The Trustees and Director of IAMS wish to dedicate this issue to the memory of their colleague, Professor R. F. Tylecote

Archaeo-Metallurgy on the Trail of History

Archaeo-metallurgy, the study of extractive metallurgical processes and metal working technology, has made impressive progress during the last generation, but the impact of these studies on a better understanding of the metal-related social and economic aspects of ancient communities and, more so, on wider historical developments, is not yet really noticeable. The fact that most archaeo-metallurgists come from the field of material science and not from the humanities seems to have predetermined the direction of archaeo-metallurgical research so far. Following up Researches in the Arabah, and as part of its endeavour to evolve archaeo-metallurgy as a better tool of historical research, IAMS has lately initiated several trial programmes, dealing with metal objects excavated in Israel. Since these programmes involved work by different specialists, who do not always look in the same direction nor agree on interpretations, and also work by others from outside our IAMS group, it was thought appropriate to let each of our colleagues speak for himself on the following pages. A concluding epilogue draws together the relevant historical implications of these specialised scientific reports and notes.

FOREWORD

The investigation of the metal finds of an ancient culture often shows a specific metal implement or object, by itself and in relation to other objects in the same context neither very impressive nor outstanding, as being characteristic for its technology and style. In this sense it may often be considered as representative for many aspects of its culture, including problems of chronology and, especially, of provenance. For this reason we initiated detailed scientific studies of several such 'type-objects' – which by themselves had important archaeo-metallurgical results – to serve as possible pathfinders into complex historical enigmas.

1. A Chalcolithic mace head from a cave in the Judean Desert.

In 1960, in the context of the famous Judean Desert Expedition directed by Y. Yadin, the archaeologist P. Bar-Adon discovered in a cave in Nahal (Wadi) Mishmar a huge hoard – wrapped in a reed mat and hidden in a crevice in the bottom of the cave – of unusual metal implements of unique type and beautiful design, dated to the Chalcolithic Period, fourth millennium B.C. (Bar-Adon 1971 in Hebrew, English final version 1980). Archaeological evidence found in the cave related these metal objects to the Ghasulian–Beersheba culture, excavated mainly in the southern Jordan Valley and in the region of Beersheba.

The Ghasulian–Beersheba enigma

This extraordinary discovery raised a great deal of interest in previous excavations by J. Perrot (1955), where this unique culture had been identified in a group of settlements along the Nahal (Wadi) Beersheba, in the northern Negev. The economy of these settlements was basically agriculture, as was shown by a whole range of vessels, tools and remains of cultivated plants, like cereals and fruits, found in the excavations. There was, however, something rather unusual about them: large groups of interconnected, dug out, 'underground dwellings', were found by the excavator (Perrot 1955; 1984) to contain numerous stores of vessels and goods, also hearths, silos and stone mortars; in short, the typical equipment of a farming community. Even if we accept the quite convincing argument (Gilead 1987, 110–17), that these subterranean cavities were not habitations but storage structures, the organisation of these villages remained rather unusual, especially when seen within the chain of the pre- and proto-historical habitational developments of this region. If we add here the extraordinary cult and prestige objects of ivory and metal found in these villages - most of which were obviously most valuable imports from a very different social and cultural environment and extremely difficult to fit into the picture of an indigenous farming community in the semi-arid northern Negev – we are definitely facing a unique culture-historical enigma.

Furthermore, the discovery of the Ghasulian–Beersheba treasure in the caves of the Judean Desert and the extraordinary technological as well as aesthetic level of
these hundreds of cult or prestige artefacts, should be taken as strong indication that we are dealing with an intrusive culture, perhaps groups of newcomers who emigrated into this region, soon mixing with and dominating the indigenous population. But who were these people and where did they come from? If archaeology cannot find an answer to these basic questions, could archaeo-metallurgy come to its assistance?

It should be mentioned here that no traces of the Ghassulian-Beersheba culture have yet been found in the Southern Negev, the Arabah, Sinai and North-west Arabia. The Chalcolithic settlements and mining and smelting sites of these areas remained essentially confined within the mainstream of the autochthonous cultural development of this arid region, untouched by the newcomers in the north.

The Nahal Mishmar Treasure of over 400 copper objects consisted of 'crowns', standards and sceptres, horns, jars and mace heads of exquisite workmanship, but also a small number of simple copper working tools, like axes, chisels and a shafted hammer. C. A. Key (1964, also in Bar-Adon 1980, 238–43) discussed the results of his spectrographical investigation of a selected group of metal objects from the Treasure, as well as a standard from Abu Matar (Beersheba) and a mace head and axe from Nahal Seelim, which belong to the same cultural context. Key concluded that the metal objects of the Treasure must be metallurgically separated into two main groups which were probably manufactured in 'two different workshops' - one for secular and one for ritual objects'. The tools, the secular objects, which he found to contain only some traces of silver and, occasionally, nickel, may have been forged from native copper, i.e. metallic copper found in nature. The ritual objects, i.e. the main part of the treasure, were cast by the lost wax technique from arsenical copper which was smelted from complex sulphidic copper ores - most likely originating from Armenia or Azerbaijan.

**Mace heads**

Conspicuous among the numerous cult objects of the Nahal Mishmar Treasure by their sheer quantity were about 240 copper mace heads (Fig. 1) of different sizes, weight, shape and colour. The mace head was a key weapon for hand-to-hand fighting in prehistoric times - until the appearance of the helmet (Yadin 1963, 1, 120–5) - and was evidently also a symbol of status. It is found in excavations in Egypt, Palestine and Syria and is present in almost each of the Chalcolithic settlements recently excavated in the Beersheba region.

Two, almost identical, copper-based mace heads were also found in a cave in a tributary of N. Badir (Aharoni 1961, 11–24). In the early 60's one of the pair was investigated by Key (1964; 1980, table) and the other was made available to our group for metallurgical studies. We soon ran into difficulties. The results from the investigation of our N. Seelim mace head (high Sb and As, probably from 'gray ore', faulerz) were significantly different from the analytical results obtained by Key from his N. Seelim mace head and from the 'ritual' objects of the Treasure. After discussing the problem with Ronnie Tylecote (Tylecote 1977, 314 and M38 on Table 9), and because it was not possible to clarify this problem without the scientific study of other objects from the Judean Desert finds - which remained unreachable for scientific research for almost a whole generation - Tylecote and myself put the issue temporarily aside.

**A new approach**

Several years later Michael Notis (Notis et al. 1984, 242) investigated once more our mace head from N. Seelim and we have now returned to it in the context of the research programme outlined above. In the meantime, Shiqqim, another important site in the area belonging to the Beersheba culture, was excavated and its metallurgy investigated by S. Shalev and P. Northover. The latter wrote a short report for us on recent, so far unpublished, analytical work on metal objects from the Treasure which has important implications for the problems discussed here.

To return to the historical implications of our archaeo-metallurgical studies in line with the programme outlined above, we turned to the problem of the nature and provenance of the metal, and technology, of our mace head, to serve as a path-finder into the Ghassulian-Beersheba enigma.

