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News from the Institute for Archaeo-Metallurgical Studies

People

The last issue of the *iams* journal appeared in 1998, and we can report significant development since then in respect of archaeo-metallurgy within the Institute of Archaeology. Probably the most visible is the establishment of a new Chair for Archaeological Materials and Technologies at the Institute at University College London. This new prestigious post covers not only research into and teaching of archaeo-metallurgy, but of other, related, inorganic materials in archaeology as well. This decision allows to study the history of ancient metals in their wider material and social context, a direction which IAMS had always encouraged and promoted. It was thus only natural for IAMS to support this new initiative, and shortly after Professor Thilo Rehren was appointed as the first incumbent of this chair, he was also invited to become a Trustee of IAMS, and is now closely involved in its daily work.

IAMS is particularly glad also to welcome as new Trustees Mr Christopher J.B. Green, former Chairman of the Board of the London Metal Exchange (1987-1990) and Mr Trevor Tarring, former Chairman of Metall Bulletin plc. Between them, they bring not only a very stimulating enthusiasm into IAMS's work, but also most valuable experience and expertise in matters metallurgical, particularly in the current world-wide metal trade.

Following nominations by the Institute of Archaeology, UCL has recently conferred the title of Visiting Professor to Dr Vincent Pigott, formerly Senior Research Scientist and Associate Director for New Technologies at MASCA, University of Pennsylvania Museum, and to Dr (hc) Tim Shaw, emeritus Professor of Mining at the Royal School of Mines, Imperial College, and Honorary Professor to Dr Ian Freestone, Deputy Keeper at the Department of Scientific Research at The British Museum. We would like to congratulate them all for these well deserved academic honours.

Donations

We are particularly glad to report a most generous donation by Billiton Plc for a PhD scholarship in archaeo-metallurgy. Scheduled initially for three years, it will be starting in September 2001. Following advice of IAMS's Scientific Committee, this scholarship will enable one or possibly two particularly able research students to pursue doctoral research in a chosen aspect of archaeo-metallurgy under the supervision of academic staff at the Institute of Archaeology. In times of increasing fees for post-graduate education, soaring costs of living in London, and widespread shortage of student funding from public sources, it is good to see the strong bond between the current mining and metal industry and their archaeological past, and cultural heritage. The recent recognition of the former mining and smelting town of Blaenavon in Wales as a World Heritage Site by UNESCO indicates the growing awareness by modern society of the central role which mining and metals have played in human history – and indeed still do today. IAMS and Billiton now highlight

this awareness, and our link to the past, as a necessary root for our future.

We are also very grateful to Mr. Tom Brown for his generous donation of a number of various British metal and glass ingots dating to the late 18th century AD. They formed part of the merchandise on board of several East Indiamen which were lost off the English coast, and salvaged during the 1970s. With the ingots then being sold for scrap metal, it is to Mr Brown's merit to have rescued several of them for future generations. They are now part of the Institute's teaching collection, and a most welcome aid in visualising the trade in copper and other commodities.

Timna

Further important work is progressing at Timna, the ancient copper mining and smelting region north of the Gulf of Eilat/Aqabah. The Timna Valley is being turned into the 'Timna Mining Park', based upon the extensive research work done at Timna over the decades by Professor Beno Rothenberg, director of IAMS. The Timna Mining Park will be a unique combination of open-air museum, real archaeological sites and environment, and educational multimedia and research-oriented exhibitions. At present, Phase One of the Timna Park is close to its completion. This will consist of the first of the planned three buildings of its Visitors Centre, which will tell the story of Timna's mining-geological development and its prehistoric beginnings, leading to the life, beliefs and culture of New Kingdom Egypt - as introduction to the huge New Kingdom copper industry at Timna (late 14th to mid-12th centuries BC). In collaboration with Professor Tim Shaw, further excavations are taking place in the underground copper mines of the Chalcolithic period, the 5th millennium BC, as well as in the sophisticated mines of the New Kingdom, also to prepare these sites for visitors. In the underground mines, special exhibits will show miners and their tools 'at work'. As the third station of Phase One, an open air Museum of Rock-Art will be located inside the mining area, and will show 6000 years of rock drawings found in the mining region. Phase One will be opened to the public within several months. Phase Two of the Mining Park will include an additional building of the Visitors Centre and a replica underground mine that will tell the story of the mining technology developed in Timna through many thousands of years, from the Late Neolithic Period to Early Islam. Phase Three will show the history of copper smelting technology through 7000 years, as preserved in the smelting sites of Timna excavated by IAMS. There will be a unique exhibition of the development of the smelting furnace throughout the ages. Phase Four will be dedicated to 'Mining and Cult', with the Egyptian New Kingdom Hathor Temple as its centre. Mine workings and smelting sites of all periods were found to be related to shrines, high places and rock-altars, presenting a highly inspiring picture of myths, rites and symbols peculiar to the miners and copper smelters of ancient Timna. A regional archaeological museum of a unique museological conception, which will show the numerous



On 9 February 2001, the Peruvian ambassador and the Attachi for Cultural Affairs were visiting iams at the Institute of Archaeology. From left to right, the Attachi for Cultural Affairs, Mr. Luis Escalante-Schuler, Mr. Trevor Tarring, Professor Tim Shaw, HE Mr. Gilbert Chauny, Ambassador of Peru, Sir Sigmund Sternberg and his wife, Hazel Sternberg, Professor Thilo Rehren, Dr John Merkel, Dr Bill Sillar, students at the Institute E Simonsson & S Kvam, and Dr Simon Hillson.

archaeological and archaeo-metallurgical finds from the excavations at Timna and the Arabah Valley, is also planned for the Timna Mining Park. The Timna Mining Park has been initiated and planned by Professor Beno Rothenberg, who is also the head of the Timna Park Project, supported by the Jewish National Fund.

Peru

On 9 February 2001, HE Mr. Gilbert Chauny, Ambassador of Peru, and Mr. Luis Escalante-Schuler, Attaché for Cultural Affairs, visited IAMS at the Institute of Archaeology. IAMS has been associated with the Institute of Archaeology since its foundation as a charitable trust in 1973. Sir Sigmund Sternberg (Chairman, IAMS Trustees) invited the Ambassador and Attaché to IAMS in order to highlight archaeological research on metals from Peru. This was the second visit to IAMS by HE Mr. Gilbert Chauny. His previous visit was in 1992 for the IAMS Invited Lecture by Prof. Izumi Shimada (Southern Illinois University) on the excavations of an elite burial at the Sican period (pre-Inca, ca. AD 900-1000) capital near Batan Grande, in Northern Coastal Peru. During the past ten years, the investigation of excavated metal samples from the Sican site has become a major research project at IAMS and the Institute of Archaeology. Seven MSc student research projects have benefited from access to the excavated metal samples. Research and teaching on Peruvian archaeology at the Institute of Archaeology includes ethnographic, technical and conservation studies of ceramics as well as extending to dental remains and other materials.

