the site and the existence of substantial ruins of historic buildings around the site, it was first assumed that there might also have been copper production at the site during the Islamic period. However, to date the excavations have not yielded any evidence for this assumption.

Historic features

Features from the Islamic period at the site of Wādī al-Ḥilo are prominent in the form of some pre-modern

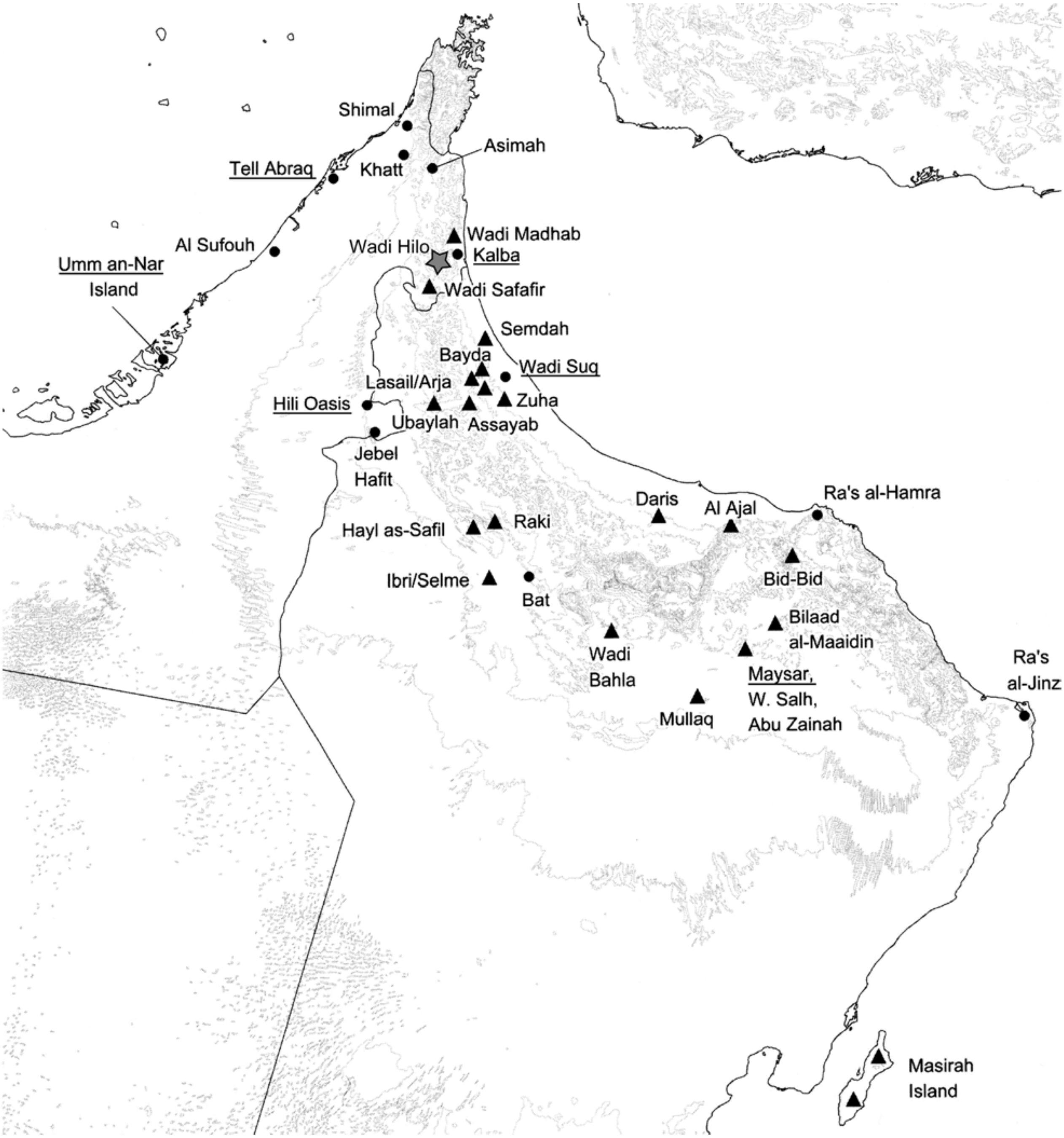

FIGURE 1. *A map showing the location of Wādī al-Ḥilo (asterisk), other copper deposits and metallurgical sites (triangles), and settlements from the third millennium BC (circles). Sites mentioned in this paper are underlined. (Modified after Weeks 2003: 11, fig. 2/2).*

