

Desert smelter

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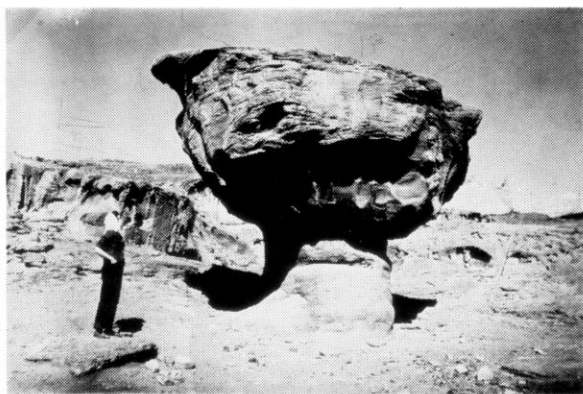
When the furnace was cool and could be safely dismantled, more than 1kg of copper metal was recovered.



Erecting a break to shield operators from the intense heat of the furnace

The metal was separated from a rich copper matte and slag by crushing. Refining was carried out by remelting in a clay crucible, the final product being around 99% copper. The crucible furnace was also copied from archaeological examples excavated at Timna Site 2, and was blown from a single pair of bellows.

The metallurgical products from the experiment closely matched the ancient specimens found nearby. A collection was saved for comparison, and the furnace was repaired for display in the Timna Valley Preserve. Together, the remains of the ancient furnaces and the experimental reconstruction, now present a complete picture of copper smelting for visitors to the "Mushroom Camp".



The "Mushroom" at Timna Site 2

And for one day, the enterprise and skill of a young researcher brought Timna's archaeological remains dramatically back to life.

Haifa experiments in line with Merkel results

In parallel with John Merkel's work at Chessington and Timna, a mathematical model of ancient smelting processes was built at the Haifa Technion by a young engineer, Dr. M. Bamberger, working under the supervision of Professors Peter Wincierz, H.-G. Bachmann and Rothenberg.

A smelter has recently been constructed, based on Dr. Bamberger's model, and first reports indicate that its results are in line with those produced by Merkel.

Thus the two researchers, working independently and approaching the same problem in entirely different ways, have achieved the same end-result. The significance of their work will be reflected in the production of a computer programme which can be applied to any study of the history of smelting processes from the primitive operations of the pre-historic metallurgists to the most sophisticated furnaces of the Classical periods.

Royal School of Mines chief joins IAMS committee

A closer relationship between IAMS and the Royal School of Mines is foreshadowed by the appointment to IAMS Scientific Committee of Professor C.T. Shaw, Head of the Department of Mineral Engineering Resources, Imperial College of Science and Technology.

Professor Shaw's experience and advice will be particularly valuable in planning the development of the archaeo-metallurgy courses at London University — a collective undertaking between IAMS and the Institute of Archaeology since 1976 — with a view to introducing a full degree-awarding course in 1982.

A graduate of Witwatersrand University, South Africa, Professor Shaw was also awarded the degree of M.Sc. in mineral exploration by McGill University, Canada.

In 1959 he joined Johannesburg Consolidated Investment Company, with which he held a number of appointments, including head of the computer division and director of the group laboratory, and was chief consulting engineer and an alternate director of JCI when he left South Africa in 1977 to take up the position of Associate Professor of Mining Engineering at Virginia Polytechnic Institute and State University.



Excavating a Late Bronze Age mining settlement near the spring at Corta Lago

Spring of sweet water marks Rio Tinto's first mining camp

A spring of sweet water trickling from the side of Cerro Salomon — the hill of Solomon — marks the site of Late Bronze Age mining and smelting at Rio Tinto, the world's oldest mine still in production today in southern Spain.

This is one of a number of important discoveries made by a team of archaeo-metallurgists and miners taking part in a second season of fieldwork in an IAMS project to probe the earliest beginnings of Rio Tinto.

The spring rises from the mountain on the north side of today's great open-cast mining operations at Corta Lago. Local people still drink from it as they have done for more than 3,000 years.

Rio Tinto's early miners settled around this spring in about the 12th century BC. And they built an aqueduct — the remains of which can still be seen — to carry its water to the furthest parts of their village.

Today, the surrounding countryside, once hills and valleys, has been flattened by bulldozers and excavators. The main objectives of IAMS's fieldwork last season were to make a detailed investigation of the ancient slag — on which much of the modern enterprise is built — and to search for relics that have survived the latest mining activities.