Journal

Readers will notice a change in the design and layout of this issue of iams over the previous ones. The traditional design was drafted more than twenty years ago by the famous graphic designer, the late Abram Games. He has also designed the covers of IAMS's various monographs, and has helped to develop IAMS's unique identity over the years. Following detailed discussions, and in consultation with IAMS's Scientific Committee, it was decided to develop the iams newsletter into an open and refereed journal. This includes going back to an at least annual appearance, and to invite contributions from scholars not directly linked with IAMS. Clearly, the implementation of such a process will take its time, and much effort will be needed to achieve it. The journal's new design, carefully based on its former appearance to underline the continuity

in the process, is to indicate this change. The success of iams as a refereed journal, however, depends ultimately on the quality of papers submitted for publication. Any correspondence related to this, including submission of compact and timely papers for publication, should be directed to the Editor, Professor Thilo Rehren, at the address given on the front cover. The Scientific Committee has agreed, in first instance, to review submissions for publications. Outside reviewers will also be sought.

Teaching

Over the last twenty years, one of IAMS's key missions has been to support the archaeo-metallurgy programme within the Institute of Archaeology at 3rd year undergraduate level and as part of the Institute's master programmes. Following the recent restructuring of the Institute's teaching programmes, and the establishment of the new Chair of Archaeological Materials and Technologies, the traditional MSc in Archaeo-metallurgy has developed into a new MSc in the Technology and Analysis of Archaeological Materials, first offered for the academic year 2000/01 (see the back page of this issue for more details). According to the pivotal role which metallurgy played throughout history, archaeo-metallurgy is very much at the centre of this new degree. This includes the teaching of extractive techniques used in ancient metallurgy, the trade in metals, and the scientific study of metallic artefacts using a host of methods. The new structure, however, allows to include the study of other archaeologically important materials as well, such as stones and lithics, ceramics and plasters, and glass, glazes, pigments and beads. This holistic approach to a wide range of materials reflects the close relationship between the different substances, at the level of raw materials and fuels used, shared technologies in their processing in antiquity, and common analytical and interpretative methods employed for their modern investigation and understanding. It is in teaching masters and postgraduate students where the various strands and activities of IAMS come together: The people behind IAMS, bringing with them their particular expertise; the donors providing the necessary means; the research activities and the teaching programme at the university; and the journal to publish some of the results; all play their unique part in the MSc and PhD projects in archaeo-metallurgy at the Institute of Archaeology UCL.

Rock drawings in the Ancient Copper Mines of the Arabah - new aspects of the region's history

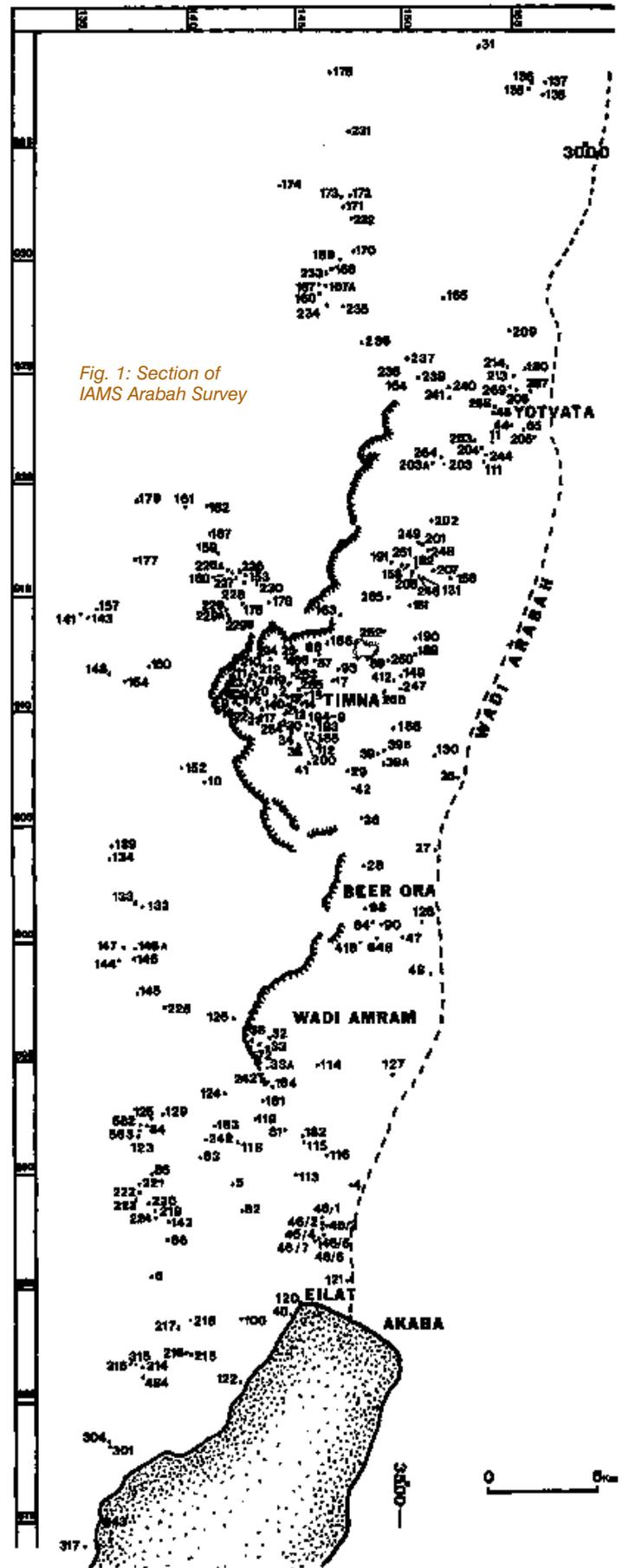
Beno Rothenberg, Tel Aviv / London

Introduction

During our extensive surveys of the Negev, the Western Arabah Valley and the Sinai Peninsula (1959-1990), we observed and recorded a huge number of rock drawings along ancient travel routes, at camping sites and in settlement areas, around cult sites and burial centers, as well as in regions of ancient mining. I have always wondered why the majority of these rock drawings seemed to be basically of the same style - engraved into the rockfaces by the same pure linear technique¹ - with chronology-related differences mainly in their material-cultural and socio-economic details as well as in the change-over from extinct to newly domesticated/introduced items of fauna and flora. The historical significance of this stylistic congruity over several thousand years has not ever been properly considered in the literature dealing with rock art, probably because of a common fundamental 'bias' in the methodology of the investigation of rock drawings: the isolation of the rock drawings from the settlements, work and cult sites, and their archaeology². In most of the publications dealing with rock art, the authors used almost exclusively methods of stylistic typology and analogy, which often left basic problems, like dating, unsolved and open to guesswork. In our surveys we integrated the rock drawings into the settlement history and emphasized not the, often minor, differences of style and subject-matter, but the fundamental stylistic congruity of most of the rock drawings - which we now understand as evidence for the continuity of the pastoral lifestyle of the indigenous population of these arid regions during several thousands of years³. Seen this way, the rock drawings are complementary to the archaeology of the settlements, in fact, the stylistic and thematic continuity shown by the rock drawings provide a clear indication for the continuity of settlement in the region by the same indigenous people even during periods not yet identifiable by archaeological remains⁴.

