Fig. 1. One of the bronze swords from Qidfa shown before conservation. A small 1mm hole was drilled in an inconspicuous place to remove a sample for compositional analysis. It will be filled as part of the conservation treatment.

U.A.E., namely Umm an-Nar, Qattarah and Qidfa. The three sites represent different archaeological periods and, consequently, different technological horizons.

The earliest group of artefacts are representative of the second half of the third millennium B.C. from the island of Umm an-Nar. The group consists of five simple objects, mostly pins and awls. These objects were very basic forms and not sufficient for typological study. The metal compositions had some characteristics similar to other Umm an-Nar objects, for example with 1–2% of nickel and arsenic. However, the concentrations of tin at 1.5%, 0.6% and 0.2%, respectively, in three of the analyzed objects represents a significant discovery. Although, one object alloyed with tin may seem early for the Umm an-Nar period in the area, the actual alloying with tin and the implied organized trade routes to tin sources would not be unexpected in comparison to what was previously known about the Umm an-Nar acquisition of other materials, such as gold, lapis lazuli and cornelian (Weisgerber, 1985).

The second group of artefacts come from a grave at Qattarah, in the Al Ain oasis. These finds form a representative collection of weapons from a classical Wadi Suq context, c. 2000 B.C. Except for one example with about 5% tin, the other short daggers and triangular blades are unalloyed with tin. The concentrations of arsenic and nickel are below about 1%. Socketed spearheads have similar compositions.

The latest group is from Qidfa, a site on the east coast of the Oman peninsula. The collection is tentatively dated to the latter part of the second millennium, B.C., in an early Iron Age context. From the collection of 26 analyzed arrowheads from Qidfa, the tin concentrations seem random, with no correlation between tin concentration, shape or incised decoration. In contrast, four examples of swords/daggers (32–40cm in overall length; Fig. 1) from Qidfa have between 7–9% tin with the inferred deliberate control of composition. Three heavy rings (each 530–1,220gms.) were analyzed as well showing tin concentrations between 8–13%. A shafthole axe and an adze were also alloyed with tin.

From the objects studied, there appears to be a good understanding of the advantages of cold-working and annealing copper for the material from both Qattarah and Qidfa. The utilization of copper-tin alloys was much more prevalent at Qidfa and seems comparable to alloying practices at later dates (Weisgerber, 1988). A preliminary typological investigation of this material revealed many parallels with other finds from Oman and the U.A.E., both in composition and form. Wider parallels were identified, with the material displaying similarities to material from western Iran, the Talysh region of Iran and from Syria/Palestine. The triangular dagger blades from Qattarah and the heavy rings from Qidfa, however, seem unique to the Oman peninsula. From the results, the introduction of tin to allow widespread use of bronze for weapons and other objects at Qidfa can be documented and manifest characteristics of both imported as well as local metalworking traditions.

The excavator and curator of the material from Qidfa and Qattarah is Dr Walid Yasin of the Al-Ain Museum. Loan of the objects to the Institute of Archaeology, University College London, for archaeo-metallurgical analysis and conservation (Fig. 2) was arranged by Dr J. Merkel through the Tourism and Antiquities Directorate, Al-Ain, Emirate of Abu Dhabi. The archaeo-metallurgical investigation of the material is now complete. It was undertaken as a M.Sc. report by the author under the supervision of Mr C. Phillips and Dr J. Merkel in the IAMS Archaeo-Metallurgy programme at the Institute of Archaeology, UCL. Presently, the metal objects are undergoing conservation treatment by students under the supervision of Dr J. Merkel and Ms K. Tubb as part of their teaching in the course 'Conservation of Metallic Artefacts'. The loan of the objects is gratefully acknowledged. It is a splendid opportunity to work on such interesting, high-quality objects in preparation for their display at the Al-Ain Museum. *Jason Ryan*

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New Archaeo-Metallurgical Evidence for the Beginnings of Metallurgy in the Southern Levant. Excavations at Tell Abu Matar, Beersheba (Israel) 1990/1