Provenance studies by way of the trace element groupings in the metal - until recently very fashionable among scientists dealing with archaeological materials - have been rather disappointing. Already in the 60's, studying the metallurgical debris at Timna, it struck me that it would be impossible to trace the copper prills from the smelting slag of Timna to the copper ore deposit nearby, which must evidently have been the source of the ores for the copper smelters of Timna. The obvious reason for this is the basic fact that the copper smelting process requires in almost every case the use of fluxes. In Timna iron oxide ore was available as a good flux from the same or similar geological horizon as the copper ore - and with the addition of such fluxes, the trace element picture becomes either significantly distorted or even totally altered (Rothenberg 1972, 237).

To establish the provenance of metal by its lead isotope composition is also far more complicated than was assumed during the initial years of the use of this new method, especially if we expect definitive, positive statements about the origin of a metal object from a certain ore body. Such definitive statements would only be possible on the basis of comprehensive chemical-mineralogical data about the ores, fluxes, fuel, slag and refractories - each a contributor of trace elements - as well as the composition and structure of the primary metal product. In addition, information would be needed concerning the smelting and refining processes, and in particular the partition of the trace elements during these processes - all of which resulted in the production of the
metal object whose origin we were investigating. If this information is not available, the lead isotope composition may be consistent with the derivation of a metal object from a certain ore source, but will not be consistent with its trace element pattern. This situation is fundamentally similar to the problem of trace element provenancing in Timna, as described above and, as at Timna, can only be properly overcome by detailed extractive metallurgy.

Yet, even a negative statement, i.e. the exclusion of certain regions and their ore deposits on the strength of lead isotope ratio pattern, can be of considerable assistance to the archaeologist and still be an indication of possible provenance. Z. A. Stos-Gale investigated the lead isotope ratio composition of the N. Seelim mace head, and of the copper ingot discussed below, and her report, though only partly positive, is of considerable significance in the present context.

2. Bar-shaped copper ingots from Early Bronze IV settlements in the Negev (Fig. 2)

The work reported below continues the series of investigations discussed in ‘Metalworking Technology at the End of the Early Bronze Age in the Southern Levant’ by J. F. Merkel and W. G. Dever (IAMS Newsletter No. 14, 1989, 1–4), and ‘The Discovery of a Copper Mine and Smelter from the End of the Early Bronze Age (EB IV) in the Timna Valley’, by B. Rothenberg and C. T. Shaw (IAMS Newsletter No. 15/16, 1990, 1–8).

The ‘EB IV enigma’ briefly outlined in the latter paper, was seen to be intimately connected with the ‘composite’ character of the EB IV population/culture of the region, i.e. the influx of more advanced newcomers from the metal-rich north which introduced the use of tin-bronze, and their integration into the local, indigenous population which previously had only known and worked unalloyed copper, presumably from local sources. It was therefore not surprising that systematic studies of EB IV metal objects from the Levant had established the coexistence of two distinctly different but contemporary metalworking technologies: one was a rather simple casting technology of unalloyed copper, followed by a certain amount of cold working for final shape and hardening of the working edges, mostly employed for the production of tools and other unsophisticated copper objects. This copper technology was found all over inland Palestine, the Negev and Sinai, evidently going back to Chalcolithic times. The second technology was based on the use of copper-based alloys — arsenical copper and proper tin-bronze — often involving the use of sophisticated ‘lost wax’ casting techniques. Most of the EB IV tin-bronzes (mainly weapons but also intricate jewellery as well as ‘torques’), were found to the north of the more arid parts of the region, where unalloyed copper remained the commonly used metal throughout EB IV. Occasionally, there was an ‘infiltration’ of tin-bronze objects into the south, especially of weapons and other prestige objects, but not a single workshop containing metalworking installations, crucibles and slag, relating to the use of tin-bronze has so far been unearthed in any of the numerous excavations of EB IV sites of the south.

Typologically, EB IV tin-bronzes have been found all over the Levant and several types of prestige objects could be followed even as far as the Balkans. At present our IAMS group is trying to follow the trail of these objects and systematic lead isotope studies are part of our programme. Following up the discovery and excavation by our group of an EB IV copper smelter in the Timna Valley (Rothenberg and Shaw 1990), we initiated a systematic study of the indigenous copper technology of the south. Besides the EB IV copper mining and smelting centre (Sites 250 and 149) in the Timna Valley and several mining-related EB IV settlements nearby in the Arabah, a number of EB IV copper smelting sites, as well as numerous food producing settlements, were located in the copper mining regions of South Sinai. In our deliberations on EB IV local metal production we have, of course, to take into consideration this wide distribution and the almost industrial scale of EB IV copper production in the arid south.

Special attention was paid to the appearance of triangular (in section) bar-shaped ingots of unalloyed copper from several EB IV settlements in the Central Negev (Beer Ressim, Har Jeruham, Ein Ziq), and also in the Hebron Hills, allegedly near the village el-Hadab, north of Dhaquirah (Dever and Tadmor 1976, 163–9) and occurring at Lachish, about 50 km north of Beersheba (Tufnell 1958, Pl. 21). Evaluating the archaeological and archaeo-metallurgical evidence unearthed in the EB IV smelter of Timna revealed not only advanced smelting installations and techniques for the production of primary copper on a scale previously unknown in the smelters of the region, but there was evidently also crucible extraction and refining of crude copper and probably casting of bar-ingots (Rothenberg and Shaw 1990, 8).

The next step in the research programme was the metallurgical investigation of some bar-ingots and, most significant, their provenancing by lead isotope studies. Previous investigation of several bar-ingots (Maddin and Stech-Wheeler 1976) had shown that they were secondary castings and ‘made from weathered copper ores containing galena and iron ores were added as flux’ (more likely oxidized copper ore with iron oxide flux containing lead, as established at Timna). To cast a bar-ingot would only require a flat stone with a triangular groove carved into its surface, not easy to recognize among the masses of discarded stones of a smelting site.

One bar-ingot from the Har Jeruham hoard was previously analyzed for lead isotopes (Brill and Barnes 1988) and found to plot into the field of Timna (Fig. 4).
This result, strengthened by the correspondence of the trace element pattern between Timna copper ingots (Roman 1988), the Har Jeruham bar-ingot and other bar-ingots from the Negev, strongly indicated the Timna region (and perhaps also Feinan, in the north-eastern Arabah – see below) as a copper source for the EB IV settlements of the Negev and also further afield. However, further analyses were obviously required to establish what we tentatively assumed to have been the EB IV copper trade route from the south, i.e. the local parameters of the EB IV enigma.

The Ein Ziq bar-ingots

The recent find of an EB IV hoard of 12 bar-shaped, triangular ingots, as well as stray finds of another bar-ingot and some fragments, in a settlement near the spring Ein Ziq (Cohen 1986, 295–6), provided suitable samples for this additional research. The hoard of bar-ingots was found hidden underneath the threshold of a house but no process-related metallurgical debris has been reported from this or any other of the houses in this settlement.