Once we understood the interconnection between the rock drawings and the settlement history, our attention was drawn to the relatively small number of obviously intrusive rock drawings, which seemed to represent datable historical events of importance. The most obvious intrusive groups of rock drawings were left behind by Sinai-Arabah Copper Age Early Phase⁵ (appr. Chalcolithic - Early Bronze I) miners and settlers and, at a much later time, by Pharaonic expeditions to the turquoise and copper mining regions of Sinai and the Arabah. The integration of these rock drawings into the settlement story, as 'told' by archaeology and ancient monuments, provided essential historical data to the history of the Sinai Peninsula and the Arabah (Rothenberg & Bachmann in preparation).

Most areas of ancient mining in the Arabah and Sinai showed groups of rock drawings by the indigenous people, but the rock engravings, mostly of quite different styles and themes, left behind by intrusive groups of miners, are historically the most significant. In the following we deal with two groups of such intrusive rock drawings, found by us in the mining region of the Arabah, one, at a site in the Arabah, north of Timna, of Copper Age date and related to copper smelting sites; the second, located inside the copper mines of Timna, dated to the Egyptian New Kingdom. Both groups of engravings, very different in style and contents from the traditional indigenous rock drawings of the Arabah, have been previously published (Rothenberg 1972), but a recent detailed and comprehensive reconsideration of the survey material, in preparation of the final publication of our Arabah and Sinai surveys, have led to a revised interpretation - first published here.





Early rock drawings in a prehistoric shrine, Sinai-Arabah Copper Age dwellings and smelters, and 'Desert Kites' in the Southern Arabah - and the Palette of Egypt's King Narmer of Dynasty 0.

1. North of the Timna Valley (Fig. 1), a small, isolated hill of 'Middle White Sandstone', which in the Arabah is the copper ore bearing rock, was conspicuous because of its grey-white colour and its unusual shape. Located at the head of shallow Wadi Odem⁶, it was about 10 m high and was cut by small gullies into several pillar-like blocks of smooth, roundish appearance. Three low, semi-circular, semi-detached enclosures were built against this rock formation (Site 191), the middle one enclosing the entrance to a narrow, man-wide canyon in between the two central 'pillars'. Inside these enclosures a number of pottery sherds were found⁷ which could be dated to the three Phases of the Sinai-Arabah Copper Age⁸ (approx. Chalcolithic⁹-Early Bronze I; Early Bronze II-III, Early Bronze IV {MB I or EB/MB}) - 5th millennium to 2000 BC. Accordingly, we suggest a Chalcolithic date for the first phase of this site, which we see as a desert shrine used for centuries by the settlers of the mining villages nearby (see below). According to the ceramic evidence found in the shrine, and the date of the nearby settlements, this shrine was used as a cult site until the end of the S-A Copper Age, about 2000 BC.

The rockface within the enclosure walls, also inside the narrow canyon, was covered by numerous rock drawings (Fig. 2) in different styles. Differences in the grade of the patination of the drawings indicated that they were made during a rather extended period of time, *i.e.* not only during the Copper Age but also in much more recent times.

The earliest drawings, deep inside the narrow canyon, represent a strange pair of anthropomorphic figures, perhaps the divinities worshipped here (right side of fig. 2). The figure at the right, 55 cm high, is reminiscent of the geometric character of the Chalcolithic frescoes of Teleilat el-Ghassul (NEAEHL 510). Possibly female, it has concentric circles on top of its head¹⁰, drawn as three short incisions, and is crowned by two horns. The figure to its left, 45 cm high, perhaps a male, has the same style head with three short, deep lines but no further emblems. It appears that both figures have wings attached below the shoulder. Next to these two 'winged' figures are several human figures with emphasized, large hands, perhaps also icons of supernatural beings. The strangeness of this group of figures is rather outstanding, compared with the rock drawings known to us from the region, and their location, deep inside the rock fissure, seems indicative of the importance attached to these figures by the 'artists'.

A second group of engravings, also unique to this site, is located outside the canyon (left side of fig. 2). Here, five engravings, ca. 100 cm high, show ostriches in an almost abstract technique, the exaggerated, upright, long necks with a mere indication of the head. The birds are represented from three different sides at a sophisticated level of abstract realism, giving the very essence of the bird's form and movement,

Fig. 2: Rock drawings in prehistoric shrine in Wadi Odem (Site 191)

and nothing more. The ostrich on the right is drawn front view, its legs as one strong line; the bird to its left is drawn in profile, with the body beautifully carved out in relief and the two legs given as two short lines with emphasized feet. The third bird has an unusually long neck; its wings are strongly drawn upwards and its two legs represented by two parallel strokes - this is obviously an ostrich in movement, drawn from the rear. The details of the body of the fourth ostrich are not quite clear; the fifth is again drawn in profile, its body damaged by later drawings. The five birds are not drawn on the same plane but more as if a flock of dispersed birds was caught unawares by the 'artist'.

Patina-wise and by their dominant location, these two groups of drawings are the earliest at the site, and we suggest that they were drawn at the time the S-A Copper Age Early Phase (Chalcolithic) shrine was established. We relate the 'tree-of-life' to the S-A Copper Age Late Phase (Early Bronze IV)¹¹, others may date to the S-A Copper Age Middle Phase (Early Bronze II-III). A number of drawings, mostly of geometric style, seem to be Bedouin engravings, some ancient, others fairly recent. It appears that this extraordinary, isolated early shrine attracted the desert nomads of many periods who encamped and buried nearby, and also carried on the ancient tradition of rock engravings here, perhaps with a similar 'magic' intent. The latter is indicated by the conspicuous fact that the Bedouin only engraved on the wall of the early shrine individual, iconic features and not any of the Bedouin narrative rock drawings so common in the Negev Highland, Sinai and the Arabah.

2. Most of the Arabah Valley is an inhospitable, arid region with rather poor soil, and our Arabah Survey map shows that there are very few sedentary habitation sites along the rift valley - with the exception of small groups of camping sites next to the few natural or man-made sources of water, and, foremost, dense clusters of settlements or sites of ancient copper production inside and around the copper mining valleys of the Southern Arabah. On top of most of the low hills along the western fringe of the southernmost Arabah, slag concentrations indicate small scale copper smelting of early dates. The shrine of the rock drawings in W. Odem was the westernmost of a cluster of ancient sites - habitation and copper smelting sites as well as 'desert kites' (see below) - located between the Timna Valley and the water-rich oasis of Yotvata¹² (see fig. 1).

It should be mentioned here, that, with the exception of a lone smelting site of the Late Pottery Neolithic Period (Rothenberg & Merkel 1995), and some very minor Chalcolithic smelting activities at the site of the Egyptian Mining Temple (Rothenberg 1988: 57), only New Kingdom smelting sites, based on obviously extraordinary logistics, were located inside the Timna and Amram Valleys. All earlier, pre- and protohistoric smelting took place in the Arabah Valley, on low hilltops and next to settlements, obviously to be nearer to water and wood. The pre-Egyptian settlements in the Arabah obviously served as the logistic hinterland, producing the nec-



Fig. 3: Chalcolithic dwelling in the Arabah

essary food, herding the animals, and housing the families of the early copper producers who had their smelting workshops nearer to the copper mines.