In IAMS *Newsletter* No. 17, 1991, the Chalcolithic (4th millennium B.C.) Ghassulian-Beersheba enigma was reviewed as one of the most significant unanswered questions in the early history of the southern Levant intimately connected with metallurgy. This enigma, which was impressively emphasized by the sensational discovery by P. Bar-Adon, a member of Yigael Yadin's famous Judaean Desert Expedition (1960), of hundreds

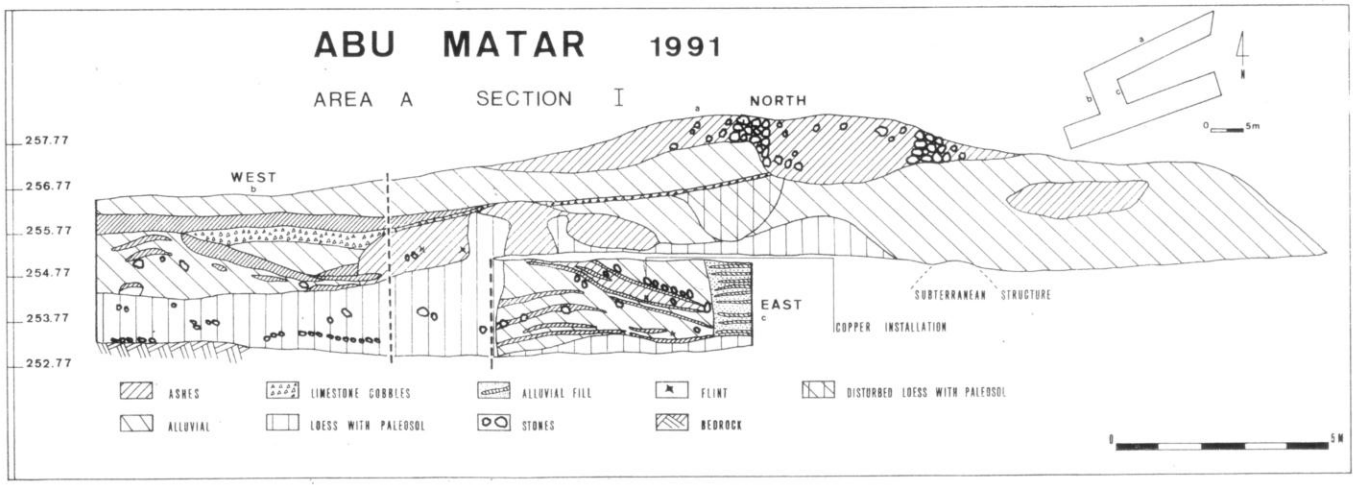
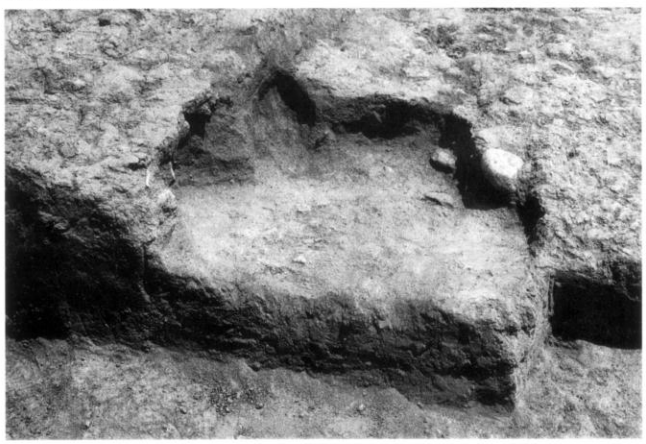


Fig. 1. The section in Trench 1, showing the location of the copper processing installation.