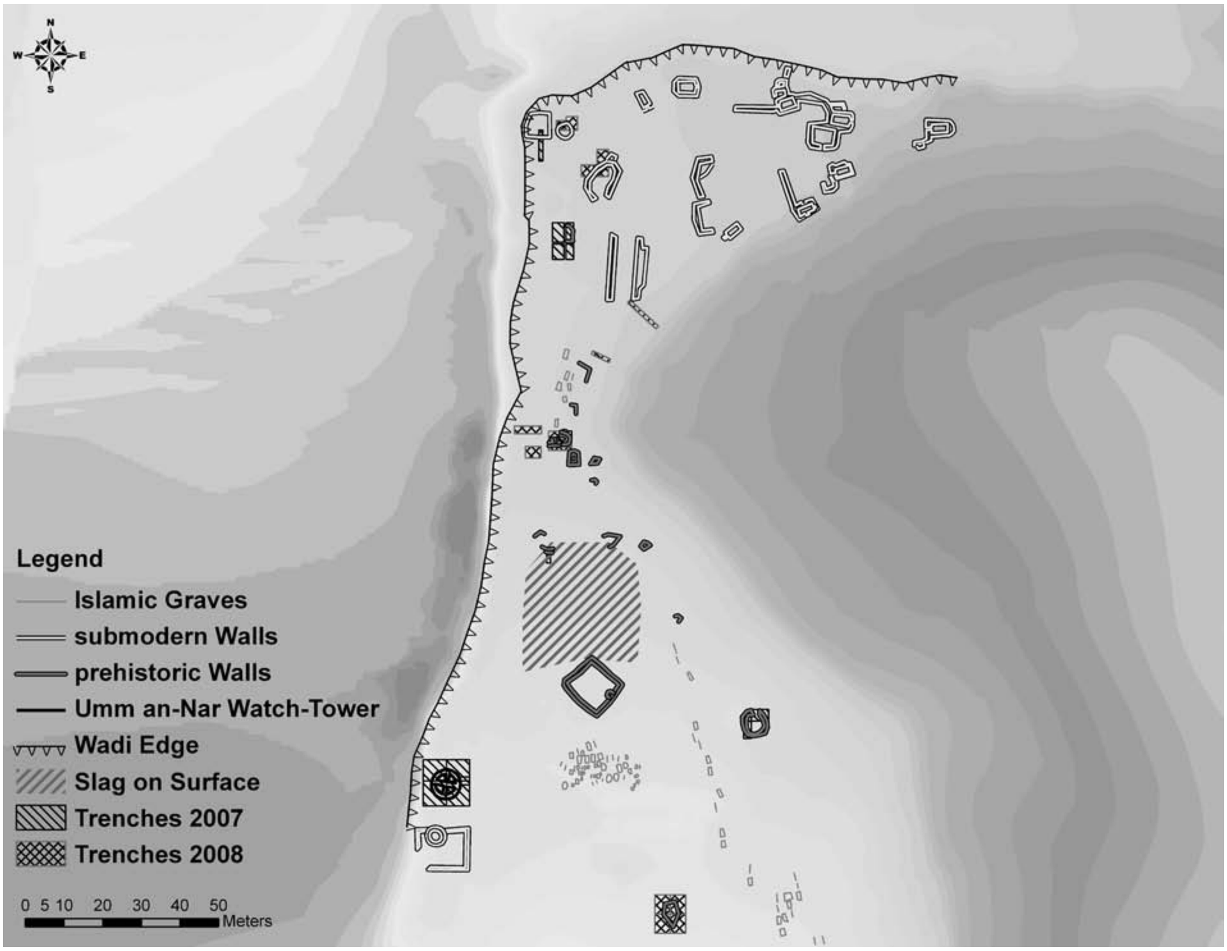

Figure 2. *A plan of the site of Wādī al-Ḥilo with surface findings and main excavated features.*