The EB IV site, located on a hill top near the bank of Nahal (Wadi) Ziq, north of the Ramon Crater, is one of the largest settlements of this period in the Negev mountains (Cohen 1986, 252–70). Its geographical location, deep south in the Negev mountains, made its connection with the copper mines of the southern Arabah (Timna, N. Amram), or even Sinai, much more likely than a connection with the copper mines in the region of Feinan, south of the Dead Sea – providing, of course, that there was at all such a connection to local copper sources.

Beno Rothenberg

3. A Mace head from a cave in N. Seelim

This mace head is similar in shape and form to those illustrated by Bar-Adon (1980, 119); the inside of the shaft hole still retained the clay core around which the head had been cast. The clay is not completely enclosed in cast metal, as is shown on p. 235 of Bar-Adon. Microprobe examination of the polished metallographic section (Fig. 3) indicated the majority of the structure to be a two-phase material. The major phase, occupying about 90% of the cross-sectional area, is a Cu-Sb-As alloy giving the following approximate analysis: 95.3 Cu−2.4 Sb−2.4 As (wt. %). The minor phase appears to be a complex intermetallic sulfide with approximate composition 61.3 Cu−25.3 Sb−7.8 As–S–b. S (wt. %). In addition to these phases there are at least two other types of inclusions found in much smaller amounts: copper sulfide with a small amount of Sb and As, and a copper-bismuth phase with small amounts of Sb and S. The overall alloy composition appears to have a combined Sb+As analysis of 9. + 0.6 (wt. %).

It appears that this mace head has been smelted and cast from 'gray ore' or fahdcrz containing tetrahedrite (Cu₆Sb₅S₁₀) and chalcocite (Cu₂S). These types of ore may have an appreciable portion of the Sb replaced by As, and Bi concentrations typically run quite high. This ore is distinctly different from those found at Timna (Milton et al. 1976) and Abu Matar (Tylecote et al. 1974), but it also appears to be different from the mace heads found at N. Mishmar, N. Seelim, and Abu Matar, all of which have little Sb content (Bar-Adon 1980). It thus appears that considerably more detailed and updated microanalysis is warranted on these mace heads as a group.


4. The Chalcolithic metal industry at Shiqmim and the Nahal Mishmar hoard

a. Pioneering metallurgical investigation of the N. Mishmar hoard was conducted by C. A. Key (1964, 1980) using emission spectrographic analysis. Key defined the technological differences between the two groups of objects as tools of 'unalloyed' copper and 'ornaments' (the cult/prestige objects) made of arsenical copper 'alloys' (1.9%–11.9% As). On the basis of his analytical results, Key reached the following main conclusions: 1. The tools might represent the forging of native copper. 2. The 'ornaments' show that a complex sulphide ore was used for their manufacture, which required long distance cultural contacts with Transcaucasia, Armenia and Azerbaijan, and the knowledge of roasting the ore before smelting.

b. Metal objects found in the Chalcolithic village of Shiqmim showed that the same correlation of two different metal types with two types of artefacts (tools and prestige/cult objects), as in the N. Mishmar hoard, existed at habitation and burial sites in the Beersheba region (Shalev and Northover 1987).

Furthermore, the analysis of crucibles, slags and ores from Shiqmim and some additional sites demonstrated that the tools were locally manufactured (Shalev and Northover, ibid). We assumed that carefully selected rich ores were brought to the villages of N. Beersheba from a considerable distance, presumably from Feinan, and possibly also from Timna, to be used there in a single step crucible-based smelting-melting process.

Thus, the question concerning the tools of the N. Mishmar hoard could be answered by the archaeo-metallurgical investigation of similar tools and materials connected with their production at Shiqmim. Yet the situation of the cult/prestige objects from the N. Mishmar hoard examined by Key remained obscure. Recent investigation of a mace head from Shiqmim by Shalev and Northover (to be published) revealed the same manufacturing process – lost wax casting over a

---

Fig. 3. Mace head from N. Seelim. Microprobe image indicating two-phase matrix and inclusions.
stone core – as the one mace head from the N. Mishmar hoard examined metallographically by Potaszkin and Bar-Avi (1980). However, the objects from Shiq‘im showed a consistent, important compositional difference, mainly in the antimony content, from those analyzed by Key.

These differences, i.e. the consistent low antimony content in Key’s data, could be explained, as suggested by Notis et al. (see his contribution above), by the use of a distinctly different type of ore. Yet the typological and technological similarities between the mace heads from Shiq‘im, N. Seelim and the N. Mishmar hoard, emphasized the puzzling discrepancy in their chemical composition.

We therefore re-investigated some of the material from the Judean Desert caves: nine artefacts from the N. Mishmar hoard and from N. Seelim were re-analyzed. In addition, we examined nine other objects, which had not been previously analyzed. All samples were analyzed by electron probe microanalyzer (EPMA) in Oxford and by atomic absorption spectrometer (AAS) in Tel Aviv.

The results (soon to be published) showed striking discrepancies with Key’s published data. Besides the identification of arsenic, the concentration of virtually all the other elements estimated by Key need to be altered. The most striking discrepancy is the constant minimal detection of antimony by Key, even when it is present in quantities larger than arsenic. These results correlate well with all the known data from other Chalcolithic sites and also with the additional nine samples from the N. Mishmar hoard. There is still much work to be done on the properties of such multi-phase ternary alloys, the provenance of the ores and the smelting technology involved. Comparisons with Early Bronze Age metalwork in Israel showed that the ‘Chalcolithic Beersheba’ technology was unknown there in the period.

It seems that incorrect analyses, as well as absence of more contextual archaeological evidence, led Key to his main conclusion concerning the origin of the Nahal Mishmar treasure. With our new data and re-evaluation of the metallurgy, a simpler working hypothesis can now be proposed. Not only can the small group of tools from the hoard be linked to a distinct temporal and spatial context, but also most of the prestige objects are found to bear a close metallurgical resemblance to similar objects found at Chalcolithic sites in the south. With this new data we can see the geographically well-defined distribution of these prestige/cult end-products and speculate about the existence of a production center appreciably nearer than Anatolia or Transcaucasia.

Sariel Shalev and Peter Northower

5. Lead isotope studies – a bar-ingot and a mace head from the Negev

(1) The origin of the bar-ingot from Ein Ziq

The ingot was analyzed in the Isotrace Laboratory at Oxford and its lead isotope composition is fully consistent with its origin from Timna ores. The lead isotope ratios are as follows: 208/206 = 2.11906, 207/206 = 0.86996 and 206/204 = 17.959.

The same origin can be suggested for three samples of objects published by Brill and Barnes (Rothenberg, 1988, 219–22), they are Pb-1079, yellow glass from the Timna Temple; Pb-643, a pellet of copper from Timna, and Pb-1229, a triangular copper ingot from EBIV Har Jeruham, in the Central Negev.

Fig. 4 represents a diagram of both objects analyzed at Oxford (the ingot is marked ‘Ing’, the mace head ‘MH’) together with the three objects analyzed by Brill, some ores and slags from other sites of Timna (Pb-208 is also from Brill and Barnes, the other ores are from the Oxford collection) and approximate ranges for Cyprus, Ergani Maden (Turkey) and Timna ores.