A cluster of sites¹³, related to the Shrine of the Rock Drawings, spread immediately west of the shrine, over an area of about 4 km². This area was close to the springs and swamps of Yotvata ('Malchat Yotvata'), a rich source of water and wood. Only one of the many sites, Site 201A, could be excavated by us¹⁴, the others were dated by surface pottery finds and by their architecture¹⁵. A number of sites could not be dated more accurately than 'S-A Copper Age', pending future exploration by excavations.

Sinai-Arabah Copper Age Early Phase (appr. Chalcolithic-Early Bronze I)

There were several S-A Copper Age Early Phase groups of round and oval enclosures (Fig. 3), probably tented dwellings. This settlement represented the only purely domestic centre of this period in the region and was, according to the pottery, connected with the nearby Shrine of the Rock Drawings. There was no copper smelting connected with any of these dwellings, though S-A Copper Age Early Phase pottery was found among the slag at Site 201F, a widely dispersed area of unidentifiable structures north of the S-A Copper Age Middle Phase hill-smelter Site 201/A2. In this area, copper was apparently smelted during several phases of the S-A Copper Age. We should mention here that the major S-A Copper Age Early Phase copper smelting activities took place at sites much nearer to the Timna Valley and not near any dwelling sites of that period. See f.i. the 5th millennium BC smelter Site 39¹⁶ (Rothenberg & Tylecote 1978; Rothenberg & Merkel 1998) and smelters of this period on hilltops outside the Timna Valley¹⁷.

Sinai-Arabah Copper Age Middle Phase (appr. Early Bronze II-III)

At least two sites, dated to the S-A Copper Age Middle Phase, were identified in this cluster, Site 201A and Site 15¹⁸. Substantial copper smelting took place at Site 201A, some of it close to the actual dwellings. The dwellings were one-room buildings, rectangular with rounded corners, 5 x 7 m, the entrance at the centre of one of the longer sides. Sometimes small storage structures were attached on the outside. It was typical Early Bronze Age II architecture, i.e. 'broadhouses' of a type common in the region (Kempinski & Reich eds. 1992: chaps 7 & 9), also well-known from excavations of EB II settlements at Nabi Salah in South Sinai (Beit-Arieh 1974) and a number of other sites found in our Sinai Surveys. The building technique here, however, was quite primitive and we may assume that the style of architecture had spread into the region but that there was no direct connection between the South Arabah and the 'Canaanite' EB II region in the north, as f.i. 'Canaanite' Arad. Some of the pottery found at Site 201A was also very similar to the local pottery of Nabi Salah

(and the Sinaitic hole-mouth pottery of Arad) though there was no Aradian ('Canaanite') pottery at Site 201A - or any of the other settlements of this period in the South Arabah.

Copper smelting slag was found dispersed at the northern edge of the settlement, but mainly on top and on the slopes of the mountain to the north (Site 201A/2-3), which was a centre of copper smelting of this period, in fact the only smelting site of the S-A Copper Age Middle Phase in the Southwestern Arabah. The slag was tapped slag and its characteristics presented the picture of an advanced extractive metallurgy. The fact that Egyptian pottery was found at the site, and the discovery of a very similar smelting site of the same period in Southern Sinai, Site 590, may indicate the Egyptian origin of this more advanced technology (Rothenberg 1999: 82-84).

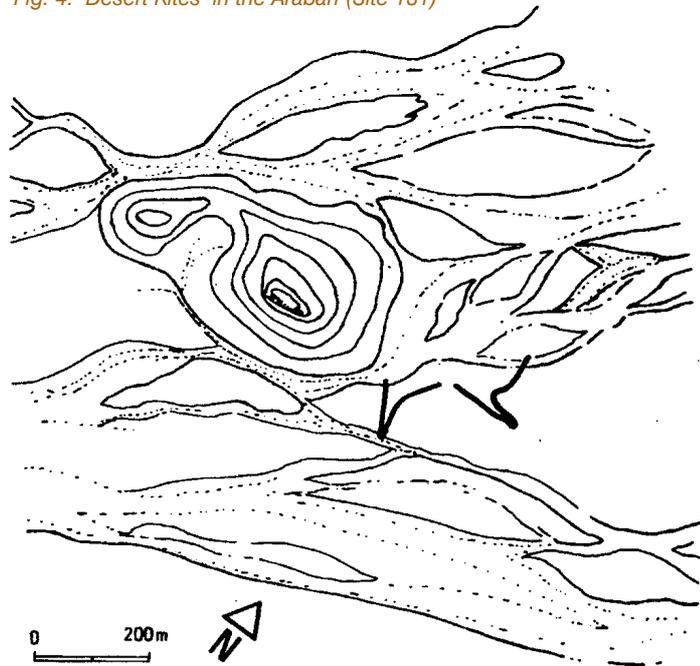
Sinai-Arabah Copper Age Late Phase (appr. Early Bronze Age IV)

In the northern part of the site cluster west of the Shrine of the Rock Drawings was a very extensive and continuous spread of dwellings, similar to a widespread Bedouin encampment, which we recorded in our survey as Sites 248 and 249. The pottery collected at these sites was similar to the pottery sherds of the S-A Copper Age Late Phase, found in the Shrine. There was quite a variation in the details of the architecture of these sites, many showing several construction and destruction phases, but the dominant type was the 'classical' EB IV (EB/MB) dwelling, well-known from the Early Bronze Age IV settlements of the Negev and Central Sinai (Cohen 1981; Clamer & Sass 1980): either individual circular enclosures, probably used as pens for the flocks, with smaller, circular dwellings attached at the outside or groups of several such semi-detached 'units'. There were also circular buildings with a stone-built 'vestibule' protecting the entrance, a feature still used by the Bedouin of the region.

There was no copper smelting at Sites 248 or 249 - or at any of the other dwelling sites of this period in the Arabah. The S-A Copper Age Late Phase copper mining and smelting took place at sites in the estuary of Wadi Timna (Site 149), at the fringe of the Arabah Valley, and was in fact the earliest 'industrial' plant properly organized for a continuous and efficient production on a scale so far unknown from any other prehistoric smelting site in the region¹⁹.

3. At the east end of the site cluster, somewhat isolated from the dwellings, were two structures of a peculiar design, Site 131 (Figs. 4-5), known as 'desert kites' (Meshel 1974; 1980)²⁰. A 'desert kite' is a structure of two long walls, meeting at an angle of appr. 30°, forming, thereby, a triangle with an open base. At the apex of the two walls was a tower-like, round structure. It is now almost generally accepted, that the 'desert kites' were built as traps for gazelles and other animals.

