Pharaonic Copper Mines in South Sinai

The next issue of Archaeo-Metallurgy, IAMS Monographs, to be published early in 1988, will be Pharaonic Copper Industries in South Sinai by Beno Rothenberg, with H. G. Bachmann, J. Glass, A. Schulman and R. F. Tylecote. The Editor of IAMS Newsletter is pleased to be able to publish a pre-view of some of the so far unpublished new discoveries which will prove to be of interest to both metallurgists and Egyptologists and of considerable importance for the history of metal in the Old World.

Are there any ancient copper mines and smelters in the Sinai Peninsula – did the Pharaohs of Egypt ever mine and smelt copper in South Sinai? Since these questions were first raised by travellers in the early nineteenth century, a lot of ink has been spilled over arguments for and against – strangely enough, not by the geologists, metallurgists and archaeologists who explored Sinai, but mainly by the philologists and historians who have never been to Sinai, and as a kind of ‘backfire’ from discussions about the meaning of some hieroglyphic texts.

Richard Lepsius, in the 33rd of his famous letters written during his antiquities hunting mission in 1845 on behalf of His Majesty Fredrick William IV of Prussia, made the following, often quoted statement concerning the Egyptian mining temple at Serabit el-Khadim in South Sinai:

‘the divinity, who was mostly revered here in the New Empire, was Hathor, with the designation, also found in Wadi Maghara, “Mistress of Mafkat”, i.e. “the copper country”; for mafkat signified “copper” in the hieroglyphical, as well as in the Koptic language. Therefore, no doubt copper was also obtained here. This was confirmed by a peculiar appearance, which strangely enough has not been observed by any earlier travellers. East and west of the temple are to be seen great slag-hills... covered with a massive crest of slag... the mines could not have been in the immediate neighbourhood but the old... paths which lead into the mountain no doubt point them out. Unfortunately we had not time for it... we rode further, and visited the Wadi Nasb, in which we also found traces of ancient smelting-places...’

The meaning of mafkat (=copper) as viable evidence for Pharaonic copper mining was entirely within ‘the spirit of the time’ of the early nineteenth century, although even then slag samples from the ‘slag-hills’ at Serabit could have been analysed. (When investigated by us in 1967, this ‘slag’ turned out to be natural nodules of haematite and manganese, common in the Nubian Sandstone horizon of Sinai and the Arabah.) It is rather amusing that as recently as 1984 the historian J. Muhly used the meaning of mafkat (now revised as ‘turquoise’) as the principal evidence for his astonishing conclusion that: ‘In contrast to the evidence from the Wadi Arabah no ancient copper mines have yet been identified in the southern Sinai. Nor have any copper smelting sites been found in the area.’ This draconian statement is even the more astonishing since for some 150 years there have been detailed reports by geologists, geo-scientists and archaeologists who explored southern Sinai, concerning numerous ancient copper mines and copper smelters in various parts of South Sinai. As long ago as 1822 Richard Rüppel undertook a mineralogical exploration on behalf of Mehmet Ali, Pasha of Egypt, in order to study the feasibility of renewing the operation of the ancient copper mines and smelters in the region of Bir Nasib:

‘... in the vicinity [of the well of Nasib] are large slag heaps and ruins of several smelting furnaces. The mines of the ore are situated about one and a half hours to the north-west [Gebel Um Rinna?]. Here, in several horizontal sandstone layers, have been squeezed wedge-shaped masses of earthy copper oxide (cuivre oxidé noir terreux) of unusual dimensions;... The old inhabitants drove shafts and labyrinth-like cavities in many directions, leaving pillars of rock untouched to prevent the whole from caving in... Judging by the dimensions of these workings the quantity of ore extracted must have been very large... even now immense masses of cuprous rock are still to be seen. Another mine, where caverns of about 80 feet had been emptied, seemed to have been deserted because of depletion... the ore contained 18% of pure copper...’
of high quality... These ores could be reduced without any additional flux and I obtained 18% pure copper and an equal quantity of iron slag... on the hill above the other mine I found a small, 8 feet long obelisk of sandstone, on its side, facing the ground, it showed... beautifully worked hieroglyphs...

This is a first-hand field report by an eminent mineralogist about ancient copper mines and huge heaps of smelting slag at Bir Nasib and his experimental smelting of the local ore.

Flinders Petrie’s pioneering work in Sinai1 was mainly concerned with excavations at the mining temple of Serabit el-Khadim and the turquoise mining camps of Maghara, but on the pages of his Sinai report, especially in the chapters contributed by C. T. Currelly, there are numerous references to substantial remains of ancient copper mining and smelting in various parts of the South Sinai. Although many of these remains, re-investigated by the present author’s Arabah Expedition, turned out to be prehistoric and pre-Pharaonic, they represent pertinent evidence for ancient copper mining and smelting in Sinai.

Modern geology

S. M. El Shazly of the Geological Survey of Egypt, published in 1959 a report on the copper deposits of Sinai: 'Several ancient [copper] mines have been reported in Sinai, which included Gebel Um Rinna, Serabit el-Khadim and Maghara... the copper ore mined in Sinai in the ancient time was largely malachite associated with a little azurite and chrysocolla... Shazly also reports, 'copper mineralisation at several localities in Sinai which include Serabit, Regeta, Samra, Abu El Nimran and others.' Heaps of copper smelting slag were reported by geologists and archaeologists at many locations in South Sinai, from Wadi Samra and Dahab in the far south, to the area of Wadi Regeta, north of St Catherine's Monastery: the miners’ camps of Maghara along the full length of Wadi Nasib, the Wadi Ba‘ba-Kharig, to the huge mining site of Gebel Um Rinna. Wherever slag heaps were located, copper mineralisation and mine workings could be found nearby. There could not possibly be any reasonable doubt about the existence of ancient copper mining and smelting sites in South Sinai; these are
overwhelming basic facts reported by generations of explorers and scientists who worked in the field.

**Dating the mines and smelters of South Sinai**

The date of the ancient mines and smelters is, of course, of decisive importance for the history of Sinai and for metal history; this problem has been one of the main objectives of the Arabah Expedition’s Sinai survey 1967–78.

The Arabah Expedition, led by the present author, worked for 15 seasons in Sinai, systematically exploring Central and South Sinai with special emphasis on mining and archaeo-metallurgy. Among the scientists taking part in some of the fieldwork mention should be made of H. G. Bachmann, R. F. Tylecote, A. Lupu, J. Glass, P. Wincierz, C. Hope and a group from the German Mining Museum, Bochum, under its Director Min. Ing. H. G. Conrad. Large clusters of prehistoric (Chalcolithic-Early Bronze Age) mining and smelting sites and related settlements were identified in the region of the ancient copper mines of Regeita, Samra and Abu el Nimran, Wadi Shelal (South) and other areas of South Sinai. However, the Pharaonic copper mining expeditions concentrated their main efforts in the area between Gebel Um Rlnna and Bir Nasib, in the north-west corner of South Sinai, adjacent to the ancient turquoise mines. Since substantial quantities of copper slag, furnace parts and crucibles were found in the mining camps of Maghara excavated by Petrie and copper mineralisation has been located in the hills around Maghara and Serabit (i.e. even in the Pharaonic turquoise mining camps copper was worked), there cannot be any doubt that these activities took place in Old, Middle and New Kingdom times. In the following we shall report briefly on two major copper mining and smelting sites in South Sinai which can be securely dated to Pharaonic times by newly discovered archaeological finds and hieroglyphic inscriptions (Fig. 1).
Old and Middle Kingdom copper mines and smelters in Wadi Ba’ba-Wadi Kharig.