![Fig. 4. Diagram showing the lead-isotope compositions of the EBIV bar-ingots compared with those of the Chalcolithic mace head, in relation to the lead-isotope fields of Timna, Cyprus and Ergani (Turkey).](image)

(2) The mace head from N. Seelim

The mace head was analyzed isotopically twice; one sample was drilled from the external part of the object, the other from the interior. The lead isotope measurements of both samples do not show discrepancies. The lead isotope compositions of the mace head are: 208/206 = 2.06754 and 2.06770; 207/206 = 0.83179 and 0.83179, 206/204 = 18.904 and 18.905.

Currently we do not know an ore deposit which would be fully consistent with this composition. The ores from Timna analyzed so far plot separately from the

![Fig. 5. Lead-isotope compositions of the N. Seelim mace head, compared with those of the metal groups of Ugarit and Ras ibn Hani, against the lead isotope field of Cyprus and Ergani.](image)
mace head (Fig. 5). The lead-isotope composition of this object is not consistent with its origin from Cyprus or the copper mines of Ergani Maden in Turkey, or the Taurus Mountains. At present the geographical origin of the ore used for the mace head remains unknown. On the other hand, a large group of copper and lead objects (unpublished data from Oxford Isotrace Laboratory's lead isotope database) from Ugarit (Ras Shamra, a port in Syria) and Ras ibn Hani seems to have a common origin with the mace head. On Fig. 5 the objects from Ugarit are marked with letter the ‘U’, and the ‘HL’ points represent lead from Ras ibn Hani.  

Zofia Stos-Gale

EPILOGUE

The Ghassulian-Beersheba Chalcolithic enigma

The hoard of ritual/prestige objects found in a cave in N. Mishmar, in the inhospitable rock cliffs of the Judean Desert, can be seen either as a tribal treasure carried by fugitives or a rich trader’s hoard. A small number of similar objects were also found in the Chalcolithic villages of the Beersheba Valley, characterized by peculiar subterranean habitations or working/storage ‘caves’. Since many of the daily life installations and vessels of these villages can be related to the indigenous Chalcolithic culture and life style of the Southern Levant, it would seem that the ‘Beersheba culture’ is the result of the influx of newcomers from a totally different cultural environment in the process of integration into the local, indigenous population. The N. Mishmar treasure, as well as similar metal objects found in the Beersheba settlements, reflect in fact the same twofold, interlocked, cultural and technological ‘strata’: highly sophisticated metallurgy, far above the common, local, metal technology of this period in the Southern Levant and based on a type of metal totally foreign to this region. It would be rather difficult to see these outstanding objects as a local product, and no traces of a suitable workshop, nor any relatable metallurgical debris, have ever been found in any of the excavated settlements of the region. Although it is ‘risky’ to identify ‘pots and people’, it seems extremely difficult in our case not to do so. The ritual/prestige objects found in the Beersheba settlements and in the caves of the Judean Desert were apparently carried by foreign people penetrating into the region, and it would be highly interesting to know why they chose the semi-arid Beersheba Valley to settle down and why they were hiding in the caves of the Judean Desert.

The few tools, mainly chisels and small axes, found with the N. Mishmar hoard and in some of the Beersheba settlements, belonged to a different technological horizon and can be seen as reflecting an unsophisticated, local metallurgy, in line with the much more primitive autochthonic metal working tradition of the indigenous population. The archaeological study of metal objects and process debris from the excavations at Abu Matar (Tylecote et al. 1974) and Shiqmim (Shalev and Northover 1987), surely provided the evidence for the local manufacture of these tools—but the picture is still far from clear.

First, the source of the ore. Investigating the Abu Matar material, the ore was found to be ‘mainly malachite and cuprite with a small amount of chalcocite and chalcopyrite’ (Tylecote et al. 1974); at Shiqmim ore fragments are reported as ‘mainly cuprite and malachite’ or ‘largely cuprite with a low iron content (0–1%)’. Such ores could not have derived from the Timna mines (Rothenberg et al. 1978; ore from Chalcolithic smelter Site 39) and the ores of the Feinan region, as recently published (Hauptmann 1989, Table 14, 1) also do not really seem to fit the above definitions. Further research is indicated to clarify this basic question, including lead isotope studies.

Second, the nature of the slag. When first investigated in 1974, there was no proper smelting slag among the metallurgical debris at Abu Matar (Tylecote et al. 1974, 32–4), and it was therefore concluded that only melting-casting operations had taken place at Chalcolithic Abu Matar. There remained, however, the problem of the ore fragments found at Abu Matar, and the suggestion that these ores ‘must have had some other use perhaps, for example, as a cosmetic or for ritual purposes’ was never considered really satisfactory. Recent investigations of additional slag samples from Abu Matar (which Tylecote et al. had not been shown by the excavator) identified proper fayalite slag (Hauptmann 1989, Table 14, 2) and provided the missing evidence for copper smelting at Abu Matar. We now have evidence for copper smelting in a Chalcolithic village of the ‘Beersheba culture’ the technology of which seems to be very much in line with local metallurgical tradition (Rothenberg 1990, 69, Table 1; Bachmann 1978, 21–2, Table 1).

However, recent investigations of similar metallurgical debris from Shiqmim (Shalev and Northover 1987, 363–4) did not find any proper smelting slag. More so, apparently most of the slag at Shiqmim was ‘definitely associated with crucibles’. Based on this result, Shalev and Northover (1987, and above) proposed to see in the Shiqmim debris evidence for crucible smelting of copper, in fact, according to their ‘process-model’ tools were manufactured directly from carefully selected rich ores ‘in a single crucible-based melting-melting process’.

Obviously, this Epilogue is not the place for a detailed discussion of extractive process-models, but it must be stated that the Shalev–Northover hypothesis would not be consistent with the processes established for Chalcolithic smelting anywhere else in the region. It does not work with Timna nor with any of the many other Chalcolithic copper smelters in the Southern Arabah (Rothenberg et al. 1978; 1990, 4-9); nor with W. Fidan (Feinan), where proper smelting furnaces were located dating to the Chalcolithic period (Hauptmann 1989, 122–6), and also not with Abu Matar, where slagged furnace lining was found as well as furnace fragments which indicated a furnace diameter of 30–40cm, quite similar to the Chalcolithic smelter at Site 39 in Timna (Rothenberg 1978). The crucibles of Abu Matar had a diameter of about 10cm and were incrustated with proper melting-casting slag.

Our ‘path-finding’ mace head from N. Seelim, which was the first indicator that there were problems with the analyses of the N. Mishmar hoard, already indicated a
fahlore source for its metal (Notis et al.). The recent analyses of a whole series of metal objects from the N. Mishmar hoard (Shalev–Notherover) confirmed this conclusion and made it imperative to look again for its place of origin. Since analyses of prehistoric metal showed fahlore as a rather common ore especially in Chalcolithic times, we put our trust in lead isotope research to find the source not only of the metal of the ‘Beersheba culture’ but also as a possible key to the enigma of the origin of the Ghassulian–Beersheba intrusive elements: people, trade, culture transfer or whatever would explain this enigmatic phenomena.