Fig. 4: 'Desert Kites' in the Arabah (Site 131)



The two 'desert kites' of Site 131 were adjacent structures, the east wall of one of them and the west wall of the other almost touched each other, forming thereby a single unit. The length of the walls was 150 – 203 m, the openings between the walls 125 and 168 m, together enclosing between their long open arms a wide stretch of land, approx. 300 m. At the apex of one of the 'kites', a tumulus had been built on top of the original structure; several more tumuli had been built close by. The tumuli were reminiscent of burials of the Early Bronze Age IV (EB/MB) in the Negev mountains.

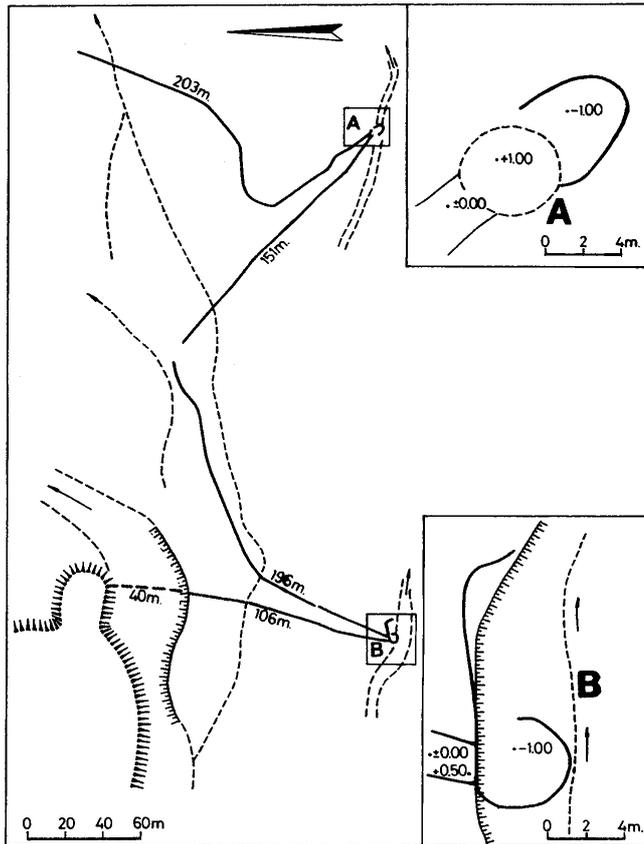


Fig. 5: Plan of 'Desert Kites' in the Arabah (Meshel 1974)

At the time of the discovery of the Arabah 'desert kites' of Site 131, we collected some pottery sherds and flint objects on the surface, especially around the apex of both 'kites', which were dated to the Chalcolithic Period (Rothenberg 1972: 53). At a later visit to the site we collected some more pottery sherds, some of which were dated to the S-A Copper Age Late Phase. During our Arabah Survey of 1982²¹ we revisited Site 131 and found some more sherds, including sherds of the S-A Copper Age Middle Phase.

Another 'desert kite', Site 156²², was located further to the east. Its arms were 114 and 137 m long, the open side 111 m. The whole structure was badly disturbed in ancient times and most of its building stones had been removed, apparently in order to build a semi-attached group of dwellings at its apex and also about 20 m further away. There were also several burial tumuli on top of the walls and next to the 'kite', also reminiscent of the EB IV burials of the region. The site was badly disturbed by recent digging and only a few pottery sherds and flint objects of the S-A Copper Age Late Phase were found, which we relate to the later dwellings and burial tumuli. The stratigraphy of the surviving structures of Site 156 clearly shows that the 'kite' was earlier than the EB IV dwellings and burial tumuli²³.

The identification of the pottery and the stratigraphy of Sites 131 and 156 strongly suggested a S-A Copper Age Early Phase (Chalcolithic) date for the construction of the 'desert kites' in the Arabah. During this period, the Shrine of the Rock Drawings, the group of dwellings and the 'desert kites' formed a unique settlement set up which was to go on into the S-A Copper Age Late Phase. It appears that at some stage of the

S-A Copper Age Late Phase, perhaps following the influx of a wave of newcomers to the region, this set up started to fold up - the 'kites' were no longer used for hunting but served as burial grounds - and we may assume that the Shrine as well as the dwellings were also soon abandoned. At that time - which we are not yet able to date accurately - prehistoric copper smelting in the Arabah had also come to a standstill, to be renewed only by Egyptian New Kingdom mining expeditions at the end of the 14th century BC.

4. The first 'desert kites' were discovered and published by the R.A.F. pilots F.L. Maitland (1927) and G.C. Rees (1929), flying over the desert region east and northeast of Amman. Rees reported that he observed at least three chains of 'kites', each some 20 miles in length (Rees 1929: 397), though there were also some isolated 'kites', like the 'kites' of the Arabah, in this region. The date and purpose of the 'kites' in the Syrian Desert have been for long a subject of intensive discussions (Dussaud 1929: 144-163; Kirkbride 1946: 1-5; Yadin 1955: 1-10; Rothenberg 1967: 290; Meshel 1974: 129-143; 1980: 265-288). The problem of dating the 'desert kites' was enhanced by the fact that there was evidence for the use of 'desert kites' still at the beginning of this century (Meshel 1974: 141). Until our investigations of the 'kites' in the Arabah - which established by pottery and stratigraphy their origin in the S-A Copper Age Early Phase (Chalcolithic) - the problem of the date of the 'desert kites' had remained unsolved, and only lately was their function as hunting traps more widely accepted.

Y. Yadin (1955) published an original interpretation of some enigmatic signs on the Narmer Palette, one of the most important documents from the very beginning of recorded history in Egypt (Fig. 6). Most of the contents of the palette is a record of the unification of Egypt, King Narmer being clearly depicted on the palette as the ruler of both Upper and Lower Egypt. However, the lowest field on the reverse side of the palette, separated from the upper part by a horizontal line, was, according to Yadin, "the earliest record of Egypt's military penetration into Asia", *i.e.* the record of "Narmer's domination of two main highways between Egypt, Syria and Mesopotamia: the 'sea road' and the 'king's way'... The former cuts its way through the most fortified part of Palestine, the latter through the less inhabited and much less fortified plateau of Trans-Jordan" (Yadin 1955: 10). Yadin reaches this conclusion by the assumption that the figures of the two naked men with long hair and Semitic features in the lowest field on the palette represent subjugated enemies of Egypt, which were identified by the two signs above the two figures: the sign above the figure on the left "is recognized by all who have dealt with the subject to represent the plan of a rectangular fortress.... namely, the area of Palestine, already fortified in this period". The sign on the right represents a 'desert kite' which identifies "the land of the kites", *i.e.* "the region which lies near the highway between Trans-Jordan, Syria and Mesopotamia". This latter conclusion is based on the distribution of the 'desert kites' as known at the time, and the assumption that "nothing of the kind (*i.e.* 'desert kites') has been discovered anywhere else in Asia or Africa".