buildings in the northern part, which — according to the locals — were associated with tobacco farming. There are the remains of several semi-subterranean houses as well as a building consisting of two parallel walls of 16 m in length and an inter-space of 6 m between them (Fig. 3). The space between the walls was originally covered with a roof: tobacco leaves were hung up there to dry after being harvested. Other important features are Islamic graves, some of them in a long line parallel to the mountain slope and others in another concentration in the centre of the terrace. The landmark of Wādī al-Ḥilo is an old watchtower at the south-western end of the prehistoric site.

Prehistoric features

The Bronze Age remnants are less obvious in the landscape. Massive prehistoric buildings are indicated by mostly curvilinear outlines of stone walls at ground level. Some of the features visible at the surface are shown in Figure 3.

The most conspicuous pre-modern feature was observed close to the Islamic watchtower. A low mound just north of the watchtower seemed to contain a prehistoric grave. Indeed, excavations at this location uncovered a round stone structure with an outer diameter of 7.7 m and an inner diameter of *c.* 5.1 m (Fig. 4). As the structure was found devoid of any artefacts — except masses of slag in its filling — no indications of its use could be reconstructed. There was neither an entrance from the outside nor doorways through the crossed internal walls, which were erected after some 20–30 cm of sediment had accumulated on the original surface of the floor inside the building.

Figure 3. *An Umm an-Nar watchtower (seen from the south).*

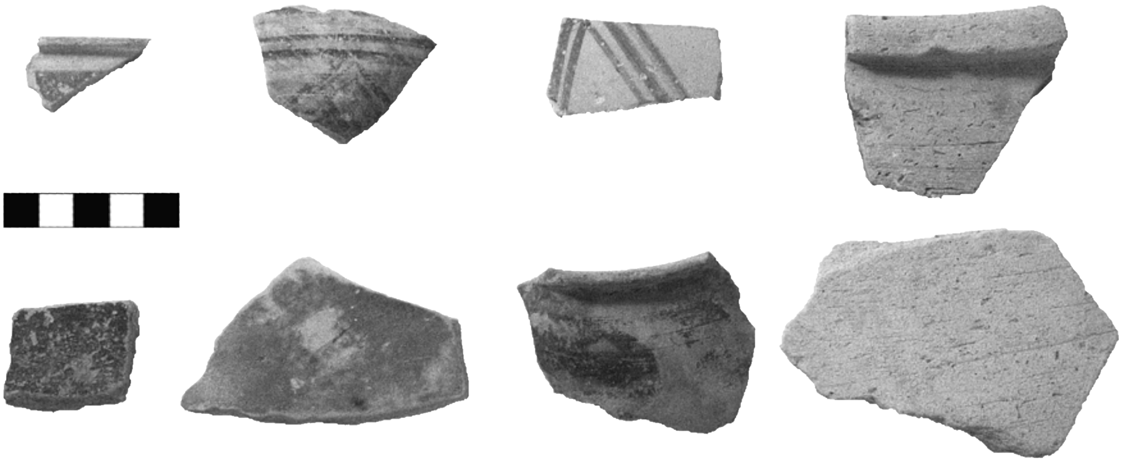

Figure 4. *Pottery sherds found at HLO-1 (lower left: Indus culture ware; top and lower right: Wādī Sūq; all others: Umm an-Nar).*