One of the many ‘old mines’ in Wadi Ba’ba is located at its junction with Wadi Kharig. Site 349 on our survey map (Fig. 2). The mine is a very rough and irregular excavated adit, about 100m. long, 10m. wide and 2m. high. It still shows copper mineralisation and manganese and iron ores; the latter had apparently been left untouched by the ancient miners as they were only interested in the copper ore. Copper mineralisation – mainly parataramite and malachite [Bachmann] – occurs throughout this area of south-western Sinai, together with manganese and iron in one and the same geological horizon, and it was exactly this complex geological situation which had previously prevented the identification of many of the ‘old mines’ as ancient copper mines.

Along the bottom of the mining hill, and further along the Wadi Kharig, copper smelting slag and furnace fragments, accompanied by Egyptian sherds [C. Hope, J. Glass, A. Schulman] were evidence of copper smelting in situ. Here too, an Egyptian rock engraving was found (Fig. 3). It is a crude drawing of a shrine in which the Egyptian god Ptah (who is frequently associated with workmen), sits on a chair, holding what appears to be a sceptre [Schulman].

Further up on the hill, right above the copper mine, a stela of Sesostris I (1971–1928 B.C.) of the 12th Dynasty, was discovered by our expedition. It mentioned Hathor as the patron deity of the Pharaoh [Schulman]. About 150m. further on, we located a typical Egyptian miners’ camp, similar to the camps of Maghara. It consisted of a long row of semi-detached rooms, constructed in a semi-circle against a cliff. Engraved on this rock was a monumental hieroglyphic inscription of the 5th Dynasty (Fig. 4), which reads: ‘... the King of Upper and Lower Egypt, Sahure, who lives forever – Thoth, Lord of Terror, who smites the Land of the Setjet [Asia]’ [Schulman]. In the workers’ camp Egyptian potsherds were found together with fragments of copper casting crucibles and casting slag. Evidently Site 349 was a centre of Old and Middle Kingdom copper mining and is, in fact, the earliest Pharaonic copper mining camp so far discovered in Sinai.

Bir Nasib (Site 350 on our map), a huge Pharaonic copper mining district (Fig. 5)

Our expedition systematically explored the whole region of Bir Nasib and a large number of copper mining sites, dated by archaeological evidence from Chalcolithic to Nabataean times and perhaps also later, could be identified.

Already in the early nineteenth century, Rüppell noted a large slag heap at Bir Nasib, immediately next to the ancient well which is still the main water source of the region. Petrie surveyed this slag heap and his calculations of about 100,000 tons of slag was recently confirmed by H. G. Bachmann, who calculated the quantity of metallic copper produced at Bir Nasib as about 5000 tons—a huge quantity of copper for ancient times. Bachmann also established that the Egyptian smelting slag at Bir Nasib is ‘manganese-rich of fayalite
Fig. 5. The huge slag heap of Bir Nasib. The ancient copper mines are located in the slopes of the many low hills surrounding the valley of slag.

Fig. 6. Base of a New Kingdom scarab found in the slag heap of Bir Nasib.

Fig. 7. Ancient copper mining adits at Bir Nasib.
Fig. 8. Entrance to an ancient copper mine with a Nabataean inscription across its 'lintel'.

Fig. 9. Egyptian Middle Kingdom (on extreme left behind the figure) and New Kingdom rock engravings from the copper mines of Bir Nasib.
type', as should be expected considering the close relation between manganese deposits and copper mineralisation typical of this area.11

During our first surveys of Bir Nasib (1967, 1972) we found a large quantity of pottery on the surface of the site, including not only Nile-ware Egyptian sherds of the Old, Middle and New Kingdom [C. Hope, A. Schulman, J. Glass, J. Crawford], but also Nabataean and Roman-Byzantine and many recent Arab sherds. It therefore became imperative to try and date the huge slag heap by excavation. In 1978 we cleared several trial trenches at different parts of the slag heap, utilising some of the large pits dug previously by treasure-hunting bedouin (see Fig. 5).12

In the top layer of the slag a scarab (Fig. 6) and glass bead were found, dating, according to A. Schulman, to the New Kingdom. In both the two uppermost slag layers a number of Nile-ware New Kingdom sherds were found, but there was also locally manufactured pottery of typical Egyptian shapes [J. Glass, C. Hope]. In the layers below, there was more Nile-ware pottery, but in the restricted space excavated not enough characteristic sherds were found to allow a more precise dating of these earlier layers.

Our trial trenches provided definitive stratigraphic and ceramic evidence for a New Kingdom date for the site's top layers and it seems reasonable to assume that the lower layers belong to earlier periods of the Pharaonic copper industries at Bir Nasib. These are probably related to the hieroglyphic and proto-Sinaitic rock engravings of the Middle Kingdom13 found on the hills surrounding the valley of Bir Nasib. The huge heap of copper slag at Bir Nasib had remained an enigma since its discovery in the early nineteenth century because of the rather pertinent and obvious question: where are the copper mines which supplied the huge quantities of copper ore for the smelters of Bir Nasib? Already during our first Sinai surveys we had noticed a large number of small adits in the hills of the area around Bir Nasib (Figs 7-8), but because of the black manganese mineralisation visible, and since we were in the region of modern manganese mining, we related these adits to old manganese prospecting. However, close investigation of them in 1978 and subsequent analytical studies of their mineralisation, in comparison with the ore fragments found in the slag heaps, carried out by the IAMS group of experts, established that most of these adits were in fact (mainly) copper as well as turquoise mining. ‘Bir Nasib, the largest smelting site in Sinai, is also a place of copper ore and turquoise mining. . . . The small adits visible in the sandstone cliffs surrounding the smelting area . . . show green lumps consisting of malachite, paratacamite and quartz. . . . The whole district, extending as far as Um Bogma and Gebel Um Rinna . . . is rich in copper mineralisation. Due to the close relation between manganese deposits and copper mineralisation, all within the Nubian Sandstone, Bir Nasib should rather be considered the centre of an ancient copper mining district instead of an individual mine’ [H. G. Bachmann, in forthcoming IAMS Monograph 2].

The copper mines close to the smelter of Bir Nasib are dated by hieroglyphic inscriptions to the Middle and New Kingdom. A well defined path, going up the steep slope east of the slag heap, leads to an area of copper as well as turquoise mining on top of the mountain.14 According to the Egyptian tradition, these mine workings were commemorated by royal hieroglyphic inscriptions and proto-Sinaitic inscriptions of the Middle Kingdom (already mentioned above). Some Nabataean inscription near the workings indicate that mining occurred here also in later periods.