The latter task was undertaken by a team from the Derbyshire Mining Museum, led by Dr. Lynn Willies, and its members faced considerable hazards in reaching and exploring old workings on the steep face of the open pits of the North Lode.

Their most exciting find was a cave, about 50 metres

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Rio Tinto

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long, where jarosites — the silver-rich ore sought by the ancients — could still be seen on its walls. This cave-mine, located at the bottom of the gossan head, penetrated the secondary enrichment zone of the pyrite deposit. It is quite possible that it was originally part of the famous Cueva del Lago, a silver mine dating to the Late Bronze Age (12th-9th century BC), most of which has already disappeared into the jaws of modern bulldozers.

The entrance to the cave is only 100-200 metres from the early mining settlement which grew up around the spring, and its discovery could provide the answer to the question how miners of 3,000 years ago recovered silver hidden beneath gossan more than 50 metres from the surface. It now seems likely that they — or even generations of miners before them, belonging to the Argar culture (of which much evidence is to be found in nearby Nerva) — drove into the side of the mountain, creating caves which early literature has described as being "as big as churches" and full of silver ore.

Last season's investigations of slag heaps has provided clear evidence of Rio Tinto's silver production going back to the days of the Tartessians. These Late Bronze Age metallurgists already used a sophisticated smelting technology which was not substantially improved upon until Roman times. Contrary to previous assumption, the Phoenicians did not import any new technology, and it seems doubtful if they ever reached Rio Tinto at all; the "Phoenician pottery" found in the area is now thought to have reached there as containers for merchandise, the Phoenicians being essentially traders.

After the Tartessian-Late Bronze Age beginnings, local Iberian traditions and technology of metal production continued throughout the first millennium BC, developing in, and radiating from, the settlement around the Corta Lago spring. By the time of the takeover of the Rio Tinto mines by Imperial Rome, smelting installations and slag heaps covered an area of several square kilometres. It was only then — in the 1st century AD — that the indigenous methods of metal production were replaced by improved technologies of silver-copper-iron extraction.

Next season's work at Rio Tinto will be mainly concerned with an investigation of dwellings and other ancient buildings. In particular, excavation is planned of a Roman town, built on top of the silver slag, which could also have been a centre of administration for extensive copper mining.

It is also considered that a strange-looking earth mound, not far from the modern mine, and first noticed by local hunters, could conceal a dolmen of the 4th millennium BC, and this, too, will be excavated.

Investigations at Rio Tinto are under the auspices of Madrid University (Professor Antonio Blanco-Freijeiro) and sponsored by Rio Tinto Zinc Minera, Madrid.

Publications

B. Rothenberg, *The Mining Sanctuary of Timna*, is at present with the printers.

IAMS Monograph Number One, Rothenberg-Tylecote-Boydell, *Chalcolithic Copper Smelting*, is still available from Thames and Hudson, 30-34 Bloomsbury Street, London WC1, or directly from IAMS London office. The monograph series is shortly to be continued with a report on excavations of the ancient mines of Chinflon (SW Spain).

A report on the excavations of the ancient mines and smelting camp No. 30 at Timna is published (in German): H.G. Conrad — B. Rothenberg (ed.), *Antikes Kupfer im Timna-Tal*, available from Deutsches Bergbau Museum, Bochum, W. Germany.

A first review of the Sinai explorations 1967-1978 by the Arabah Expedition, affiliated to IAMS, is published by Kummerly & Frey, Bern, Switzerland: B. Rothenberg — H. Weyer, *Sinai, Pharos, Miners, Pilgrims and Soldiers*, (also in French and German editions).

Papers on Timna metallurgy by Prof. H.G. Bachmann and Dr. P. Craddock, members of the IAMS research group, and by Prof. B. Rothenberg on Chinflon are published in *Scientific Studies in Early Mining and Extractive Metallurgy*, British Museum, Occasional Papers, No. 20 (obtainable from British Museum, Great Russell Street, London WC1B 3DG).

Prof. R.F. Tylecote's *Metallurgy in Archaeology*, which has become a standard text book and has been out of print for many years, is to be republished in a revised and enlarged edition in 1984. This will be followed by a further work on metallurgy in prehistoric Europe in 1986.

Chinese excavate ancient copper mine

A recent publication of the Chinese Relics Publishing House, Beijing, recounts the history of the Tonglūshan mine, in the ancient State of Chu, on the Yangtze River.