of sophisticated prestige metal objects in the Nahal Mishmar cave, has its focal point at Tel Abu Matar, near the town of Beersheba, in the Negev of Israel. Here, similar sophisticated prestige objects, as well as remains of more primitive, local copper working, were uncovered by J. Perrot in the early 1950's. However, because of the sparsity of metallurgical process debris in these excavations, it had hitherto not been possible to reliably reconstruct the ancient copper smelting and working technology of this early, prehistoric phase of metallurgy, or to establish the source of the sophisticated prestige objects and their manufacturing technology. The following preliminary report on the recently renewed excavation at Tell Abu Matar reviews the unique find of technologically comprehensive groups of metallurgical production and working remains, from the ores to the finished object, and their significance for the reconstruction of the beginnings of copper technology in the Chalcolithic Period. This unique find is now providing the material base for a new research programme, which will follow the trail of archaeo-metallurgy towards the solution of the Ghassullian-Beersheba enigma.

Tell Abu Matar was originally excavated by Jean Perrot in the early 1950's, who revealed a group of underground structures and stone walling on the surface above, related to the Ghassulian Chalcolithic culture (Perrot 1955; 1984). Between January 1990 and March 1991 salvage excavations were carried out at Tell Abu Matar by the Archaeological Division of Ben-Gurion University of the Negev, Beersheba, under the auspices of the Israel Antiquities Authority, and directed by Isaac Gilead, Steve Rosen and Peter Fabian. Beno Rothenberg was called in to take charge of the archaeo-metallurgical investigations. The immediate goal of these excavations was to establish the extent of the ancient site in connection with development plans in the area. Due to the huge size of the site (in the order of 1.5 hectares) it was only possible to excavate systematically a number of key points, supplemented by trenches in places where no surface remains were evident.

Fig. 2. The centre of the copper processing installation. The pit is about 60cm across.



Area A: A metallurgical workshop

Adjacent to the habitation area excavated by Perrot, Trench 1 (Fig. 1), was cut in order to provide a deep section for the study of the environmental and geomorphological history of the site, an aspect unknown from the previous excavations. Trench 1 proved to be a most informative stratigraphic section and led to the discovery of a metallurgical workshop. The section showed a series of tilted thin ash layers, which contained more stones than anywhere else in the section and here were numerous pockets of charcoal, pottery sherds, including a slagged rim of a small crucible, and many little lumps of copper slag and bits of copper. Since the stratigraphy and finds in the section suggested copper production or working, a 5m square was excavated in this area.

In the centre of this square was a shallow pit of about 0.5m diameter, with hard-baked walls indicative of high temperatures, which we considered to be a metallurgical installation (Fig. 2). Above its floor were lenses of charcoal, brick fragments, and vitrified lumps of silt. The same type of material, including also a spread of dark ashes, was found in the immediate vicinity of the installation in a circle of about 2m diameter, indicating pyrotechnical activities related to metallurgy. Evidence for this assumption can be seen in the numerous pieces of slag and fragments of crucibles, several pieces of slagged 'furnace lining' and lumps of copper ore. There was also a ceramic fragment which seems to be part of a tuyere. The small crucibles, about 6cm in diameter and 6–8cm deep, were made of the local loess, tempered with straw, and showed on their rim a thin layer of slaggy encrustation with traces of corroded copper, sometimes also

'spilling over' to the outside. Their inside had a smooth, vitrified surface. The crucibles were obviously heated from the top (not from below and outside) – typical for melting/casting crucibles. This was recently confirmed by a preliminary petrographic study of crucible fragments from Abu Matar by J. Goren (Goren 1992, unpublished ms).

Although there were fragments of bricks and vitrified brick material inside and in the immediate vicinity of the furnace-like installation, its original contours could not be established with certainty. However, the overall character of the finds related to this installation, especially the dark wood ashes close to the installation, not normally found in or near a smelting furnace, would indicate casting operations at this location. There remains of course the question of the presence of ore lumps and fragments of slagged 'furnace lining' at this location, but these could well be stray finds from a nearby copper smelting furnace, not yet uncovered. The damaging effect of flood water (indicated by lamina in the section) above the installation caused, in some cases by puddling, could well have been the cause also of the dispersion of 'intrusive' metallurgical debris over the site.