On the opposite side of the valley, about 200m. south of the slag heap, and right next to the ancient copper mines, a large hieroglyphic inscription of the Ramesside period, and a smaller inscription probably of the Middle Kingdom, were discovered by the present author (Fig. 9). The Ramesses II inscription is of particular interest because it shows, on either side of the royal cartouche, two figures who are named as the ‘Royal Butler Neferrone’ and the ‘Captain of the Host, Paenlevi’; ‘high ranking members of the Egyptian hierarchy, and clearly the joint leaders of an expedition to the Pharaonic mines and smelters of Bir Nasib’.15

Since some of the pottery found by our surveys in 1967 and 1972 at Bir Nasib dates to the Old Kingdom, it is hoped that future excavations at the site will provide stratigraphic evidence also for such early Egyptian workings. There is already evidence for prehistoric smelting in the area, producing copper by a very primitive smelting process, but these sites are outside the scope of this report.

Beno Rothenberg

References
1 R. Lepsius, Discoveries in Egypt, Ethiopia and the Peninsula of Sinai in the years 1842-1845. London, 1852.
8 See Map of Survey of Egypt (1936), based on J. Ball, Geography and Geology of West Central Sinai, 1916.
9 See plan in Rothenberg, ibid., 1979, p. 163.
10 Petrie, ibid., p. 27.
12 This is the first report published on our trial excavations at Bir Nasib. The full report will appear in IAMS Monograph 2.

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 (QY). Telephone: 01-387-7050. Printed by Pardy & Son (Printers) Ltd., Ringwood, Hampshire, England.
Recovery of Silver from Speiss at Rio Tinto (SW Spain)

Within the frame of IAMS's Iberian Project, led by Professor Beno Rothenberg, the site of Las Arenillas in the region of the Rio Tinto mine, was explored and partly excavated in 1983-4 (IAMS Newsletter 7, 1984, p. 3). The archaeometallurgical finds from Las Arenillas are now under investigation by a research group of the British Museum Research Laboratory and the following report is the first publication of the rather unexpected results of these investigations. According to the authors of this report, 'there is now evidence that speiss was treated at the Roman site to separate the silver – the first time such a process has been recognised at an ancient site'.

Professor I. Keessmann, Institute of Geo-science, Mainz University, since 1986 the co-director of the Rio Tinto Project, sent us the following note: 'Silver extraction in the region of Rio Tinto was a very complex process. At most of the smelting sites of Rio Tinto the process remains represent only one or two steps of the whole complex process, and this fact makes the reconstruction of the extractive process at the stage somewhat tentative. It should also be noted that the findings at Las Arenillas are not identical with those at other sites in the Rio Tinto area, which are at present under investigation by the Archaeo-Metallurgy Research Group at Mainz University and other IAMS related groups'.

(Editors)

Most silver from the Bronze Age onwards was produced from argentiferous galena (lead sulphide) (see IAMS Newsletter No. 9), but Rio Tinto lead is rather scarce and the main silver ore smelted there was jargosite. Jarosite is basically a mixture of iron and potassium sulphates with a variety of other metals such as tin, gold, lead and copper as well as the silver, and includes arsenic and antimony. These last two metals have a profound effect on the smelting process as they combine with the iron to form a mixed iron arsenide/antimonide which has the tendency to absorb substantial quantities of the silver. In Agricola's sixteenth century De Re Metallica it states:

'If pyrites are smelted the first to flow is a white molten substance injurious to silver for it consumes it. For this reason the slag which floats on the top having been channelled off, this substance is poured out or if it hardens this is poked out with a crooked bar.' (Transl. Hoover and Hoover, 1912, p. 408)

The Germans called this material, with its very distinctive silver-white metallic appearance, Speiss. The German metallurgist Lazarus Ercker (1580), defined it thus:

'The difference between speiss and slag-matte is supposed to be that, while in the latter sulphur exceeds arsenic, in speiss arsenic exceeds sulphur. This makes speiss whiter than slag-matte, and is the reason why it cannot be diminished much by roasting, whether in a strong fire or a moderate one. Neither can it be overcome by lead, it always shows up again, even if it is slightly diminished, though certainly not by much.' (transl. Sisco and Smith, 1951, p. 48)

Clearly, speiss was a problem! At Rio Tinto in the seventeenth and eighteenth centuries it was called metal blanquillo. In Rio Tinto speiss iron comprises over half of the total weight with arsenic and antimony making up most of the rest. It is a hard and dense material with a white crystalline fracture which rapidly rusts. Superficially at least, speiss has a strong resemblance to cast iron and indeed in the seventeenth century Spanish government officials, sent to investigate the possibilities at Rio Tinto, found the speiss in the heaps and suggested it could be used for making bullets, or even to replace tin in church bells (Salkield, 1987, p. 14).

However, the Spanish officials did note that the metal blanquillo contained about 2,800 grams per tonne (g/t) of silver, but concluded that it would be difficult to extract, a conclusion with which Ercker and Agricola would have heartily agreed. However, our investigation of material excavated in 1983-4 at the site of Las Arenillas, suggests that these difficulties may not have deterred the Romans (IAMS expedition to Rio Tinto, under the direction of Beno Rothenberg).

Las Arenillas, Site RT 103 on the IAMS survey map of Rio Tinto, called Cerro del Moro by the local people, is a prominent, steep hill next to the small mining town of Nerva, about 3km from the main slag heaps of the Rio Tinto mine. The site had already been noticed by Oliver Davies and described in his classic study Roman Mines of Europe (1935, p. 128) as follows:

'On a hill immediately to the south-east of Nerva is a Roman village fortified with a rude wall. Inside the enclosure are house foundations and I found a few sherds, a piece of glass, a fragment of coal and some slag probably from a smithy. The site may have been

Fig. 1. Small slag heap on the very summit of Cerro del Moro, the slags are different from those in the main heaps and suggest the treatment of speiss.'
an agricultural village unconnected with the mines which are some distance away'.

The more detailed survey by the IAMS team discovered considerable quantities of speiss, lead and litharge scattered all over the hill, and a small slag heap was found in a trial trench (Fig. 1). The excavators were puzzled as to why speiss was brought to this area well away from the main heaps, and why a small smelting operation should have been conducted right on top of a very steep hill, where everything would have to be carried up several hundred metres.

Our preliminary analyses showed that the slag was not from the processing of iron, as assumed by Oliver Davies, although it seems different from the usual silver smelting slags of Rio Tinto. Since our analyses of the speiss (Table 1) showed that, unlike small speiss pieces from the main slag heaps, they contained no detectable silver, we assume that silver was being systematically removed from the speiss at Las Arenillas.

The crucible

This assumption was strengthened by the discovery of a bowl of heavily slagged rough ceramic (Fig. 2), found on the slag heaps near the North Lode of the Rio Tinto mine. At first it was believed to be a large cupel for the separation of silver from lead, but the analysis showed that no lead was present. The vessel (19.0 x 8.0cm) was heavily slagged on both its inside and outside, and was originally heavily impregnated with speiss (now largely weathered); see Table 2. Clearly someone had been treating speiss!