Tonglūshan is the biggest of all Chinese ancient copper mines so far excavated, and the one with the longest production record. Four hundred thousand tons of ancient slag have been found on the site, together with several hundred vertical shafts and drifts of different structures, and 25 smelting furnaces of various dynasties.

Tools found dating to before the 6th century BC include wooden shovels, rakes and hammers, bronze adzes, chisels and pickaxes. With these simple implements, miners excavated shafts and drifts as deep as 50 metres and solved the problems of timbering, ventilation, drainage and illumination.

The Tonglūshan mine was in production nearly 3,000 years ago and it has been estimated that 80,000

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IAMS invited to probe Cyprus metal secrets

A small team of archaeo-metallurgists, led by Professor Beno Rothenberg, is to undertake a preliminary survey in Cyprus next May for an IAMS project to explore for the earliest mines on the island.

The survey is to be carried out on an invitation from the Cyprus Department of Archaeology following an international conference on the island last February. Attending this conference on behalf of IAMS were Professors Rothenberg, Tylecote and Bachmann.

Cyprus is one of the world's traditional sources of copper, the metal having been produced there extensively for several thousands of years; it was the main attraction for successive waves of Egyptians, Assyrians, Phoenicians, Greeks, Persians and Romans. The island's copper was particularly important to the Roman Empire, the material being known as *aes cyprium* — "ore of Cyprus" — later corrupted to *cuprum*, from which comes the English name, copper.

Whilst a considerable amount of investigative work has been done on the Roman remains, which include vast slag heaps, there is little authentic knowledge of the island's metallurgy earlier than the Late Bronze Age though copper was being mined and smelted there on quite a large scale at least 5,000 years ago.

The IAMS team is expected to be on the island for about a week, and its prime concern at this stage will be to ascertain whether the methods of exploration which have proved so successful in Israel and southern Spain can be applied to Cyprus where, according to Professor Rothenberg, "the laws of nature can be quite different from anywhere else".

Tylecote team finds slags in Sardinia

Recent discovery of the first verifiable slag in Sardinia confirms that metal smelting and casting were carried on in antiquity on the island.

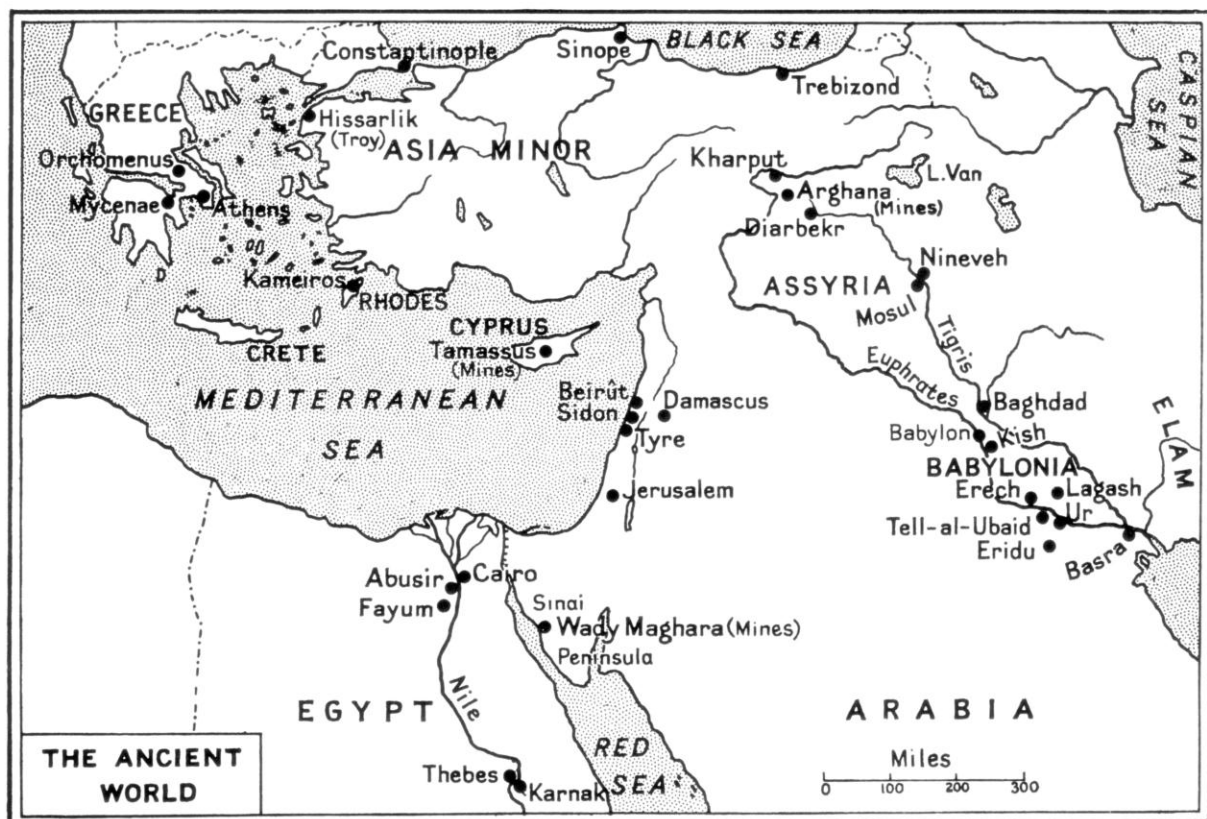
The slag, found with what was originally metallic tin, came to light during a survey of the mineral and metal resources of the island undertaken by Professor R.F. Tylecote, of IAMS; Professor Miriam Balmuth, an archaeologist of Tufts University, USA; and Professor R. Massoli-Novelli, a geologist of the University of Cagliari.