Yadin, by a somewhat circular argument, dated the 'kites' "to at least the beginning of the third millennium BC and possibly to the later half of the fourth millennium", a date (EB IB) that would fit the identification of a 'desert kite' on the Narmer palette (Yadin 1955: 10). It seems difficult to accept such a dating argument, and this for the simple reason that the types of 'kites', especially those which appear as huge chains in Jordan, vary from place to place, and apparently also within the same area, and were most likely built during different periods. We do, however, agree with Yadin's date of the Chalcolithic-Early Bronze I period for the earliest construction of 'desert kites', and this in the light of the archaeological evidence which we found at the 'kites' of the Arabah.

Yadin's rather clever interpretation, identifying the sign on the Narmer palette as a 'desert kite', will now have to be considerably changed in the light of recent discoveries of many more 'desert kites' over a very wide region, from the



Fig. 6: Reverse of the Narmer Palette. Detail of Reverse.

vicinity of Homs in Syria to Qasr el-Azraq and further east and northeast in the desert of Jordan, down to the Arabah and further on to South Sinai. We may assume that more 'desert kites' will be discovered by surveys in so far unexplored desert regions of the Near East and North Africa. Obviously, the conclusion by Yadin that we are dealing with a record of an "Egyptian military penetration into Asia" is no longer acceptable in the light of the present distribution map (Meshel 1980: 284) of the 'desert kites' (Fig. 7), the newly established terrain of the 'desert kites'. Narmer could not possibly have campaigned over such huge areas²⁴ - Yadin, based on his interpretation of additional symbols on the Narmer palette (Yadin 1955: 10-16), extended the area of Namer's military expeditions even as far as Mesopotamia.

We would suggest to identify the two naked men, and their identifying signs on the palette, not as subjugated countries but as subjugated people from the neighbouring fertile regions, people from the rectangular fortresses, as well as from the arid desert areas characterized by the 'desert kites'. The latter must have been the nomadic pastoral people often depicted as the subjugated Asiatic enemy on early Egyptian pictorial records. Whether these were military expeditions into the neighbouring countries or punitive actions against intruding groups of people on Egyptian territory, is a question still to be answered by archaeologists and historians. It is of considerable interest that the two men with Semitic characteristics were depicted on the palette as running away, because our Sinai Surveys provided the evidence for a gradual takeover of the Peninsula by Egyptian mining expeditions to the turquoise and copper mines. Starting in pre- and early dynastic times in West and Southwest Sinai - the indigenous, local inhabitants, the 'desert kite' people, were pushed out, their settlements destroyed or abandoned - Pharaonic Egypt became active in East Sinai, including the mining sites in the Arabah, only at the time of the New Kingdom. At that time most of the indigenous 'desert kite' people had already been destroyed or pushed out of Sinai into the territories across the Arabah, probably into Syria, Jordan and Arabia.

Notes

1. We proposed to date this group of rock drawings from the late Early Bronze Age to fairly recent times. During early periods of prehistory, 6th-4th millennium BC, especially in the Negev mountains but also in the Arabah, hunting scenes were not linear engraved but fully pecked onto the rockface, which created more dynamic, realistic representations than the linear engravings. However, the linear type engravings represent the largest and dominant group of rock drawings in the region - closely related to extensive habitation remains.

2. Many of the well-known publications of rock art of different regions were entirely based on photographs provided by the archaeologist who performed

the fieldwork and recorded the rock drawings (f.i. Anati 1968; Winkler 1938-9). Others surveyed exclusively for rock art and did not relate to any archaeological data (f.i. Lutz 1995).

3. Rothenberg & Glass 1992 on the chronological aspects of the existence of an autochthonous, pastoral population in the Arabah and Sinai.

4. See f.i. Finkelstein 1995: 101. Finkelstein in his discussion of the 'gaps' in the archaeological evidence of the regions under consideration here, does, however, not take in consideration the rock drawings of these regions.

5. Since the common chronological terminology of the Levant or Egypt was not really applicable to the early cultures of Sinai and the Arabah, we proposed phase- rather than period-related chronological concepts: the Sinai-Arabah Copper Age - Early, Middle and Late Phase. These phases reflect the slow technological and cultural development in this region (Rothenberg & Glass 1992).

6. Wadi Odem, Israel G.R. 14979166, Survey Site 191. In our first publication of this site (Rothenberg 1972: 54) we related it to Nahal (wadi) Quleb, the shallow wadi at the south side of the rock formation.

7. The walls were badly disturbed by Bedouin camping and there was no proper stratigraphy left for excavation. We cleared the disturbed ground down to virgin soil and collected the sherds and several flint tools.

8. In our first publication (Rothenberg 1972: 54-62) the pottery was dated to the Chalcolithic Period but this date had to be revised after the petrographic investigation of all our pottery finds (Rothenberg & Glass 1992 c.f. note 3).

9. The Sinai-Arabah Copper Age Early Phase started in the Late Pottery Neolithic Period (Rothenberg & Glass 1992; Rothenberg & Merkel 1995) but no pottery sherds of this period were found at this site.

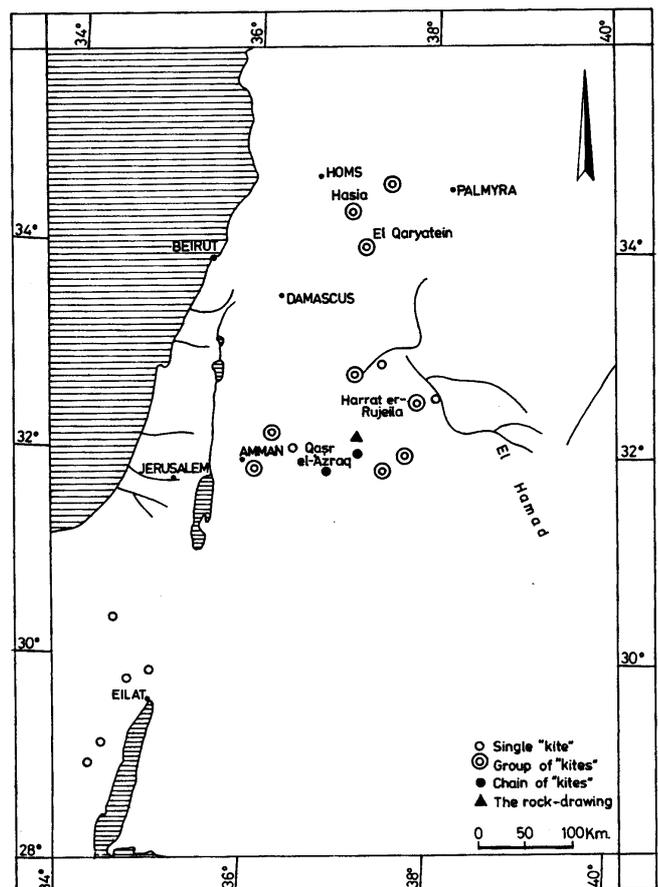
10. The patina of these concentric circles seems somewhat lighter and E. Anati suggested that they are a later addition (Anati 1981: 41). However, further inspection of the drawing by our team showed that the difference in the patina is caused by the many circular incisions and depends on the changing light conditions at the time of inspection. After several inspections of the site, we concluded that the whole drawing represents one graphic unit made by one and the same hand.