The slags

The small slag heap found in situ in a trial trench on top of Las Arenillas was about two cubic metres in volume and completely insignificant compared with the main slag heaps of the mining region. The heap was made up chiefly of broken slag pieces up to fist size. Three samples were selected at random for further investigation and analysis (Table 2). Although they are of the usual fayalite type, they are rather different in bulk

### Table 1

<table>
<thead>
<tr>
<th>Speiss from main slag heaps at Corta Lago</th>
<th>%</th>
<th>Fe</th>
<th>As</th>
<th>Sb</th>
<th>Pb</th>
<th>Mo</th>
<th>Sn</th>
<th>Ag</th>
</tr>
</thead>
<tbody>
<tr>
<td>CL-79 T2 layer 4 17</td>
<td>33.5</td>
<td>39.0</td>
<td>19.5</td>
<td>2.3</td>
<td>0.5</td>
<td>4.3</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>CL-79 T2 Box 17</td>
<td>50.5</td>
<td>40.5</td>
<td>6.0</td>
<td>0.83</td>
<td>0.15</td>
<td>1.7</td>
<td>0.27</td>
<td></td>
</tr>
<tr>
<td>CL-79 T2 Layer 15 69 HS 419</td>
<td>52.5</td>
<td>38.0</td>
<td>7.2</td>
<td>0.8</td>
<td>0.8</td>
<td>0.8</td>
<td>0.07</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Speiss from Las Arenillas</th>
<th>%</th>
<th>Fe</th>
<th>As</th>
<th>Sb</th>
<th>Pb</th>
<th>Mo</th>
<th>Sn</th>
<th>Ag</th>
</tr>
</thead>
<tbody>
<tr>
<td>RT 103 HP 507 site E</td>
<td>72.7</td>
<td>18.6</td>
<td>7.2</td>
<td>0.6</td>
<td>0.1</td>
<td>0.6</td>
<td>&lt;0.02</td>
<td></td>
</tr>
<tr>
<td>RT 103 surface</td>
<td>72.6</td>
<td>20.0</td>
<td>6.6</td>
<td>0.5</td>
<td>0.12</td>
<td>0.5</td>
<td>&lt;0.02</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Silver from Las Arenillas</th>
<th>%</th>
<th>Fe</th>
<th>As</th>
<th>Sb</th>
<th>Pb</th>
<th>Mo</th>
<th>Sn</th>
<th>Ag</th>
</tr>
</thead>
<tbody>
<tr>
<td>RT 103 surface</td>
<td>72.1</td>
<td>18.6</td>
<td>7.2</td>
<td>0.6</td>
<td>0.1</td>
<td>0.6</td>
<td>&lt;0.02</td>
<td></td>
</tr>
</tbody>
</table>

### Table 2

<table>
<thead>
<tr>
<th>Slags from main heaps RT19a</th>
<th>%</th>
<th>SiO₂</th>
<th>Al₂O₃</th>
<th>FeO</th>
<th>MgO</th>
<th>CaO</th>
<th>Na₂O</th>
<th>K₂O</th>
<th>PbO</th>
<th>BaO</th>
<th>Fe₂O</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plate slag 180</td>
<td>23.2</td>
<td>2.66</td>
<td>42.0</td>
<td>0.3</td>
<td>1.9</td>
<td>0.07</td>
<td>0.7</td>
<td>0.05</td>
<td>25.0</td>
<td>&lt;0.5</td>
<td></td>
</tr>
<tr>
<td>Plate slag 181</td>
<td>30.66</td>
<td>4.46</td>
<td>36.57</td>
<td>0.7</td>
<td>3.75</td>
<td>0.2</td>
<td>1.75</td>
<td>1.12</td>
<td>12.0</td>
<td>&lt;0.5</td>
<td></td>
</tr>
<tr>
<td>Ropey slag 182</td>
<td>28.42</td>
<td>5.91</td>
<td>50.54</td>
<td>0.2</td>
<td>0.15</td>
<td>0.13</td>
<td>0.7</td>
<td>0.66</td>
<td>1.4</td>
<td>&lt;0.5</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Slag from small heap on Las Arenillas</th>
<th>%</th>
<th>SiO₂</th>
<th>Al₂O₃</th>
<th>FeO</th>
<th>MgO</th>
<th>CaO</th>
<th>Na₂O</th>
<th>K₂O</th>
<th>PbO</th>
<th>BaO</th>
<th>Fe₂O</th>
</tr>
</thead>
<tbody>
<tr>
<td>RT 103 D2A Layer 4 14 HP567</td>
<td>24.0</td>
<td>4.7</td>
<td>60.4</td>
<td>&lt;0.5</td>
<td>1.4</td>
<td>&lt;0.5</td>
<td>1.2</td>
<td>1.7</td>
<td>2.8</td>
<td>&lt;0.5</td>
<td></td>
</tr>
<tr>
<td>BMRL 27963</td>
<td>23.0</td>
<td>4.1</td>
<td>60.5</td>
<td>&lt;0.5</td>
<td>1.8</td>
<td>&lt;0.5</td>
<td>0.9</td>
<td>2.5</td>
<td>2.9</td>
<td>&lt;0.5</td>
<td></td>
</tr>
<tr>
<td>BMRL 27964</td>
<td>34.73</td>
<td>5.2</td>
<td>45.6</td>
<td>&lt;0.5</td>
<td>0.4</td>
<td>&lt;0.5</td>
<td>1.4</td>
<td>1.8</td>
<td>4.2</td>
<td>&lt;0.5</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Imregnated ceramic matrix of crucible</th>
<th>%</th>
<th>SiO₂</th>
<th>Al₂O₃</th>
<th>FeO</th>
<th>MgO</th>
<th>CaO</th>
<th>Na₂O</th>
<th>K₂O</th>
<th>PbO</th>
<th>BaO</th>
<th>Fe₂O</th>
</tr>
</thead>
<tbody>
<tr>
<td>RT 103 D2A Layer 4 14 HP567</td>
<td>23.4</td>
<td>15.3</td>
<td>51.0</td>
<td>&lt;0.6</td>
<td>&lt;0.2</td>
<td>0.9</td>
<td>3.0</td>
<td>&lt;0.4</td>
<td>—</td>
<td>4.2</td>
<td></td>
</tr>
</tbody>
</table>

Zn, Sn, Co, Sb, As, Ni not detected.
composition and inclusions from the slags of the main heaps; their iron content is somewhat higher and the high barium contents encountered in most of the smelting slags of the main heaps are not found here. One of the samples contained numerous globules of plumbospeiss which is not typical of the slags of the main heaps. The globules were internally heterogeneous with at least four major phases present (Fig. 3): lead (with some antimony and the silver), a copper-antimony phase, iron arsenide and areas rich in both lead and antimony with some sulphur. Typically these inclusions contain about 30–50% of lead, 26–45% of antimony, 2–15% of iron, 1–12% of arsenic and about 3% copper and 1% tin, etc. Silver was concentrated in the lead-rich phase and in one case the lead contained 1.3% of silver.

Lead, litharge and silver

Samples of lead, litharge and silver from Las Arenillas were examined. The lead and litharge are now both heavily corroded and the exposed surfaces are covered with lead carbonate, cerusite (PbCO₃). The litharge pieces tended to be quite rich in antimony and also have some copper, absorbed during the cupellation processes, whereas the lead is uniformly pure. The analysis of one piece of silver is given in Table 1; note the extraordinarily high bismuth content – raw silver from Rio Tinto normally contains only about 1 to 5% of this element. The other elements are quite typical for Rio Tinto silver.