The lead isotope study of the mace head by Zofia Stos-Gale confirmed, first of all, the exclusion of a local source for this metal and its technology, including the Arubah mines, Timna, Feinan, and Sinai. It also seems to exclude some of the major sources of copper of the ancient world, leaving many others as candidates, pending further 'lead isotope mapping' of the mineral sources of south-east Europe, the Mediterranean region and even further afield.

The possible identification of the metal source of our mace head, and through it presumably also of the N. Mishmar hoard and other Ghassulian–Beersheba metals, with the origin of a large group of copper and lead objects from Ugarit and Ras ibn Hani represents a very significant first positive trail into the Ghassulian–Beersheba enigma.

Bar-ingots from the Negev

The lead isotope mapping of all of the bar-ingots so far investigated clearly points to the Timna region for their origin. Only one EB IV smelter, Site 149, was discovered in the Timna Valley, which had produced copper on an industrial scale, and also contained evidence for crucible refining, and probably casting of copper. We may therefore, albeit still tentatively, assume that the bar-ingots of the Negev were actually produced in this workshop.

The distribution of the EB IV settlements where bar-ingots have been found, clearly indicates a wide spread of this merchandise, and the line Hebron Hills – Har Jerusalem – Ein Ziq perhaps represents the actual copper route from the far south to the hills of Jerusalem.

The tentative conclusion above has its reason in the fact that the geology of the Feinan region is very similar to that of the Timna region and we may find that the lead isotope ratios are also very similar. This would require a more detailed study of the extractive parameters, especially the trace element distribution between the ores and fluxes and the detailed local geology of the mineralized zones and their lead isotope ratios.

The EB IV phenomena is still enigmatic in its basic parameters, as described in the previous IAMS Newsletters issues, and the finger-printing of the bar-ingots to a source in the Arubah is of considerable significance. The archaeological evidence in Timna – and incidentally also at the metallurgical sites of southern Sinai – tends to emphasize their indigenous character, as it is obvious that in this area we do not have the solid 'intrusive' presence of the more northern EB IV sites. At this stage of our knowledge it would appear that the bar-ingots are a local product of somewhat limited distribution – still pure, unalloyed copper as are most of the local metal objects of this region. For the next step of isotope study we intend to use an arsenical copper-type object as well as a proper tin-bronze as path-finders to trace the 'intrusive' elements of the EB IV enigma.

Beno Rothenberg

References

Additional copies of this Newsletter can be obtained from the IAMS Secretarial Office, Institute of Archaeology, University College London, 31–34 Gordon Square, London, WC1H 0PY.

Telephone: 071-387 7050, ext. 4721.
Ronnie Tylecote – through the desert to IAMS

In Ronnie’s now classic book *Metallurgy in Archaeology* (London 1962), appeared the first proposal for the reconstruction of a copper smelting furnace at Timna, based on the descriptions of the metallurgical finds made during my Arabah survey and first published in my report ‘Ancient Copper Industries in the Western Arabah’, *Palestine Exploration Quarterly*, 1962. Since this paper in *PEQ* had caused a ‘tidal-wave’ of opposition by eminent representatives of Biblical Archaeology against my conclusion that Nelson Glueck’s metallurgical theories about ‘King Solomon’s Mines’ and, foremost, the ‘huge Solomonic copper smelter of Ezion-Geber (Tel el Kheleifeh on the shore of the Red Sea), “Pittsburgh” of the Near East’, were not acceptable from the point of view of the facts in the field and basic metallurgy, this was the first, and very welcome, sign that metallurgists took the Timna findings seriously.

Several years later, in 1966, Ronnie walked into my excavation of the large smelting camp Site N.2 in the Timna Valley, accompanied by Alexandru Lupu, metallurgist of the Technion Haifa, who shortly before had joined my Arabah team. First I was somewhat upset about the unannounced ‘visitor’ but I soon became fascinated by Ronnie’s personality, his straight-forwardness and unreserved readiness to share information and experience. For several days we inspected the Timna sites and the metallurgical debris uncovered at Site No. 2, including the first almost complete copper smelting furnaces ever discovered. These days laid the ground for our collaboration – and friendship – which was to last for more than twenty-five years. Believing that scientific information should be made available as soon as possible, Ronnie immediately drafted the first metallurgical report on our Timna excavations: R. F. Tylecote, A. Lupu and B. Rothenberg, ‘A Study of Early Copper Smelting and Working Sites in Israel’, published in *Journal of Metals* 95, 1967.

During the years that followed, Ronnie took part in the excavations at the Roman-Early Islamic smelter at Beer Ora, the Egyptian Mining Temple at Timna, and he dug the first trial trench at the Egyptian smelting camp No. 30 in Timna, which was decisive for our work plans afterwards. Ronnie also took part in several of our field expeditions in Southern Sinai and himself excavated an Early Bronze Age smelting furnace (at Site 590 in Wadi Riqeit). It was quite astonishing to watch Ronnie
working with heavy tools in the heat of the desert, in spite of his handicap (a leg lost in a climbing accident). In the enormous slag heap of Bir Nasib, in South Sinai, Ronnie excavated a deep trial trench and we could not get him out of this ‘hole’ until he had reached its bottom – and the answer to a decisive stratigraphic problem.

In the wake of the Timna Exhibition at the British Museum in 1971, which showed our finds from the Egyptian Mining Temple and also the first copper smelting furnace ever seen in Europe, ‘archaeo-metallurgy’, as a distinct branch of archaeological science, began to take shape. Due to the initiative of Sir Val Duncan (then chairman of RTZ) and Sir Mortimer Wheeler (Secretary of the British Academy) the Institute for Archaeo-Metallurgical Studies (IAMS) was set up, and Ronnie was invited to become one of its founder Trustees. Ronnie continued to serve IAMS and on its Scientific Committee until his untimely death. He contributed decisively to the structuring of IAMS as an independent research group directed towards extractive metallurgical investigations at major mining and smelting sites, in the Near East (Arabah, Timna, Sinai) as well as in southwest Europe (Huelva Province, Rio Tinto, Almeria and others).

During the early years of IAMS, and in the context of its metallurgical research programme, Ronnie, together with his students at Newcastle University, began the experimental study of early, prehistoric, smelting technology, based on our excavations at Timna. It was Ronnie’s ‘do-it-yourself’ research approach which became instrumental for the development of experimental ‘archaeo-metallurgy’ – a term first introduced in the IAMS Monograph Series ‘Archaeo-Metallurgy – One: Chalcolithic Copper Smelting’, by B. Rothenberg, R. F. Tylecote and P. J. Boydell, 1978. This first experimental copper smelting study, laid the foundations for subsequent large-scale experimental research into Bronze Age copper smelting, initiated by IAMS as the concluding archaeo-metallurgical research programme of the Arabah Project. The definitive report on the two major experimental research programmes based on Timna, one of which (by Dr John Merkel) was supervised by Ronnie, has now been published (Beno Rothenberg (ed.), The Ancient Metallurgy of Copper, IAMS, 1990).