11. The tree-of-life is an intrusive icon probably of Mesopotamian origin and is unique in the Arabah. It will need further research to be certain about its dating and symbolic function.

12. Yotvata is a modern Kibbutz at the ancient site of ad-Dianam on the Peutingier map of the fourth century AD, its former name Ein Ghadyan. It is the richest source of water in the Arabah, surrounded by large tracks of arable land. Due to its high watertable there is very extensive grazing land and very large forests of acacia trees, both extensively exploited by the ancient settlers and miners. According to the finds in our excavations in Timna and the Arabah, it seems certain, that the water and acacia trees, perhaps also palm trees, of Yotvata, were a major source of fuel for the ancient copper smelters of the Arabah, including the Egyptian New Kingdom mining expeditions to Timna.

13. More than a hundred structures were dispersed over this area and recorded in detail by our survey. In the present paper we shall outline the characteristics

Fig. 7: Distribution of 'Desert Kites' (Meshel 1974).



of the settlements of each period, the detailed survey report is in preparation (Rothenberg & Bachmann in preparation).

14 At Site 201A, Israel grid 15109175, two dwellings A1 and A7, were excavated in 1967 by the Arabah Expedition (Dir. Prof. Beno Rothenberg). The final excavation report will be published in forthcoming Researches in the Arabah Vol. 3:1-2.

15 The survey sites will be published in Rothenberg & Bachmann (in preparation). For a preliminary report see Rothenberg 1999.

16 Site 39 was an early Chalcolithic smelting site with a smelting furnace separated from the workshop which included also two round habitation buildings. Site 39 is actually in this respect an exception, so far unexplained. (Rothenberg & Tylecote 1978).

17 These sites will be published in the final report of the Arabah Surveys (Rothenberg & Bachmann eds. in preparation).

18 Site 151 was a solitary hill somewhat south of our site cluster. On its top we found some crushed slag which appeared to be early and was definitively not of the tapped type. However, petrographic study of the sherds, found among the slag, indicated a S-A Copper Age Middle Phase date.

19 The mine, Site 250, and the smelter, Site 149, were excavated in 1984, and again in 1990 (Rothenberg 1999: 84-86; Rothenberg & Shaw 1990).

20 Site 131, Israel Grid 15129150, was discovered by the present author in 1960 (Rothenberg 1967: 290; 1972: 53). The plan of the site published here was first published by Meshel 1980: fig 7.

21 In 1982 we reinvestigated all sites discovered during our first surveys (Rothenberg 1962; 1967; 1972) in the light of the data produced by our excavations. Unfortunately, many of the sites had been ransacked by a local archaeologist who never published his finds. All the pottery finds of this survey and most of the pottery of our previous surveys were petrographically investigated by Jonathan Glass (Glass in Rothenberg & Bachmann in preparation). The dates of the pottery in Rothenberg & Glass 1992 relate mainly to the pottery of the 1982 survey.

22 Site 156, I.G. 15249160, was also much disturbed by a local archaeologist, cf note 21. It was first published by Meshel 1980: 271, fig. 8.

23 Meshel (1974: 141, fig. 11) published a plan of 'kites' in northeastern Jordan which showed several building stages, strengthening the assumption that 'kites' were in use for thousands of years, probably build and re-build during the ages.

24 It should be mentioned here, that Yadin himself raised the question whether the Narmer palette should be taken as unequivocal evidence of such events (Yadin 1955: 16).

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Forging Folklore - About Iron in Early Jewish Folklore

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'Metal and Metallurgy in the Jewish Sources, from the Hebrew Bible to Maimonides', is a joint project of IAMS and the Department of Hebrew and Jewish Studies, UCL, by Prof. Beno Rothenberg and Dan Levene. These ancient sources cover about 2000 years of Jewish life in Ancient Israel and the Diaspora, and this is the first attempt to identify and understand metal-related technologies from the book of Genesis to the medieval commentaries of the Biblical and Talmudic texts in the light of modern archaeo-metallurgy. Our study of the Jewish texts is accompanied by a review of contemporary texts of many languages as well as related archaeological finds and their analytical investigation. This unique study of the realia in the ancient Jewish sources is concerned with metallurgical as well as linguistic problems of terminology and techniques. Although the nature and ultimate purpose of these sources is religious, the texts are anchored to a large extent in the physical and social world and lifestyle of those who created this literature. Our objective is the reconstruction of this realia, an objective which demanded the gradual development of a new and complex research methodology. Several years of study resulted in the reconstruction of most of the base metal tech-

nologies in use during these 2000 years and also contributed so far untapped knowledge about social and economic/trading aspects - and early folklore, related to metal. We have created a very extensive and detailed data base and several publications, in periodicals as well as a comprehensive volume, are in press and in preparation. In the following pages we present a 'sample' of Jewish early folklore concerned with iron as well as the status of the blacksmith in Jewish life of this era.

In Genesis 4, the generations which followed Adam and Eve are listed. Lamech, the fifth generation from Cain had three sons. His first wife's two sons are described as 'the ancestor of those who dwell in tents and amidst herds' (Genesis 4:20) and 'the ancestor of all who play the lyre and the pipe' (Genesis 4:21). Their half-brother, the son of Lamech's second wife, was Tubal Cain the 'forger of all implements of copper and iron' (Genesis 4:22), *i.e.*, the first metal-smith and therefore the ancestor of all metalworkers. It is interesting that this account of the appearance of the various crafts, ending with metallurgy, reflects a Neolithic technological environment, at the very beginning of material culture. Obviously, iron was not part of the innovations of the Neolithic period, which saw the

beginning of copper smelting at its very end (Rothenberg and Merkel 1995). The fact that iron was included in this description in Genesis is probably just a reflection of the fact that the final redaction of Genesis would not have been earlier than the Iron Age, when iron was already in common use and the technology of its working already at a highly developed state. Tubal Cain's metal smithing came to be associated in later Aggadah (Bereshit Rabbah 23:22) with Cain's primal act of murder. Whereas the latter killed without a tool, his descendant and namesake was responsible for a technological leap in the manufacture of lethal weapons. This idea is further elaborated in a story in Midrash Tanhuma (Genesis 11), which relates that as a boy Tubal Cain would go out hunting with his blind father Lamech. Acting as his eyes, he would point out the prey to his father, who upon this instigation would draw his bow and shoot. One day, the prey which Tubal Cain pointed out to his father happened to be Cain, his wandering ancestor, whom he briefly saw and mistook for an animal. Lamech aimed and shot the arrow with fatal consequences. When he realized what he had done, he was so upset that he lost control and accidentally struck Tubal Cain, his son, on the head and killed him. Thus, Aggadah would have it that both the ancestral Cain and his descendant, the young Tubal Cain, suffered the fate of accidental death.