The process of speiss treatment

Speiss was treated at Las Arenillas to recover silver as evidenced by the abundant finds of speiss, lead, litharge and the slags from the excavated slag heap, although exactly how this was done is still far from clear. Percy (1870, p. 313) describes the process carried out at Freiburg in Germany where silver and lead were smelted from pyrites. The speiss formed was broken off the matte (Percy uses the term regulus) and roasted, then smelted with lead, or lead products such as litharge from the cupellation process. The smelt produced speiss, matte and lead. The last two contained the silver and they were returned to the main smelters, and the speiss was treated to recover the nickel and cobalt which it contained before being discarded.

The Rio Tinto speiss is somewhat different, being the product of a different ore. The jarosites are low in both nickel and cobalt, so these elements do not figure in the speiss, and the ore is, of course, a sulphate and not a sulphide as was the case at Freiburg, so there is no matte with the Rio Tinto speiss. We assume therefore that the silver-rich speiss at Rio Tinto was routinely collected from the furnaces where jarosites were smelted and taken to centres such as Las Arenillas for further processing. The few small fragments of speiss which were left behind and/or entrapped in the slag of the main slag heaps, show that the speiss often contained several thousand ppm of silver.

We suggest the following process model (Fig. 4): First, the speiss would have been roasted in crucibles to that found in the heaps on North Lode. This would have oxidised a substantial portion of the iron arsenide, driving off the arsenic as arsenious oxide and leaving behind oxides of iron. Analyses of the speiss from Las Arenillas do indeed show that the arsenic content is much reduced. Silica in the form of crushed quartz would then be added to the molten speiss to form a slag with the iron oxides. Inevitably some speiss would get incorporated into the slag, as happened with the slag found on Las Arenillas. This slag reflects the material treated, and is thus much lower than the main smelting slag in the alkaline earths such as barium, which are quite prominent in the jarosite ore, but of course, absent in the speiss. The small percentage which is present probably derives from the fuel, flux and furnace linings.

The now concentrated speiss would then be treated with lead or litharge in such quantity that the bulk of the silver transferred from the speiss to the lead. Because the quantities of speiss were very low compared with the original ore, the Romans could afford to use a large excess of lead ensuring that the amount of silver left in the speiss was minimal. The lead itself, run off from the furnace, would also have quite a low concentration of silver (several hundred ppm), but it was not necessary to recover this by cupellation at this stage. At Freiburg the still relatively small volume of lead could be returned to the main ore smelting furnaces to be further enriched with silver before tapping and cupellation, and this could have been done at Rio Tinto.

The ores at Rio Tinto are unusual and their successful treatment required sophisticated and complex processes. As more work is done on the Rio Tinto material the greater becomes our appreciation of the technical skills of the ancient metallurgists and our respect for their craft.

P. T. Craddock, I. C. Freestone and M. Hunt Ortiz
Clay Moulds for Copper Ingots — a first discovery

For a long time metallurgists and archaeologists assumed that bun-shaped and similar copper ingots often found in ancient hoards and shipwrecks are the primary product of the copper smelting process, i.e., the plano-convex-shaped ingot was assumed to be a 'replica' of the furnace bottom. The smelting process model was thus presented: after pre-heating the bowl-shaped smelting hearth, the ore mixture was charged into it and then reduced to metallic copper prills; these sank through the liquid gangue material, the 'slag', to form a plano-convex copper ingot on the concave furnace bottom. In advanced process models the slag was then tapped out of the furnace and the copper ingot, remaining at the bottom, could then be simply recovered.

Experimental and theoretical research into copper smelting carried out during the last few years by IAMS's metallurgical research group and its students established that this model was an over-simplification. Most of the copper ingots were, in fact, secondary products, i.e., cast into shape after the conclusion of the primary smelting process in an additional operation and from raw copper, not necessarily from one and the same smelting operation. In other words: most of the common ingots and, of course, ingots of more elaborate shapes like the 'ex-hide' ingots of the Mediterranean, are the product of a casting operation not directly connected with the primary smelting of copper. However, the essential piece of missing evidence was a casting mould for ingots.

In the collection of our Arakah and Sinai research unit (The Institute of Mining and Metallurgy in the Biblical World, Tel Aviv) are a large number of furnace fragments, lining parts, clay tuyères and other refractories which were uncovered in the excavations of the Timna smelting camps in 1962–83. As part of the current preparations for the definitive publication of

References
these excavations, all these process-related finds were recently meticulously reinvestigated, measured and recorded by Craig Meredith (the member, since 1969, of IAMS’s permanent field team in charge of finds), in order to establish the essential data on the dimensions and shapes of the different furnace types represented by these fragments.

Working patiently through masses of very dusty furnace fragments, Craig noticed and separated a small number of flat, grey-burned, saucer-shaped clay objects, very thick-walled and brittle, for which there was no immediate explanation. These were obviously heavily fired, showing heat stratification in the sections. The bottoms are flat and the top mildly concave, bordered by a vertical rim several centimetres high. All these fragments came from Layer 1 of Timna Site 30 which related to Egyptian 22nd Dynasty activities during the 10th century B.C. These latecomers to Ramesside Timna (14-12 centuries B.C.) introduced a new and much more advanced copper smelting technology, involving tempering the clay furnace lining and tuyères with tiny bits of crushed slag (Bachmann and Rothenberg, in Antikes Kupfer im Timna-Tal, ed. Conrad and Rothenberg, 1980, p. 220). Craig’s enigmatic objects showed the same slag temper but otherwise they could not be fitted into the furnace model of this period (see Rothenberg, Copper Smelting Furnaces in the Arabah, Israel: the Archaeological Evidence, in British Museum Occ. Papers No. 48, 1985, pp. 129-30, Figs. 12-13). There was simply no way in which these saucer-like objects could be parts of the wall or bottom of a furnace. Further close inspection established that these ‘saucers’, which were not slagged must have been used in a horizontal position and that the heat was mainly concentrated on their inside, observations confirmed subsequently by the British Museum Research Laboratory.

At the end of his task, Craig presented his detailed report, including a surprise chapter: Casting Moulds. Subsequent measurements and comparisons resulted in the final definition: Casting moulds for ingots, the first ever identified.

The identification of casting moulds for bun-shaped ingots provides essential additional archaeological evidence for the historic reality of our newly proposed copper smelting models.


Beno Rothenburg

The Production and Trade in Copper in Medieval Times

Underwater and land-based sites have produced evidence of extensive Bronze Age trade in metals, and this continued into the Roman period with lead, tin and copper all finding their way across the Mediterranean in the general direction of Rome. Until we come to Venice, in about A.D. 1000, it is difficult to find much evidence of trade in the 1st millennium A.D. but, by the Early Middle Ages, Venice had an extensive trade, obtaining her raw copper from Italy and Central Europe. The arsenal at Venice processed this and exported it to various sites in the Mediterranean and beyond. Later, this trade was taken over by the Portuguese who extended it into Africa.