Although systematic archaeo-metallurgical research and the study of Metal in History, has initially been the major objective of IAMS, it was soon realized that it would be of decisive importance for the development and proper academic establishment of archaeo-metallurgy, to set up full-scale academic training facilities for archaeo-metallurgy, which at the time did not exist in any academic institution. Since for many years I had close connections with the Institute of Archaeology, London University, we began to teach an MSc course in archaeo-metallurgy and soon became officially affiliated to the Institute. This was the right opportunity to create closer ties with Ronnie. For some time he had intended to take early retirement from his post as Reader at Newcastle University and we invited him to take up a Visiting Professorship at the Institute of Archaeology within the IAMS programme. Ronnie moved to Oxford and his participation in our projects and teaching programme proved to be of exceptional significance. Although Professor H. G. Bachmann, Dr John Merkel,
myself and others, took part in the supervision of our research students, the major share of this task fell to Ronnie. Ronnie’s weekly student’s day in the Institute soon turned into an important ‘establishment’.

Ronnie could be quite demanding with his students, but hidden beneath was a devoted and patient teacher, especially for talented and hard-working students. His students will forever remain grateful to him for his dedicated tuition.

For his colleagues Ronnie was always ready to discuss problems, to take on the investigation of intricate material, and to evaluate results; he would soon come up with short, comprehensive reports which, over the years, have become Ronnie’s ‘trademark’. Some of these ‘progress reports’ are still on my desk, to be included in forthcoming IAMS publications on Timna and Sinai, and are very much treasured.

We shall always remember Ronnie’s good humour and friendly smile, even in difficult circumstances, in the harsh desert or under professional strain and, not least, his loyalty. IAMS will miss Ronnie Tylecote’s wide scientific experience and his professional integrity.

*Beno Rothenberg

To his friends, Ronnie’s death on Sunday, 17 June 1990, did not come as a surprise, though none of us had given up hope that he would overcome his severe, malicious illness. Brave as he was all through his life, he had faced and mastered his fate, as became evident through his will. His special library, a working instrument of a lifelong engagement in metallurgy and metallography, has been bequeathed and will subsequently be made the R.F. Tylecote Bequest within the library of the Institute of Archaeology, University College London. Furthermore, scholarships for students will be established. Ronnie Tylecote, justly named the founder of archaeometallurgy, will be remembered not only by those who have known him, worked with him and relied on his experience plus knowledge, but also by those who will follow in his and our footsteps.

Obituaries in *The Times* (27 June 1990) and by Amina Chatwin, honorary editor of the *Journal of the Historical Metallurgy Society*, have given ample reference to Ronnie’s contributions to the many fields and sectors which can be summarised under the heading: Metals, Past and Present. His books: *Metallurgy in Archaeology* (1962); *The Solid Phase Welding of Metals* (1969); *A History of Metallurgy* (1976); *The Prehistory of Metallurgy in the British Isles* (1986), and *The Early History of Metallurgy in Europe* (1987), his numerous articles in scientific journals, and his almost thirty years as editor of ‘his’ journal, the *Journal of the Historical Metallurgy Society*, will secure him a paramount place in the pantheon of our science.

Though I knew him for many years through his publications, I first met him in person in 1972 in Israel. We were both members of a team on one of those memorable field trips through the Sinai peninsula organised and led by Beno Rothenberg. Ronnie’s affiliation with Beno and the Timna Project dated back to the early sixties. One of the early papers by Tylecote, A. Lupu and B. Rothenberg appeared in 1967 in the *Journal of the Institute of Metals* under the title “A Study of Early Copper Smelting and Working Sites in Israel”. It is justly considered a true classic. Many more papers on Timna at large were to follow. The field work kindled experimental studies on copper smelting, research on many related topics, and teaching at the University of Newcastle and in his later years as Honorary Professor at the Institute of Archaeology, University College London. One of these days we will have to compile Ronnie’s complete bibliography. This will be a formidable task well worth its while. Only then will we know what a prolific man he was.

He will always be remembered as a warm-hearted, always cheerful and good-humoured friend. The day’s hardships in the field could never upset or unbalance him, though since he had only one leg he had to suffer more than any of us. The discussions around the camp fire, his catching laughter and his sound judgement when different opinions arose, are still vividly on my mind. He has given us much as a colleague in science and as an unforgettable personality in comradeship. We pledge not to forget him.

*Hans-Gert Bachmann*
A Unique Assyrian Iron Smithy in the Northern Negev (Israel)

In 1978 Beno Rothenberg was invited by the Director of the Tel esh-Shari’á excavation, to investigate an unusual metallurgical installation which had begun to show up in the excavation of the Citadel’s courtyard. A small IAMS team excavated the iron-working installation, the metallurgical investigation of the finds was undertaken by Ronnie Tylecote. Although originally written for the final report on the excavations at Tel esh-Shari’a (still in preparation) it was considered appropriate to publish it in the present issue of IAMS Newsletter, which is dedicated to the memory of Ronnie Tylecote.

An Assyrian Citadel at Tel esh-Shari’a

Tel esh-Shari’a is situated in the north-western Negev of Israel. It has been identified with the Biblical city of Ziklag (1 Samuel 27: 6-7), a town in the ‘country of the Philistines’. It was under the political patronage of Philistine Gath and was given to David by Achish, king of Gath, as a refuge during his flight from Saul. It remained David’s headquarters until he became king of Israel.

Tel esh-Shari’a has been excavated since 1972 under the direction of Professor E.D. Oren, Ben Gurion University of the Negev, Beersheba. Twelve archaeological strata were exposed, dating from the Late Bronze Age.

Fig. 1. Plan and section of excavated smithy. 1 and 2—two tuyeres found in situ; 3—piece of furnace bottom; 4—iron spike.
light-red discolouration of burned brick material, the
two other sides of the hearth showed a fairly uniform, 1-
2cm thick, light-grey layer of highly vitrified silicious
clay, behind which typical grey-to-red heat dis-
colouration penetrated the surroundings for about 15cm.
At first this grey layer appeared to be furnace lining, as is
often found in metallurgical installations, but closer
investigation revealed that it was not a proper, intention-
ally applied refractory lining, the result of a settling
operation, but a heavily vitrified crust created by the
effect of intense heat on the sandy walls of the hearth. 3

Two tuyeres were found in situ (Figs. 3 and 4),
penetrating the furnace wall at an angle of about 35°,
without, however, protruding into the actual hearth.
Strangely enough, the two tuyeres, located close together
and obviously acting as protective nozzles for ‘twin-
bellows’, were of quite different shapes and method of
manufacture. Tuyere 1 was round in section, slightly
conical, with an inner diameter of 11 mm, its length about
8 cm, and its outer diameter, at the furnace end, 4.3 cm.
Tuyere 2 was rectangular, 4 x 3 cm, with an inner
diameter of 10 mm, its length more than 10 cm. Tuyere 1

An iron working furnace (Locus 2785) in the citadel’s
courtyard.

Excavating Locus 2785 (on the Tel esh-Shari’a excava-
tion plan) turned out to be a small furnace, roughly
triangular, formed in a shallow depression in the floor of
the courtyard (Figs. 1 and 2). It was possible to establish
the method of its construction. First, a shallow, egg-
shaped pit was dug into the hard floor of solidly
cemented crushed limestone and brick fragments, 20 cm
deep, 75 cm long and 30 cm (A) to 40 cm (B) wide. Then the
narrow half of the pit (A) was filled with a mass of highly
silicious clay and the actual hearth, shaped as an iso-
sceles triangle, was roughly hand-shaped into this clay
mass. Numerous fingerprints were found preserved in its
hard-baked inner surface.