About 3m west of this installation, in another shallow, pit-like depression, and embedded in a layer of ash, was a concentration of stone implements, probably connected with the metallurgical activities in this area: large cobbles, split in the centre and used as anvils and smaller pebbles with flaking and pecking marks indicating their use as hammerstones. Some of these implements showed green copper stains. There were also pieces of slag, charcoal, crucible fragments, pottery sherds and flint artefacts.

Area M: A habitation quarter – with metallurgical activities (Fig. 3)

Area M, about 100m from Perrot's excavations, was essentially a densely build up habitation quarter, where the excavation uncovered several strata of stone and brick walls and more underground structures, thereby providing a much improved picture of the nature and history of Chalcolithic Abu Matar (Gilead et al. 1991).

Dispersed between the structural remains were ore lamps, slagged furnace parts, small pieces of crushed slag and a few crucible fragments. Many more metallurgical process remains of the same kind, including a fragment of furnace wall covered by a 5mm thick layer of solid slag, were found inside a large and deep pit, located underneath a stone wall. The preserved curvature of this slagged furnace fragment indicated a furnace diameter of about 35cm.

Fig. 3. A typical habitation of Chalcolithic Abu Matar.

Although most of the metallurgical remains, found between the structures of Area M, seemed to be stray finds, these appeared to represent somewhat different metallurgical activities than the finds in Area A. Considering the character of the slagged furnace wall fragment and the small, crushed slag lumps, as well as the fact that far less crucible fragments were found here than in Area A, we would, tentatively, suggest that somewhere near or in Area M copper smelting took place in furnaces very much the type of the Chalcolithic furnace at Timna Site 39 (Rothenberg 1990, 4–6).

Area B: Chalcolithic remains underneath a farmhouse of the Arab Period

In a 1.5m thick debris layer underneath the Arab farmhouse, located about 80m west of Area A, numerous metallurgical finds were made, consisting of ore and/or slag nodules, copper prills, some larger lumps of copper ore and slag, and several corroded copper objects. This find clearly shows the wide extent of metalworking at Chalcolithic Tell Abu Matar. It appears that metalworking of one kind or other took place almost everywhere in the area of this Chalcolithic settlement, inside and outside the actual habitation quarters.

Summary

The excavations at Tell Abu Matar provided a uniquely comprehensive assemblage of metallurgical process debris, from the copper ore and metal extraction to the casting operation and their product, the finished metal object. The scientific processing of these finds is planned to commence early in 1993 and we hope to be able to establish a comprehensive model of Ghassulian-Beersheba Chalcolithic copper metallurgy. This investigation should also establish whether, besides (unalloyed) copper metallurgy, there was also working with arsenical copper, the alloy used for the manufacture of the 'prestige objects' found at the Ghassul-Beersheba sites, including Tell Abu Matar.

One of the major aims of the archaeological and material-science investigations of the finds of Abu Matar will be to establish the stratigraphy of the commencement of metallurgical activities at the site and 'the stratigraphic moment' of the appearance of the prestige objects in the settlement. It will also be highly important to establish the character of the seemingly different metallurgical processes in the different quarters of the site, which will show the degree of craft specialisation already at this early stage of metallurgy.

Preliminary comparative studies have shown that the copper ore fragments found at Tell Abu Matar originate, most probably, from the mining area of Feinan, on the north-west of the Arabah, as already suggested by J. Perrot (1957, 38, 87, see now also Hauptmann 1989, 126–8). The evidence of widespread Chalcolithic ore trading, based on the copper mines of the Arabah – where no sites of Ghassulian-Beersheba culture have been located – represents a highly significant new parameter in the culture-history of the southern Levant.

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IAMS Workshop Series: Archaeo-metallurgy in the Ancient Near East

In the Arabah, the geological rift valley from the Dead Sea south to the Gulf of Aqaba/Elat, copper mining and smelting has taken place since early prehistoric times. The two most investigated archaeo-metallurgical areas in the region are Timna and Feinan. The remains at Timna have been the focus of interdisciplinary study for almost thirty years under the direction of Professor Beno Rothenberg. Feinan, to the north-east, has large scale remains of prehistoric mining and smelting which have been intensively investigated since 1984 by a team of archaeologists and scientists from the Jordanian Department of Antiquities and the Deutsches Bergbau-Museum directed by Dr Andreas Hauptmann.