In the elucidation of trade and production of copper, archaeology is our only tool up to medieval times, as detailed descriptions of technique are lacking and trading records confined to tablets which rarely give a clue as to place of origin.

In the medieval period we begin to get written records of how things were done, paintings of furnaces and equipment, and we can say that the prehistoric period of metallurgy comes to an end. We not only have technicians such as the twelfth-century monk, Theophilus, and others like Biringuicchio and Cellini, but also writers and theorists like Agricola and Leonardo da Vinci. Their technical treatises are more than supplemented by trading archives which begin to give us details on prices and quantities, although it is not easy to get accurate data on the output of metal as these often pass through several hands.

Venice

Venice was one of the earliest trading centres after the Roman period, and it is useful to take it as an example. It imported copper at first from the area south-east of Bolzano, and Tuscany and later from Central Europe generally and Turkey (Kastamonu). Some of this copper was refined and stamped in Venice and its environs, like Treviso. The rest was sent onwards as part of Venetian trade, mainly with the East.

This work was done in the getti, the area near the arsenal on the east end of Venice (gettando = casting) and the term ‘Ghetto’ is said to have originated from the fact that in 1516 the sites of the old and new foundries, Ghetto Vecchio and Ghetto Nuovo, were assigned to the Jews.

Venice got its refined copper mainly from the Harz and Tuscany. Copper was refined in the arsenal in Venice and was then transported to the Made of St Mark (probably like those so often seen in Venice today). It was made in two grades: hard and soft. The former was used for bells and mortars; the latter for malleable applications such as wire and sheet and it was sold as buns, masses, etc. The ductile yellow copper came from Poland through Bruges and, up to the fourteenth century through Krakow (probably from Slovakia?). The copper office in Venice—the Getto—refused to refine the hard copper, presumably because it needed too much fuel.

Lots of copper came from the north Italian mines
around Bergamo. Copper was exported to Malabar by the Venetians and this came from Nuremberg and apparently was exchanged for copper from Cochin (China?).

After about 1500 most of the Fugger's copper went northwards, but between 1495 and 1504 Fugger exported more than 3000 tons of copper from his Hungarian mines (Slovakian) through Venice. In the fourteenth century a large part of the copper arriving at Venice came from the mines of Pontus (around Kastamonu in Turkey, Ramen de Romania in Italian).

**Portuguese Transport 1460–1600**

During 1494–5, 71,000 manillas went to Africa from Europe, and in 1514, 384 tonnes were sent. In all, for the period 1495–1524, 1250 tonnes of manillas, etc., were exported from Flanders (Antwerp). It would seem that most of this came from Central and Northern Europe. The manillas had variable compositions and, according to Herbert in 1948, analyses of those in circulation in Nigeria gave: Cu 62.68%, Pb 30.05, Bi 0.05, As 0.65, Sb 2.81, Sn 0.98, Zn 0.48. Ni 0.48. This composition has been used since 1720. The weight range was about 8.5 to 100zs. (300g.).

The objects produced include wire for pins, sheet copper, bells and cauldrons, and guns. While the total output of copper in Europe in 1550 was no more than 2000 tonnes, this was increased by the use of scrap and alloying elements such as zinc ore to some 2500 tonnes of copper-base alloys and was to become a very important factor in Renaissance civilisation.

R. F. Tylecote

---

**Director's Report**

This opportunity is taken to give an up-to-date overview of the ideas which led in 1973 to the formation of IAMS, and to discuss what has been achieved so far, together with our future research and publication plans.

IAMS was formed to initiate internationally the investigation of the fundamental technological parameters of metal history as well as the often decisive role of metal in history.

1. From 1964 to 1970, the Arabah Expedition, led by Beno Rothenberg, excavated ancient copper smelting sites in the Timna Valley (Southern Israel). This was the first systematic field research ever undertaken at metal production sites. The excavations culminated in the discovery of a unique Egyptian-Midianite mining temple – which led to the Timna Exhibition in 1971 at the British Museum and other major museums of Europe.

In the wake of the highly successful Timna Exhibition in the British Museum, Sir Val Duncan (RTZ chairman) and Sir Mortimer Wheeler (Secretary of the British Academy) initiated the setting up of IAMS, joined shortly afterwards by Sir Ronald Prain, OBE, Professor R. F. Tylecote, Sir Sigmund Sternberg, KCSG, JP, Dick Altham, Nigel Lion, Professor John Evans and others. In the late 1970s IAMS became affiliated to the Institute of Archaeology, University of London, where it initiated and supported the development of archaeo-metallurgical teaching and research. I would like here to thank Sir Sigmund Sternberg for his continued support of our teaching project. The comprehensive, final report on the excavations of the Timna Temple (The Egyptian Mining Temple at Timna, Researches in the Arabah, Vol. I, by Beno Rothenberg and others) is now in the press and is scheduled to be published early in 1988.

The Arabah (and later also Sinai) Project under the of IAMS, could be conceived as a large scale and long term systematic archaeological and metal-technological research programme, which continued, mainly due to the financial support of the Volkswagen Foundation, up to 1984, with the active participation of English, German, USA and Israeli scientists, students and academic institutions. Ten years of intensive field and laboratory studies, included the first ever excavations of Bronze Age underground copper mines (undertaken with the German Mining Museum, Bochum), extensive excavations of copper smelting camps dating from the beginning of extractive metal working in the 5th–4th millennium B.C. to Roman times as well as theoretical (mathematical modeling) and experimental metallurgical research programmes. The results of this unique project, which covered 5000 years of copper mining and smelting, provided the first firm scientific base for a major chapter of the history of metal, due to be published in 1988 as Vol. 2 of Researches in the Arabah: The Ancient Extractive Metallurgy of Copper – The Archaeological Data; theory and experiment, ed. H. G. Bachmann and Beno Rothenberg.

2. Already in 1973 Sir Val Duncan had initiated the setting up of the Huelva Archaeo-Metallurgical Project, with the emphasis on Rio Tinto. RTZ has since been the principal support of IAMS in Spain and in general.

As most of the huge mineral deposits of the Huelva Province and Rio Tinto consist of primary sulphide ores, exploited in ancient times for silver, gold and copper, the Huelva project was indeed a 'natural sequence' to the Arabah-Sinai research programme (which dealt exclusively with secondary, oxidized ore types). As a first, exploratory step, our Huelva Project undertook a detailed archaeo-metallurgical survey over the whole of the Huelva province, published by Beno Rothenberg and Antonio Blanco Freijero, Studies in Mining and Metallurgy in SW Spain (Metal in History, Vol. I, IAMS, London; Spanish edition, Barcelona, 1981). This survey produced the picture of a huge area – the southern Iberian Pyrite Belt – of ancient metal production which, compared to the Arabah and Sinai, presented totally different technological challenges for the ancient miner and substantially different extractive problems of metal production.