Two bricks were used to close the triangular hearth at
its base, but care was taken to leave a narrow opening
between them. Whilst these bricks showed the typical
was apparently made by rolling the clay mass around a cylindrical rod, the removal of which left a perfectly regular tubular hole for the airstream. Tuyere 2 was made in a mould and its ‘seams’ were still discernible. Both tuyeres, which were found damaged and seemingly in secondary use, were made of the same reddish-brown clay used for making the hearth, and both showed light-grey discolouration at the end nearest to the fire. In fact, the tuyere ends (at the left side on the drawings in Fig. 4) and the hard ‘crust’ of the hearth wall were found cemented together by the intense heat inside the furnace.

It was very informative to study in detail the heat discolouration visible around the hearth. The relatively deep penetration into the furnace wall and fill behind the tuyeres showed, as would be expected, that the hottest area of the hearth must have been right in front and above the air-blast of the tuyeres. The bottom of the hearth was charred to whitish-grey, typical for metallurgical furnace bottoms. Near the tuyeres, and also further up in the narrowing end of the hearth, a thick layer of cinder-like, slaggy material had formed at the bottom of the hearth (Fig. 5).

The upper part of the furnace structure was found to have been damaged during the excavation of the fill layers above. However, a number of curved furnace fragments found in the vicinity, and the shape of the preserved parts of the walls, provided the evidence for the reconstruction of a furnace with an arched top, probably with an opening for the escape of the exhaust gases. Its inner total height, when reconstructed with the arched top, was 15–20cm (see section in Fig. 1).

The wider part of the pit (B), in front of the hearth (A), was a semi-circular working space, also used as a store for charcoal. Here an iron spike was found, 25cm long, and 2cm diameter (see Figs. 1 and 6).

Hearth A, as found in the excavation, was not the first metallurgical installation built into the shallow pit, as was shown by the thin layer of charcoal and charred soil cropping out from underneath the clay mass on both sides of the preserved furnace structure. We may therefore assume that this spot had been previously used as a smithy and the furnace was repeatedly repaired or even reconstructed when rendered unserviceable by use.

**Metallurgical examination of the metallurgical finds.**

1. A friable ‘cake’ of typical smithy furnace bottom material (Sample No. 1134, basket No. 8528, Locus 2785) consisting mostly of sand and charcoal, but here and there were pieces of crystalline material which were found to be hammer-scale. This sample was found in situ at the bottom of hearth A, near the tuyere. Microscopically two main phases could be identified: a light phase which was mostly wustite with some iron and magnetite precipitated due to the eutectoidal decomposition $4\text{FeO} - \text{Fe} + \text{Fe}_3\text{O}_4$. A dark phase was anorthite glass.

2. Four pieces of magnetic slag (Sample No. 1132, basket No. 7869, Area D, Locus 2755).

3. A heavy piece of vesicular magnetic slag, greenish with holes on one side only.

Samples 2 and 3 were virtually the same. They were not found in Locus 2785 (the installation excavated by our team) but elsewhere in the courtyard of the Assyrian citadel indicating that further metallurgical operations were taking place in other installations in the courtyard.

![Fig. 6. The iron spike found in the pit (B) in front of the hearth (A).](image-url)
These pieces of slag looked more like smithing than smelting slag. Microstructural examination showed that the hammer-scale had been virtually absorbed into the vitrified wood-ash producing a slag with relatively low iron content. Some of the dissolved iron had been precipitated out of the dendrites of wustite and some of the hammer scale had not been completely absorbed.

The matrix consisted of thin, lathy, crystals which were certainly not fayalite but probably one of the wollastonites, wollastonite-beta (CaFeO₂SiO₄) or pseudo-wollastonite-alpha CaO·SiO₂. The lime would be derived from the wood ash and some of this would be replaced by Na or K. The vesicles in sample 3 would come from the decomposition of the alkali carbonates.

Slag samples 2 and 3 were completely vitrified and must have been raised to a temperature of the order of 1110-1200°C by means of bellows.

4. A fully rusted magnetic iron spike. (Sample No. 1137, basket No. 8539, Locus 2785). (Fig. 6).

5. A piece of completely rusted magnetic iron, weighing 60g. Its size was about 5 x 4cm, 1cm thick. Its original shape or function could not be established. (Sample No. 1133, basket No. 7828, Locus 2785).

Since samples 4 and 5 contained no residual metal, not much could be done with them. Residual 'relic' structures are only met with when corrosion has just been completed and residual metal is present somewhere in the specimen.

6. A round tuyere made of yellowish clay, 12cm long, its inner diameter 1.4cm. (Sample No. TSA 10142, Locus 2783–Fig. 7). Although found in the vicinity of the excavated smithy at Locus 2785, it did not seem to be related to this installation, especially as it was unused. The tuyere, tapered at its active tip, was typical for a crucible furnace or smithy.

Discussion

Although Furnace A was the only metallurgical installation found in the courtyard of the Assyrian citadel, there was evidence for additional metal working in the area. The very fact that two quite different types of tuyeres were used in Hearth A for one and the same set of 'twin-bellows' was a clear indication of the existence of other installations serving pyro-technological purposes. The builder of Furnace A just used available tuyeres, which had been used before and were damaged. Furnace A would not have been suitable for smelting, it was obviously a smithing furnace for the repair of iron weapons and tools.

There was, however, a basic problem. Furnace A was not built at all like an ordinary smithy because its builder took the trouble to carefully construct his furnace with an arched top. A blacksmith would not need highly reducing conditions in his forge, which would best be achieved by such an arched hearth. In fact, a smith does not really need a special furnace installation but could do just as well with a pair of bellows attached to a tuyere and a pile of charcoal. The smith would place his iron implement in the pile of charcoal in front of the tuyere where a high enough temperature (above 800°C) was easily obtainable. If he dealt with wrought iron, most of the work could have been done by cold hammering and annealing at 700°C. Many primitive smiths still work this way quite satisfactorily. So why the arched and triangular shaped hearth?

Furnace A would be quite suitable for an intentional carburization process used to substantially improve the quality of iron weapons and tools. Iron packed in red-hot charcoal (above 920°C) in the reducing zone of the hearth, i.e. at some distance from the oxidizing zone right in front of the tuyere, would convert to its austenite state and absorb carbon extremely easily. At a temperature of 1150°C, easily reached in Furnace A, as much as 1.0% carbon could dissolve in the iron and diffuse. By this process wrought iron, low in carbon, would be converted into steel.

It is rather unfortunate that we have no information on iron objects with residual iron from Tel esh-Shari'a to verify that intentional carburization was already known there in Assyrian times, but the furnace at Locus 2785, difficult to understand as simply a smithing hearth, could well have had such a purpose.