The role of copper production at Timna and Feinan for the ancient history of the southern Levant, however, is not yet fully understood. Recent publications of the results of these investigations have caused lively debate in scholarly journals, especially relating to the chronology of the sites and proposed reconstructions of the metallurgical processes and installations. There are a number of other critical issues which have not yet been resolved concerning trade in ores and copper for different archaeological periods. Unfortunately, since the modern border between Jordan and Israel separates these two ancient metallurgical centres in the Arabah, it has not been possible before to approach the problems by detailed comparative studies.

Therefore, this first in a planned series of specialist workshops addressed **Archaeo-Metallurgy in the Arabah, The Negev and Sinai.** The main purpose for this workshop was to provide an informal forum for discussion of the archaeo-metallurgical evidence from these contiguous regions. It was co-organized by the authors and took place on 23–24 October 1992 at the Institute of Archaeology, University College London. Archaeologists and scientists actively engaged in archaeo-metallurgical research in the Wadi Arabah attended from Germany, Great Britain, Jordan and Israel.

The workshop was divided into three parts. The first was dedicated to dating archaeo-metallurgical activities and culture historical problems in the Arabah. B. Rothenberg and J. Glass proposed a developmental sequence for copper metallurgy based upon three technological stages. Evidence for this division was extensive study of the mineralogical and chemical composition of pottery both from Timna and Sinai. Rothenberg especially stressed the enigma of the Ghassulian and Beer Sheba cultures relative to the developments in the Chalcolithic of the Arabah and Sinai. He proposed a Late Neolithic date for the earliest copper smelting site (F2) at Timna. The development of mining technology at Feinan from the Chalcolithic up to the Roman period was explained by G. Weisgerber. He was able to set up a chronology both by archaeological evidence and 41 radiocarbon dates derived from charcoal samples from different archaeo-metallurgical sites. At Feinan it was not possible, even by extensive archaeological excavation at Tell Feinan by M. Al-Najjar, to find evidence of smelting activities earlier than the middle of the fourth millennium B.C. During the fourth millennium, the copper ore itself was traded to settlements in the Negev and had been smelted there. Very interesting are changes presented by S. Shalev in copper metallurgy from the Chalcolithic period to the Early Bronze Age. During the EBA, copper ore was smelted near the mines and the metal traded. Early Bronze Age smelting sites have been reported from both Timna (EB IV) and Feinan (EB II). W. Fritz reported on the excavation of an EB II and Iron Age site at Barqa al-Hetiye in Feinan. Midianite pottery is present at this site.

The second major topic dealt with the evaluation of provenance studies based upon lead isotope analyses and geochemical data from Timna and Feinan. Z. Stos-Gale voiced concern regarding sample numbers used for characterization of ores and slags. It was agreed that it is necessary to compare artefacts with both the ore deposit itself and slags at the smelting sites. This contribution was followed by a lecture on the most recent measurements on lead isotope composition of ores from Timna by N. Gale in comparison with the data available from Feinan. So far, more than 50 ore samples have lead isotope results at Timna. Generally, the Timna ores have a similar pattern as the ores from the Dolomite-Limestone-Shale Unit at Feinan, but overall reveal a larger range. As emphasized by E. Pernicka, not only lead isotope analyses, but also the geochemical characteristics of the ores, slags and metal are necessary to study provenance. Slags are particularly important to provide a direct link between ores and metals. The increasing number of isotope and chemical data for Timna and Feinan provide an excellent basis for future research on the provenance of metal artefacts from the region.

In the third session, aspects of extractive metallurgy were discussed. It could be demonstrated by the investigation of slags and metals from Feinan (A. Hauptmann) that very pure copper ores have been smelted during the