Since 1978 IAMS's Spanish activities have been based on the Rio Tinto mine. This mine, because of its
well-preserved huge and complex ancient industrial metal production remains, dated from the Late Bronze Age (end of 2nd millennium B.C.) to Imperial Rome, offers unique archaeo-metallurgical research potentials and is probably the most important site in the world for systematic archaeo-metallurgy. It is now the centre of IAMS’s European projects. Already we can look back with considerable satisfaction to almost ten years of systematic excavations, which created a completely new picture of early Rio Tinto (see IAMS Newsletter, No. 8). Lately, especially since the Volkswagen Foundation’s major support for our scientific metallurgical research programme, we could begin systematic studies of the Rio Tinto metallurgy (in collaboration with the Department of Material Science, I. Keesmann, Mainz University, and the British Museum Research Laboratory, which, besides active participation in our research programme, also put at our disposal secure and convenient space for our large sample collection). The aim of our Rio Tinto research programme is the theoretical (mathematical models) and experimental reconstruction of the extractive processes used for the production of metal from sulphide ore deposits, from the 3rd millennium B.C. to Roman times. Because of lengthy disruption of our field work in Rio Tinto, due to labour problems at the mine, our work has not yet been concluded, but we have already begun preparations for a major publication, Early Rio Tinto, Vol. 1: Surveys and Excavations, to contain the definitive publication of our Rio Tinto fieldwork and the studies of the excavated material. After the completion of the current archaeo-metallurgical analytical and experimental research programme, Vol. 2: Ancient Mining and Metallurgy of Silver and Copper at Rio Tinto, will be published.

As the Rio Tinto mine and its mineralogy is representative for many of the metal producing areas of the Old World, our work in Rio Tinto may well lay firm foundations for yet another major chapter of metal history.

3. Parallel to the current archaeological and process-technological research programme, IAMS initiated work on a comprehensive data bank for the study of the role of metal in history. This work, still on a fairly small scale, has so far been funded by private contributions and the Director wishes to take this opportunity to thank Nigel Lion for his continuous efforts.

History books speak about the Copper, Bronze and Iron Ages but these concepts of relative, archaeological chronology, have still not much more historical significance than when they were originally conceived as basic material categories used to sort out museum collections. However, many years of preliminary studies and observations by members of our research group indicated that the introduction, development and changes of metal-based technologies involved deep reaching economic, social, geo-political and intellectual implications. As very little detailed research work has been undertaken in the past, it was seen as imperative for IAMS goals to initiate a research programme with the aim of achieving a better understanding of these fundamental interrelations. About three years ago, a small team based on Tel Aviv’s Institute of Mining and Metal in the Biblical World, began detailed studies of archaeological excavations against the background of metal technology and culture-history, and recently we also began the screening of anthropological reports and research projects for relevant material related to these problems. Already a considerable body of information has been assembled which is not only related to the economy and social consequences of the use of metal and the geo-political implications of the control of metal sources, trade routes and working techniques – in war and peace – but also concerning the role of technological stimulation, in the widest meaning of this term, in the intellectual development of Man. It is in the context of these problems that IAMS is trying to set up a comprehensive research project in Southern, Sub-Saharan, Africa, where archaeo-metallurgical studies, combined with Recent Anthropology, may well help to bridge the gap between archaeological features and living man. We are also exploring the feasibility of such a research programme in other suitable areas such as South America, the Far East and the Pacific, where recent metal-related anthropology is still possible.

Beno Rothenberg

[Presented to a meeting of the Trustees in April 1987. Ed.]

News from the Director’s Desk

An appeal to the Editor of Radiocarbon

Members of IAMS and its Director strongly appeal to the Editor of Radiocarbon and other scientific journals which publish radiocarbon dates, not to accept for publication any samples taken from an excavation unless their stratigraphic context is confirmed by the archaeologist responsible for that excavation. If for some reason such confirmation is not available, it should be explicitly stated and the results marked ‘unconfirmed stratigraphy’.

Judging by three recent cases of erroneous correlation between unauthorised and stratigraphically unconfirmed samples and the actual stratigraphy of sites in the Timna Valley, the present way of publishing radiocarbon results may be causing a great deal of misleading and futile arguments (see J. D. Muhly, ‘Timna and King Solomon’, Bibliotheca Orientalis, 1984, p. 288):

1. BM1116 Timna Site 39 1945 ± 309 BP

The charcoal sample was taken by M. Barbetti from a smelting furnace excavated many years previously. He apparently did not realize that the furnace had been backfilled with stray material to prevent its collapse. No wonder Barbetti noted (in a letter of 9.12.74), ‘the samples (for magnetic determination) from Timna 39 do not appear to have been back in antiquity, which I find rather puzzling’. Incidentally R. Burleigh wrote: ‘BM1116 is also apparently invalidated by misassec’.

14
2. BM 1368 Timna Site F2, Sq. 3, L. 3 3030 ± 50 BP
'Site F2 is a small smelting installation thought to have belonged to Chalcolithic period by analogy with adjacent site, but date shows that it was contemporaneous with main, large scale, Late Bronze Age smelting activities... Comments based on information supplied by P. T. Craddock, Res.Lab.Brit.Mus'.

This sample was taken by Craddock in 1976, without coordination with the excavator, whilst taking part in the excavation of F2 by the Arabah Expedition. Since in a previous season the large quantity of Chalcolithic flint and ceramic finds had been removed form the extremely shallow site itself, and not from any 'adjacent site', Craddock apparently did not have a clear conception of its stratigraphy. The small fireplace cleared by Craddock, from which he took the charcoal sample, was stratigraphically clearly a late intruder (also according to the section recorded at the time of the excavation by Mrs Brenda Craddock). In the forthcoming publication of the Timna Mining Temple, Paul Craddock revised his view about the date of Site F2 accordingly.

3. C14 Lab. Heidelberg Univ. Timna Site 2
920 ± 50 BC
Published by U. Zwickcr in Metall 29 (1975), 1194. 'The C14 determination gave the time of the operation of the furnace as 920 ± 50, which would be the time of King Solomon' (transl. B.R.).

This sample was taken by U. Zwickcr from a dump of excavation debris about ten years after the excavation of Site 2. The site is a large smelter of the Egyptian New Kingdom with traces of short-lived occupation by later intruders, definitely not including King Solomon's people.

Ancient smelting of copper – a mathematical model

The first trial trenches excavated in 1959 into a heap of copper smelting slag in the Timna Valley by the present Director of IAMS signified the actual beginning of Archaeological Metallurgy as full scale archaeological field research in ancient mining and smelting sites. This was followed by systematic scientific investigations and the reconstruction, by experiment and theory, of the ancient extractive processes.

Continuing the archaeological and experimental research into the early copper metallurgy of Timna, mathematical modeling was employed in order to develop equations and relationships governing the one-step process of smelting oxide copper ore and to reconstruct the most probable process data, e.g. furnace diameter and height, ore plus flux and charcoal charging rates, air supply rate, ration of fuel input to copper output and process duration. The validity of this mathematical model derives from the agreement of the mathematical calculations with the archaeological evidence and the simulation experiments. Mathematical modeling has thus been shown to be a valuable completion of the methods used in archaeological metallurgical research.