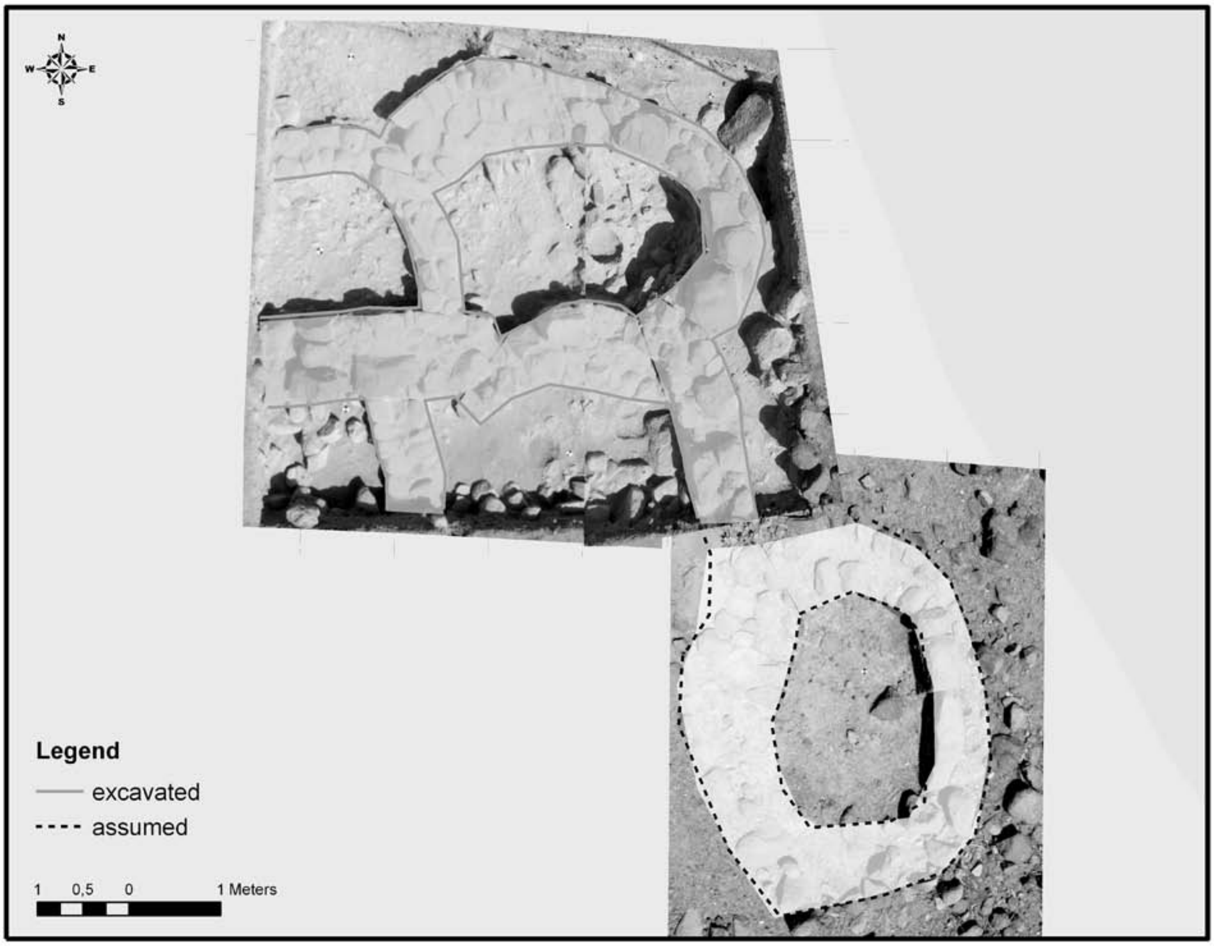

FIGURE 5. *An orthophotograph of the workshop area.*

The fact that no finds were obtained from inside the structure precluded a typological dating of the building. However, excavation of a fire pit visible in an exploration trench dug against the outer circumference of the tower yielded a radiocarbon date in the early second millennium BC (Hd-26446: conventional Age BP: 3470±34; cal BC 1886-1692 (2σ)), i.e. in the early Wādī Sūq period. As this fire pit does not extend underneath the structure, but was obviously built against it, the radiocarbon date is a *terminus ante quem* for the tower.