The main problem with the study of early metallurgy in Sardinia is one common in most of the Eastern Mediterranean, except Cyprus, that is to determine the degree to which the island used its own indigenous supply of minerals and how much was imported.

There is no doubt that by the Late Bronze Age the use of metals in Sardinia was of great as, or greater than, elsewhere, and there is evidence of import or trade by the existence on the island of ox-hide shaped copper ingots containing so-called "Cypro-Minoan" inscriptions common in the Aegean. This invites the question whether the supply of copper in the Late Bronze Age was inadequate to meet the needs of the community, or whether it was so great to provide a surplus for export in the form of an internationally-accepted ingot-type.

The recent investigation was carried out as part of a collaborative effort to define and treat the problems of the significance of metal technology and trade for

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Book review

Huelva report throws new light on Spanish mining history

A major contribution to the understanding of the history and development of mining and metallurgy in the ancient world is provided in a new IAMS publication expected soon (Benó Rothenberg and Antonio-Freijeiro Blanco, *Studies in Ancient Mining and Metallurgy in South-West Spain*).

Basically, the book is a report of the findings of an expedition which explored sites in Spain's Huelva Province between 1974 and 1978 under a project set up by Seville-Madrid Universities and the Institute for Archaeo-Metallurgical Studies, London. The co-authors — Professor Rothenberg, director of IAMS, and Spain's leading archaeologist, Professor Blanco, of Madrid University — directed the investigations which were carried out by teams of scientists working all over the central part of the great Iberian pyrite belt.

Their survey, backed up by detailed analytical and metallurgical studies, has provided the foundation for a new history of metal production in this part of the world. Early Copper Age (4th-3rd millennium BC) mines and mining tools, the earliest of Western Europe, were discovered, and Rio Tinto now appears to be the oldest mine in the world still in operation. It was originally opened up by indigenous people and worked by them during most of the ancient periods. Contrary to previous supposition, the sophisticated metallurgy of South-West Iberia can now be seen as a local development without any interference from outside.

Case study

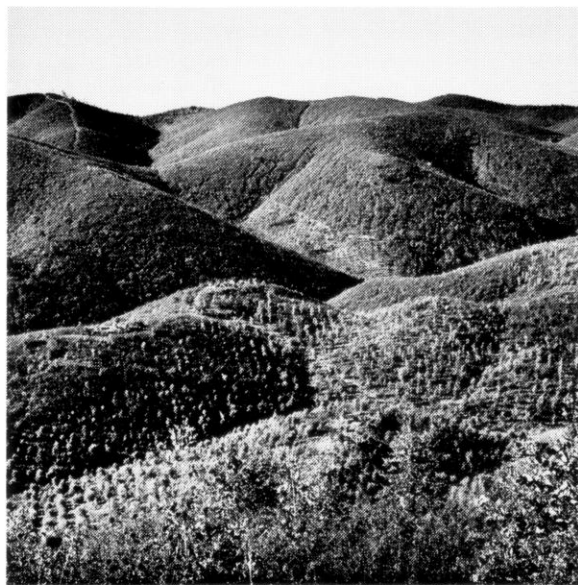
The overwhelming importance of metal in the history of the province is indicated by the very scale and extent of the remains since early chalcolithic times, and in this sense Huelva can serve as a model *par excellence* for the study of metal in history. The authors are at pains to point out that it was no purpose of the project to produce anything like a complete historical and geographical picture of the province. Its aim was more to present a profile of the history of its metal production and its manifold implications for the complex ethnic, social and geopolitical development of the area. This is a first, and in some respects, still rather tentative synthesis, which may have to be

Sardinia

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the Bronze Age nuragic populations.