Since hitherto no iron forge or smithing installation has been found at Assyrian sites – in fact no smithy of any period especially constructed for a carburization operation – the Tel esh-Shari'a smithy is a welcome addition to archaeo-metallurgical knowledge.

Beno Rothenberg and R. F. Tylecote†

Notes

1. In the following report we have retained loci, sample and basket numbers as given by the excavators of Tel esh-Shari'a in order to make it possible to relate our results with the details of the general report of the excavation. For the same reason, the metallurgical investigation of the finds from Locus 1785, by R. F. Tylecote, also includes a few metallurgical finds not directly connected with the smithy excavated by our team.


3. See Rothenberg, B., The Ancient Metallurgy of Copper, 1990, Chapter 1. The smelting experiments by John Merkel, M. Bamberger and P. Wincierz, reported in chapters 2 and 3 of this volume showed that a very hard, heavily vitrified crust, looking very much like proper furnace lining, was formed on the sand-built walls of an unlined smelting furnace by the intense heat of the smelting process. Similar findings were reported by Kingery, W. D. and Gourdin, W. H., Examinations of Furnace Linings from Rothenberg Site No. 590 in Wadi Zaghra (Sinai), in Journal of Field Archaeology, Vol. 3, 351–3. 4.


8. On the problem of intentional carburization see Wheeler-Maddin (n. 7) and Cyril Smith, quoted by V. C. Piggott, ibid (n. 7), 432–3.

From the Director’s Desk

The Timna Park to become an open air archaeo-
metallurgical museum – and an invitation to join the Timna
excavations.

For several years the Timna Valley has been open to the public as an ‘Archaeological Park’ and a surprising number of foreign and Israeli tourists have visited it (about 250,000 a year). Although the dramatic desert landscape and its colourful rock formations are a major attraction of Timna, a great many of the visitors go there to see the ancient mines. Unfortunately, the local authorities in charge of the region have so far done very little to turn the ancient copper mining and smelting sites, excavated by IAMS (1964-90), into attractive exhibits. Considerable damage has already been done to the almost unprotected ancient remains by visitors walking all over them as well as by unprofessional, amateurish reconstructions. This is very regrettable since Timna and its archaeo-metallurgical sites – huge mine workings and numerous smelting camps dating from the fifth millennium B.C. to early Medieval times – is unique in the world and should be preserved for future generations.

There is now good news. Recently the decision was made by the authorities concerned to turn Timna into a proper open air museum park, with the emphasis on the reconstruction of the ancient mines and smelters, and a central museum for the numerous finds made in our Timna excavations. I have been asked to prepare the necessary plans. Since this is a highly professional task I was very pleased that James Gardner, the eminent British museums designer, agreed to prepare the plans for the ‘Timna Mining Park’ in collaboration with the excavator. It is expected that James Gardner will also participate in the actual setting up of the Timna Park exhibits. The master plan is ready and is now under consideration by the Timna Park Authorities, recently set up for this purpose.

IAMS is of course very intrigued by this welcome news since Timna, where we conducted our archaeo-metallurgical investigations for almost thirty years, has become the cradle of modern archaeo-metallurgy and its sites are unique culture-historical and techno-historical monuments.

Besides the reconstruction of mines and smelters, excavated by our team, it is planned to initiate the excavation of one of the major copper smelting sites at Timna as an ongoing activity and attraction of the Timna Park. The site chosen is expected to add important information to the scientific and historical story of Timna. We are interested to collaborate in this project with a suitable academic institution – please get in touch if you are interested.

Sir Ronald Prain. As we go to press we have learnt of the death of Sir Ronald Prain, aged 83. Sir Ronald was particularly noted for his business acumen and connections with the copper industry in South Africa. He was a founder Trustee of IAMS and served on its board until retiring from it only in recent years.

Become a Member of IAMS

Since 1980, when IAMS began to publish its Newsletter, many people throughout the world became interested in archaeo-metallurgy and joined our regular subscribers. The very wide geographical distribution and the steadily growing number of individual and institutional subscribers were indeed very encouraging and supported the continuation of its publication. However, more recently we have had many requests for information, publications and regular contact from scientists and interested laymen, research institutions and libraries in countries which only recently could openly approach the free world. It also became obvious that for colleagues in these countries it would be very difficult to subscribe to our Newsletter and obtain our book publications at their published price. We have therefore decided to discontinue the old subscribers list and introduce instead a
IAMS Membership.

The annual membership fee (starting June 1991, instead of the previous subscription) has been set at £5, be it for individuals, institutions or companies. We would, however, appreciate it if any of our previous subscribers, or any of the new members, who wish to make an additional donation in support of the IAMS Publication Fund, would do so. Anyone wishing to take it even further in terms of sponsorship of one of IAMS many research projects, scholarships for students, or publications, will be most welcome. IAMS is a British Registered Charity (Number 265914) and donations from the USA can also be made tax deductible.

Members of IAMS will receive the Newsletter annually. We intend to continue to issue the new 16-page Newsletters (instead of the previous 8-pages) to be able to include more information and first hand up-to-date reports about ongoing archaeo-metallurgical research projects. Although the IAMS Newsletter has until recently mainly dealt with ongoing research from the close orbit of IAMS, we shall in future willingly open its pages to colleagues wishing quickly to produce short up-to-date reports on their most recent research results. This new editorial approach should considerably enrich our future Newsletters.

Members of IAMS will be able to purchase IAMS publications from the IAMS Secretarial Office at the Institute of Archaeology, University College London, at very favourable special discounts, usually at least 25% off the published price (see the enclosed order form for books now available).


An order form and application form for membership of IAMS is included in this issue of the Newsletter—please make use of it.
THE ANCIENT METALLURGY OF COPPER
Researches in the Arabah 1959–1984: Vol. 2
Beno Rothenberg

The first volume in this series published the comprehensive archaeological report on the discovery of the Egyptian Mining Temple at Timna.

This second volume now examines in full detail the early smelting technology of the Arabah from its primitive beginnings in the fifth-fourth millennium B.C., through its exploitation by the Egyptian pharaohs of the Late New Kingdom, and down to the sophisticated high technology development in Roman and Early Islamic times.

The book is divided into three major parts: the first deals with the archaeological data, the furnaces, slag, moulds, ingots, etc.; the second is a detailed account of the experimental research into ancient copper melting techniques carried out by Dr John Merkel of the Institute of Archaeology, London University; the third part comprises the theoretical and experimental examination of the smelting of oxidized copper ores, culminating in a mathematical model for the smelting of copper. The latter is a world “first” and of the greatest importance for metallurgical studies.

Published here are the results of over 20 years of systematic research in the field and laboratory which have enormous ramifications for our knowledge of early metallurgy and its influence on modern metal technologies.

With an obvious archaeological readership this book is also of importance for anyone concerned with the metallurgy of copper and the introduction of metal technology.

30.5 x 21.0cm, 191pp., 7 pages of colour plates, 111 black and white plates, 44 figures and numerous diagrams and tables
Cloth bound with pictorial dust cover

Published price £48 (plus £3 postage and packing)
ISBN 0 906183 03 0

SPECIAL OFFER TO IAMS MEMBERS
£36 including postage