According to Gerd Weisgerber (personal communication), the excavator of the smelting site at Maysar in Oman, such towers are well-known features at Early Bronze Age sites in the Omani mountains and are considered to have been Umm an-Nar watchtowers. The date of the fire pit is a first indication for a continuation of the site into the Middle Bronze Age: we do not yet know if copper production continued into that period. A second radiocarbon mesurement on charcoal from a fire pit in one of the trenches near the workshop yielded the date of 3824±15 BP (Hd-27591: cal BC 2336–2203 (2σ)) which is in the Umm an-Nar period.

Another complex structure is a building with curved walls in the north-western part of the site, apparently consisting of four rooms. Our excavations reached the floor level of the room in its north-eastern corner. Its entrance was from a central corridor and a doorway is visible leading towards the room further west. This north-western room was excavated to what appears to have been a sort of floor level within the rubble filling this compartment. The connecting doorway seems to have been lifted to the relevant level. It is clear that this room

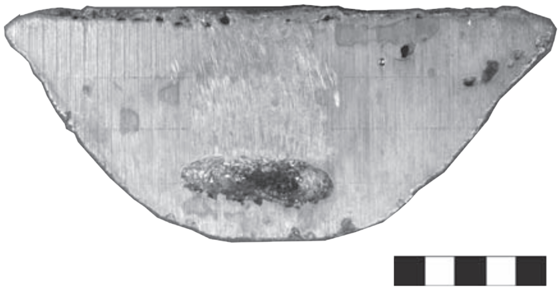

Figure 6. *A cross-section of the ingot showing a large air bubble at the bottom.*

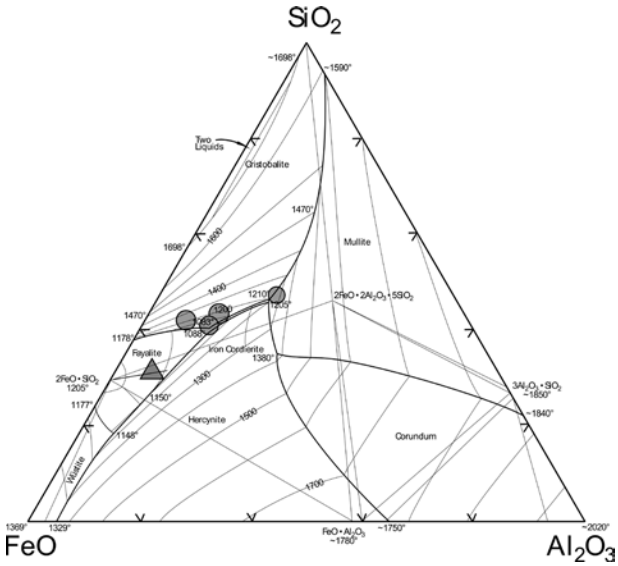

Figure 7. *A phase diagram showing the slag from HLO-1 (circles) and the average chemical composition of the analysed slag from Maysar 1 (triangle). The amounts of MnO, MgO, and CaO have been added to the amount of FeO. (Modified after Osborn & Muan 1960).*

was reused at some time after the main use of the north-eastern room. According to some potsherds, this seems to have been during the Wādī Sūq period. Apart from the fire pit dug against the watchtower, this is the only *in situ* evidence for the Wādī Sūq occupation of the site found to date.

There are also some Wādī Sūq pottery fragments from other parts of the site. However, most of the diagnostic prehistoric ceramics found at Wādī al-Ḥilo are from the Umm an-Nar period. They also include fragments of typical Indus culture ware, indicating that Wādī al-Ḥilo was connected to contemporary trade networks (Possehl 2002: 219).

Archaeometallurgy

Excavations at the foot of the slope, in the area where the slag distribution seems to have had its point of origin, revealed the massive walls of a workshop with a complex architecture (Fig. 5). The walls evidently represent several phases of use and rebuilding. At least one floor level was clearly associated with the processing of copper ore, as its greenish colour is still visible in the section. Apparently ore processing and smelting took place in this workshop, explaining the high copper content of the floor sediment. Some other interesting findings are also associated with this horizon: a round pit, lined with half-baked clay was filled with very fine-grained sediment, containing drops of oxidized copper. It appeared to have been a casting pit for raw copper. A second pit near the first one was visible but poorly preserved.