The Timna region (Israel) provided archaeological evidence of copper smelting from the Chalcolithic period to the Bronze and Iron Ages and, after long abandonment, again in the Roman and Early Islamic periods. The archaeological finds prove a remarkable technological development in the smelting procedure during this period of time. Experimental simulation of the smelting process, together with mass and heat balance calculations, led to technological parameters, e.g. furnace dimensions, air flow and charging rate of the process, which cannot be derived from archaeological evidence. A paper, 'Mathematical Modeling of Late Bronze Age/Iron Age Smelting of Copper Ore' is due for publication in Metall in April 1988.


First Spanish IAMS-trained archaeo-metallurgist in our Newsletter

Marc Hunt Ortiz, the co-author of the paper on Roman spess processing (pp. 8–11), was born in Rio Tinto and studied archaeology at Seville University. For a number of years he took part as a volunteer in our excavations in the slag heaps of Rio Tinto and became involved in the archaeo-metallurgy of the area. IAMS offered him a scholarship for postgraduate studies at the Institute of Archaeology, University College London, where he took the IAMS course in archaeo-metallurgy. Together with a group of members of the British Museum Research Laboratory, he investigated metallurgical debris from Rio Tinto and is now working on his Ph.D. thesis on Silver in Southwest Iberia. Marc is the first Spanish IAMS-trained archaeo-metallurgist, and we are pleased to publish his first publication in our Newsletter.

Book Reviews


This book aims to be a 'comprehensive history of the early metallurgy of tin' and in this aim it succeeds admirably, although the epigraph 'early' is hardly relevant, as the author has taken the history of the exploitation of tin up to recent times. It is the first comprehensive work on the subject and is a veritable mine of information, arranged in three main sections – Africa and Asia, Europe (excluding SW England) and South-west England. Although the title of the book mentions only tin, the book, in fact, deals with tin as both a pure metal and also when alloyed with other elements. Hence, in the discussion of pre-history in particular, most of the information relates to bronze, rather than to free tin.

In fact, the geographical grouping is this reviewer's only
serious criticism of the book, as it means that it is difficult to get a chronological impression of the use of tin throughout pre-history and the historic periods. Whether, however, we really know enough to write such a coherent history is, perhaps, doubtful, but Penhalurick has ducked the issue and leaves the reader to search through his information-packed pages in search of the facts he/she needs.

The first section (51 pp.) deals with Africa, the Near East, Russia, China and the Far East, and the book, is illustrated with maps and line drawings. The author quotes numerous published analyses of metal objects containing tin, and also explores numerous myths about unsubstantiated reports of the occurrence of tin. This is one of the great services provided by the book, and the informed assessment of old reports of (nonexistent) tin mines or ore bodies will be extremely useful to historians of technology in the future.

The second section (54 pp.) discusses tin in Europe, initially chronologically and then by region – Bohemia, the Mediterranean islands, France, Iberia, Wales, Scotland, and Ireland. Of particular interest is the chapter on mining in the Erzgebirge, that great mining area in Central Europe now shared by several countries. Each separate chapter is provided with a thorough bibliography.

Finally, in the third section of the book (130 pp.), Penhalurick takes us onto home ground with his account of tin in South-west England. Every possible facet of the subject has been explored, but inevitably, for the early periods, information is scanty and we rely on occasional references by classical authors and on the analysis of surviving implements and other objects to allow a history of the use of tin to be reconstructed. One feels, however, that it is the history of tin in the Medieval and Modern periods which are the author’s prime interest and he has assembled numerous fascinating illustrations to guide us through the subject.

The book as a whole does succeed in its stated purpose of providing a history of tin, but it fails to present it in a readable fashion. The text, for the general reader, is too full of facts and figures and the arrangement of the information too much resembles a series of encyclopaedia entries for the various parts of the world. However, this fault, if fault it is, makes the book invaluable to the specialist, and it will be a must for all archaeological libraries.

W. A. Oddy

Department of Conservation, British Museum, London.
(Reprinted with permission from The International Journal of Geoa-

Metallurgical Reprint Series

This is a new venture from De Archaeologische pers (Zeel-
sterstraat 147, NL-5652 EE Eindhoven, Netherlands). Alec
den Ouden has long been known for his enthusiasm for publish-
ing work on technical history and already has an imposing number of titles on sale mostly related to metal-
lurgy. This new series is equally important. So far 14 works are available such as Percy’s Metallurgy, the section on gold in Schnabel’s Handbook on Metallurgy, Mushet’s Manufacture of Cheap Steel of 1883 and numerous other volumes, some taken from long articles (many over 100 pages long) in journals such as the Annales des Mines, which form conven-
ient publications in their own right.

The volumes are all in English, translated by Alec den Ouden himself where necessary, and footnotes and comments to the original texts have been added. These inexpensive reprints of often inaccessible works are very useful (more details and order forms from the publisher).

Smelting of Lead Ores in Reverberatory Furnaces as in Great Britain. Coste Perdonnat 1830 translated and reprinted by De Archaeologische Pers, 1986. 60p. Soft cover. £6.25 exclu-
sive of post from the publisher.

The original appeared in French in the Annales des Mines in 1830. The two young authors toured Britain and recorded in detail the processes in use at works in Derbyshire, North

Wales, Cumberland and Cornwall. The reverberatory furn-
aces used and the whole procedure are clearly described in

great detail with plans. The authors seem to have had full access and freedom to witness and record what they chose during their visits and their comments are most illuminating.

The work concludes with a synthesis of the British method and a comparison of the numerous variations witnessed on their visit, also comparison with European practice, including

the Scotch hearth. The conclusions show that technically the

British works were no more advanced. The greater efficiency

and the dedicated work force were responsible for the advan-
tage Britain had gained over their Continental rivals.

This is an important source work now made generally

available for the first time.

P. T. Craddock

Institute for Archaeo-
Metallurgical Studies

Director Professor Beno Rothenberg
Institute of Archaeology, University of London

Trustees

Professor R. J. J. Altham
Professor J. D. Evans
Sir Alistair Frame
Tom Kennedy (USA)
Nigel Lion
D. Rafael Benjumex Cabeza de Vaca (Spain)
Robert Rice
Professor Beno Rothenberg
Sir Sigmund Sternberg KCSE, JP
Simon D. Strauss (USA)
Professor R. F. Tylecote
Patricia Walker (USA)
Casmir Prinz Wittgenstein (Germany)

Scientific Committee

Professor A. Arribas Palau
Universidad de Palma de Mallorca
Professor H.-G. Bachmann
Institute of Archaeology, University of London; J. W. Goethe-Universität, Frankfurt-M
Professor Antonio Blanco-Freijerio
Universidad Complutese Madrid
Dr Paul Craddock
British Museum Research Laboratory
Professor J. D. Evans
Institute of Archaeology, University of London
Dr N. H. Gale
University of Oxford
Dr F. Molina Gonzales
Universidad de Granada
Dr John Merkel
Harvard University
Robert Rice
Rio Tinto Finance & Exploration Ltd.
Dr Nigel Seeley
Institute of Archaeology, University of London
Professor C. T. Shaw
Royal School of Mines, Imperial College of Science and Technology, London
Professor R. F. Tylecote
Institute of Archaeology, University of London
Professor P. Wincierz
Metallgesellschaft A.F., Frankfurt/M;
Clausthal Universität

Editor Peter A. Clayton