Combined with increasing evidence for early interaction with Mycenaeans and Phoenicians, the team's finds support a concept of Sardinia as an emporium after 1200 BC, in dramatic contrast to the notion of withdrawn isolation held only a decade ago.



In country such as this in southern Spain — much of it now planted with eucalyptus trees — archaeo-metallurgists discovered remains of mining and smelting dating to the 4th millennium BC

amended by future discoveries and excavations of key sites.

However, it should be remembered that previous surveys in the Arabah and Sinai succeeded, by the very accumulation of detailed information from a large number of sites, in producing a valid picture that has not changed in its basic concepts by subsequent excavations.

Huelva's "new look", presented here, is therefore painted against a background of factual evidence — on archaeological finds (buildings, pottery, flint implements, coins, tools etc.) and, parallel to it, extractive metallurgical findings (mining technology, smelting products and waste, and the logistics of the operations).

Copper was the first metal used in Iberia, and its production had primitive beginnings: crude trench mines in quartz outcrops, and malachite veins roughly hammered out with grooved pebble-tools fitted with wooden handles.

Earliest yet

The chalcolithic smelting sites in Huelva are the earliest found to date in south-western Europe and, like their contemporaries in the Arabah, the local metallurgists in constructing their hole-in-the-ground bowl furnaces and preparing their charges, achieved almost the optimum principle of copper smelting in use throughout history.

No permanent habitation sites of Copper Age date

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Huelva Report

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were found in the Huelva survey, and a small excavation at Chinflon indicated only temporary dwellings in tents or huts near the mines. However, a group of dolmen, located near Chinflon, strongly suggests that these were the burial places of the first miners and metallurgists of the province.

The arrival of Republican Rome in Huelva did not cause any fundamental change in local mining activities, but the picture changes dramatically with the beginning of the Roman Empire under Augustus. In the early 1st century AD, many new mines were opened up and many active small mines were expanded into large-scale workings.

The famous Roman shaft-and-gallery system was now generally applied and made possible the intensive exploitation of the rich silver and copper ore deposits. It came as a surprise to the explorers to discover that nearly all the presently operating, and most of the old abandoned, copper mines of Huelva had previously been worked in Imperial Roman times and had produced silver as well as copper.

Millions of tons of ore, fluxes and slags and enormous quantities of charcoal were involved in the operations at this time. The Romans had also to cope with the very complicated logistics of feeding their labour force in remote mountainous areas, where few crops grew; drinking water was scarce, and large numbers of miners had to be housed.

All these elements make it difficult to accept the often-propounded view that the Roman mines in southern Spain were run by companies formed by private capitalists or contractors. Such economic systems may have worked during the Republican period, but at the huge industrial sites such as Rio Tinto, it seems far more likely that the operations were soon placed under state administration and technical management.

The book, which is being printed in Spanish as well as in English, is the first in an IAMS series, *Metal in History*, which aims to publish definitive reports of archaeo-metallurgical research in the major centres of ancient mining and metal production. The present volume is distributed by Thames and Hudson, 30-34 Bloomsbury Street, London W1, price £18.

Chinese excavation

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tons of copper were extracted before the digging was abandoned, for reasons yet to be investigated, though it is probable that it was flooded by a great inrush of water.

Seventeen of the smelting furnaces unearthed belong to the Song Dynasty (960-1279 AD). Bowl furnaces, which show signs of repeated fettling, were used, with hearth of about 37 cm diameter and a tap-slot at their lower part.

A number of other ancient sites in the nearby hills remain to be explored.

The Aims of IAMS

The Institute for Archaeo-Metallurgical Studies was formed as a charitable organization in 1973 to provide support for, and co-ordinate the work of, international research into the development of mining and metallurgy from earliest times.

Its formation was a direct consequence of successful expeditions made in the Near East during the previous 15-20 years by teams of archaeologists, metallurgists and other scientists, who explored the deserts which stretch from the Mediterranean to the Red Sea. Since then, researches have expanded into Western Europe where project teams have been making discoveries which are not only significant in mining and metallurgical history, but are also providing new and interesting information for others concerned in the study of early cultures and the development of industry and international trade in ancient times.

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