A hemispheric copper ingot (Fig. 6) was found in the vicinity of this pit. It has a diameter of 15 cm and weighs 4.6 kg and thus represents the largest such find known up to now from south-east Arabia. There are ingot fragments of similar shape from a hoard in Maysar and al-ᶜĀqir. The hemispheric shape of the Bronze Age ingots is due to the fact that they were moulded in sand pits (Weisgerber & Yule 2003: 48; Weisgerber 1981). Samples were taken from the ingot for chemical X-ray fluorescence analysis. One of them is from the corrosion layer and three from inside the ingot (top, middle, bottom). The three samples (Fig. 8) from the inside show that the ingot consists of almost pure copper (99.5%) with traces of other metals (including iron, nickel, and arsenic). The amount of nickel and arsenic is not as high as in copper artefacts from Oman whereas the content of tin, which is lower than 0.005%, is similar to those artefacts (Prange 2001: 96). The corrosion layer contains a little more iron.

In order to analyse further the technology of copper production, some samples of tapping slag were examined with the help of X-Ray fluorescence (WD–XRF) analysis. Around 40% of silicon dioxide (silica), 20% of iron oxide, 12% of aluminium oxide, 13% of magnesium oxide and 5% of lime could be observed (see Fig. 9) as the main components. There is also 1.7% of copper left in the slag. The HLO-1 slag has a chemical composition deviating from that of the slag from Maysar 1 in Oman. The most obvious difference is a much higher amount of SiO_2. All slag samples so far analysed from Wādī al-Ḥilo

	Fe	Co	Ni	Cu	As	Se	Ag	Te	Pb
Corrosion layer	3.50	0.01	0.16	96.00	0.18	0.01	0.02	0.01	0.06
Top	0.17	-	0.10	99.56	0.04	0.03	0.01	-	-
Middle	0.22	-	0.09	99.53	0.05	0.01	0.02	0.02	-
Bottom	0.21	-	0.08	99.55	0.05	0.02	0.01	-	-

Figure 8. *XRF-analysis results of the copper ingot.*

Main and minor elements in wt-%										
Sample	SiO_2	TiO_2	Al_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5
1019	42.29	0.23	11.60	28.87	0.21	13.02	5.50	-	0.30	0.06
1077	38.03	0.21	11.10	36.31	0.10	7.14	11.09	-	0.20	0.02
1183	39.20	0.20	11.60	34.53	0.13	10.49	6.43	-	0.14	0.03
291	44.09	0.16	6.00	44.68	0.08	7.20	4.81	-	0.23	0.05
Maysar 1*	29.50	0.17	5.92	41.19	0.31	8.41	8.31	0.51	0.53	0.08

Trace elements in ppm															
Sample	Sc	V	Cr	Co	Ni	Cu	As	Sr	Y	Pb	Ba	La	Hf	Ta	S	Cl
1019	364	224	1060	357	547	17314	-	520	8	4	366	2	60	68	116	175
1077	432	278	1015	206	296	21266	62	492	9	9	496	8	78	116	303	223
1183	539	227	1114	217	488	26675	47	425	4	10	546	-	99	138	538	112
291	411	225	945	247	483	21256	60	512	2	9	447	7	72	80	213	671
Maysar1*	-	-	2177	1456	1000	16900	-	-	-	-	-	-	-	-	2700	-

Figure 9. *X-Ray fluorescence (WD–XRF) analysis of tapped slags from HLO-1 and the average values of tapped slags from Maysar 1. (*data for Maysar after Hauptmann 1985: 41, table 4).*

contain over 10% more silica than the slag from Maysar. In addition, the amount of Al_2O_3 is higher in the HLO-1 slag. On the other hand, the quantity of FeO is lower (see Fig. 7). Further research will be necessary to indicate whether these discrepancies are due to differences of the respective ores, or whether they are the result of deviating technologies.

With the help of a phase diagram (Fig. 7) a temperature of around 1200°C can be estimated at which the slag was liquid. Together with the chemical composition this indicates that the HLO-1 slag is so-called Fayalite with a high silica and aluminium oxide content. The phase diagram also depicts the difference between the slag from HLO-1 and Maysar 1.

Figure 2 shows the distribution of slag on the surface and the densest part is indicated by the hatched area. This area comprises about 2800 m^2. An exploration trench opened here contained approximately 100 kg of slag per square metre, therefore there are roughly speaking at least 280 t of slag on the site. The weight proportion of slag to metal is between 5:1 and 10:1 (Hauptmann 1985: 108; Weeks 2003). Thus, the estimated amount of copper produced at the site is between 28 and 56 t.

The natural base for the local copper production is an ore vein, the remnants of which are still visible in the landscape. The ore efflorescence is embedded in the local ophiolite, a fairly hard rock which was probably not easy to break. Some tools associated with mining were found on the surface, such as a grooved hammer stone, which is a typical tool of early miners. Much more numerous on the surface are indications of ore processing — in particular as evidenced by pitted crushing stones of all sizes, some of them with multiple pits, and many of them reused to line the Islamic graves in the northern part of the site. These tools clearly indicate the local extraction and processing of the copper ore.

Conclusions

Two seasons of exploration at the Bronze Age smelting site in Wādī al-Ḥilo yielded promising results. It seems that, after the work done twenty-five years ago at Maysar in Oman, another such site has come to the attention of archaeology. Future excavations at the site — especially in the workshop areas with their deep sedimentation along the bottom of the slope — will, it is hoped, shed further light on the smelting technology of the Early Bronze Age. The evidence for the presence of people at the site during the Middle Bronze Age allows us to hope for indications on the metallurgy of the Middle Bronze Age. Indigenous copper production must be at the origin of the rich metal finds in many Wādi Sūq burials of south-east Arabia.

References

Hauptmann A.

1985. *5000 Jahre Kupfer in Oman.* i. *Die Entwicklung der Kupfermetallurgie vom 3. Jahrtausend bis zur Neuzeit.* Bochum: Deutsches Bergbau-Museum.

Osborn E.F.& Muan A.

1960. System K2O–Al2O3–SiO2. Plate 5 in *Phase Equilibrium Diagrams of Oxide Systems*. Columbus, Ohio: The American Ceramic Society/The Edward Orton, Jr. Ceramic Foundation.

Possehl G.L.

2002. *The Indus civilization: a contemporary perspective.* Walnut Creek, CA: AltaMira Press.

Potts D.T.

1990. *The Arabian Gulf in Antiquity.* Oxford: Clarendon Press.

2001. Before the Emirates: an Archaeological and Historical Account of Developments in the Region c. 5000 BC to AD 676. Pages 28–69 in I. al-Abed & P. Hellyer (eds), *United Arab Emirates: a new perspective.* London: Trident Press.

Prange M.

2001. *5000 Jahre Kupfer in Oman.* ii. *Vergleichende Untersuchungen zur Charakterisierung des osmanischen Kupfers mittels chemischer und isotopischer Analysenmethoden.* Bochum: Deutsches Bergbau-Museum.

Weeks L.R.

2003. *Early Metallurgy of the Persian Gulf: Technology, Trade, and the Bronze Age World.* Boston, MA: Brill.

Weisgerber G.

1981. Mehr als Kupfer in Oman: Ergebnisse der Expedition 1981. *Der Anschnitt* 33/5–6: 174–263.

Weisgerber G. & Yule P.

2003. Al-Aqir near Bahlāʾ — an Early Bronze Age dam site with planoconvex “copper” ingots. *Arabian Archaeology and Epigraphy* 14/1: 24–53.

Authors’ addresses

Johannes Kutterer, Institute of Pre- and Protohistory, Centre of Scientific Archaeology, University of Tübingen, Rümelinstraße 23, 72070 Tübingen, Germany.

e-mail johannes.kutterer@uni-tuebingen.de

Sabah A. Jasim, Directorate of Antiquities, Department of Culture & Information, Government of Sharjah, PO Box 5119, Sharjah, UAE.

e-mail sjasim@archaeology.gov.ae