Iron had as much impact on the spiritual as on the material culture. It was revered for its strength, which was likened to human might and power as well as erudition and sharpness of mind. It was also feared for the weapons, which could be manufactured from it. In another Midrash (Genesis R. 5 and Otsar Hamidrashim p. 253) it is written that on the third day of creation, when God introduced iron to the world, the trees, which at that time were the tallest in the land, began to tremble for they knew that they were no longer safe. God comforted the trees by reminding them, that as wood they provide the handle by which the blow of the axe is directed. This was the control they were destined to yield over iron. The awareness of the inherent fatal potential of iron is also reflected in Numbers 35:16 where it is stated that the penalty for death caused by a blow dealt with an iron object would always be death, as opposed to other materials for which a verdict of an accident could be considered.

In the Mishna (Midot 3:4) it is explained that the reason for the prohibition against the use of iron tools for the making of the altar in the temple of Jerusalem was that 'iron was created to shorten man's days and the altar was created to prolong man's days, and it is not right, therefore, that that which shortens should be lifted against that which prolongs'. This statement comes to explain I Kings 6:7 which states 'that there was neither hammer nor axe nor any tool of iron heard in the house while it was being built.' The Babylonian Talmud (Gittin 68) expands this motif considerably with a story about how Solomon overcame this prohibition of the use of iron in the construction of his temple. For this purpose he sought the help of Ashmedai the 'king of demons' whom, he was told, possessed secret knowledge of how to accomplish stone cutting without iron. To catch this powerful demon it was necessary to bind him in chains of iron; a metal considered to have the magical power to neutralize and remove the threat of demons. When bound and in captivity, Ashmedai revealed to Solomon the whereabouts of the miraculous shani worm which could be used to cut stone. Solomon was successful in his quest and managed to build his temple without the use of iron tools.

Since the profession of blacksmith was not uncommon amongst the Jewish people, it is no surprise that iron entered deeply into folklore also in the Rabbinic literature. We are told that in the 'Great Synagogue of Alexandria' (about 250 BCE) there were five guilds which had separate seating arrangements, so that travelling Jews visiting the synagogue could join their own craftsmen and find employment. One of the guilds mentioned is that of the blacksmiths (Tosefta Sukkah 4:6, Babylonian Talmud Sukkah 51b).

Johanan, a famous 3rd century CE rabbi, is repeatedly referred to in the Talmud as 'the son of the blacksmith'. Indeed, some of his comments reveal the insight of a skilled smith. Another famous second century CE rabbi called Joshua is mentioned in both, the Jerusalem and Babylonian Talmuds in a story relating an incident concerning Rabban Gamliel, the president of the Sanhedrin (the supreme Jewish political, religious and judicial body in Roman Palestine). At one time Rabban Gamliel visited R. Joshua at his house and was shocked to see that it was a blacksmith's workshop and that he was no more than a smith. R. Joshua retorted to this insult by saying: 'Alas for the generation of which you are the leader, seeing that you know nothing of the troubles of the scholars, their struggles to support and sustain themselves!' Maimonides, the twelfth century scholar and philosopher, also considered it important to remind his readers (Hilkhot Matanot A'niyim 10:18) of the fact that many of the greatest sages were artisans, blacksmiths amongst them.

To conclude, we have seen iron feature in Jewish folklore in a wide range of contexts. The importance of iron working in the formation of human society and the change that it affected is acknowledged by the figure of Tubal Cain, the eponymous metal smith, who is numbered amongst the first antediluvian generations. The ready availability of iron and the relative ease of carburizing and case hardening made it a popular metal for the manufacture of a whole variety of useful tools, not least of which were weapons. And so we find that it is associated with killing, both in legislation in Numbers in which its lethal quality was recognized, as well as the reasoning we find in the Talmud that explains the prohibition of the use of iron in the temple precinct that is mentioned in I Kings. In later Aggadah this deadly quality of the products of iron was expressed in the form of the tragic fate of Tubal Cain, whose craft unleashed the instruments of terror and fear. Iron was a common feature in every day utilitarian life, as in the Alexandrian synagogue the blacksmiths must have inhabited an important place amongst the guilds of other places and periods. However, as common as the use of iron was, its versatile properties which can be explained in modern scientific terms must have been a mystery to the ancient. Iron was not only a metal from which you could forge a weapon to protect yourself, people came to believe that it also possessed magical properties that could bind even the fiercest of demons. So we are told in the Talmud and other magical literature which has survived from that period.

As we have stated above, the nature of the literature that we are investigating is religious. And though there is nothing within it that even resembles an artisan's technical manual, it does, nevertheless, include a wealth of information about the material culture of the different eras in which these texts were composed. The references that we have cited here are but an expression of some of the more abstract subject matter relating to metals that occurs in this literature. The presence of iron in everyday life over a long period of time, assured it a mythical dimension in the literary imagery that represents the Israelite and later Jewish culture. This is but a scratch on the surface of an enormous corpus of literary products. In the process of our work we have also identified reference to a variety of techniques relating to the use of iron and steel, as well as other metals. We now have two articles in print (Levene & Rothenberg 2000, 2001), and another article which has been submitted for publication is titled: "Early Evidence for Steelmaking in the Judaic Sources". A number of further titles are in advanced stages of preparation.

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An Analysis of Romano-British Lead Pigs

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Although the importance of the lead industry in Roman Britain has long been appreciated, our understanding of its organisation and operation remains relatively limited. In the absence of reliable documentary sources and intact Roman mine workings, the lead ingots commonly known as "lead pigs" (Fig. 1) constitute the primary evidence for this activity. Less than half of the 102 examples discovered since the sixteenth century are still extant, while the range of published literature on this subject has been found to contain significant errors and variations concerning the details of both these ingots and those which are now lost. By contacting the majority of institutions holding lead pigs in their collections, and by an intensive examination of published sources regarding their details, it has been possible to produce a comprehensive listing of these objects, and to obtain an overview of the industry which produced them and the society within which that industry functioned.

By examination of the inscriptions, weights, compositions and find-spots of all the known Romano-British lead pigs, it has been possible to answer a number of important questions concerning the lead industry during this period. The evidence for the chronology of its operation and the shift between Imperial and commercial operation of the mines will be examined, while the existence of standard policies both for the production of pigs of standard weights and for the desilverisation of argentiferous lead will be considered. On the basis of evidence from finds of lead pigs, patterns of distribution and export from each ore-field will be suggested and the possible use of lead-isotope analysis as a sourcing tool will be considered.

Chronology

Lead ores, primarily in the form of galena (lead sulphide, PbS), occur mainly in hydrothermal deposits in the Carboniferous limestone regions of Britain and it was in these areas that extensive mining occurred during the Roman period (Fig. 2). The Mendips (Somerset) were the earliest to be mined, starting as early as AD 49 on the evidence from inscribed lead pigs found in the area (Elkington 1976). As the Roman conquest proceeded over the next three decades, the ore-fields of Flintshire (north Wales), Shropshire, Derbyshire and Yorkshire were opened for exploitation. In the last of these areas, the earliest lead pig bears an imperial inscription dated to AD 81 (Raistrick 1931). By the use of such inscriptions, it has been possible to propose four phases of exploitation of the Romano-British lead mines, with control shifting according to the military and economic climate of the time.

The first of these, the **Military** phase, is evidenced by the presence in the Mendips of lead pigs bearing the names of

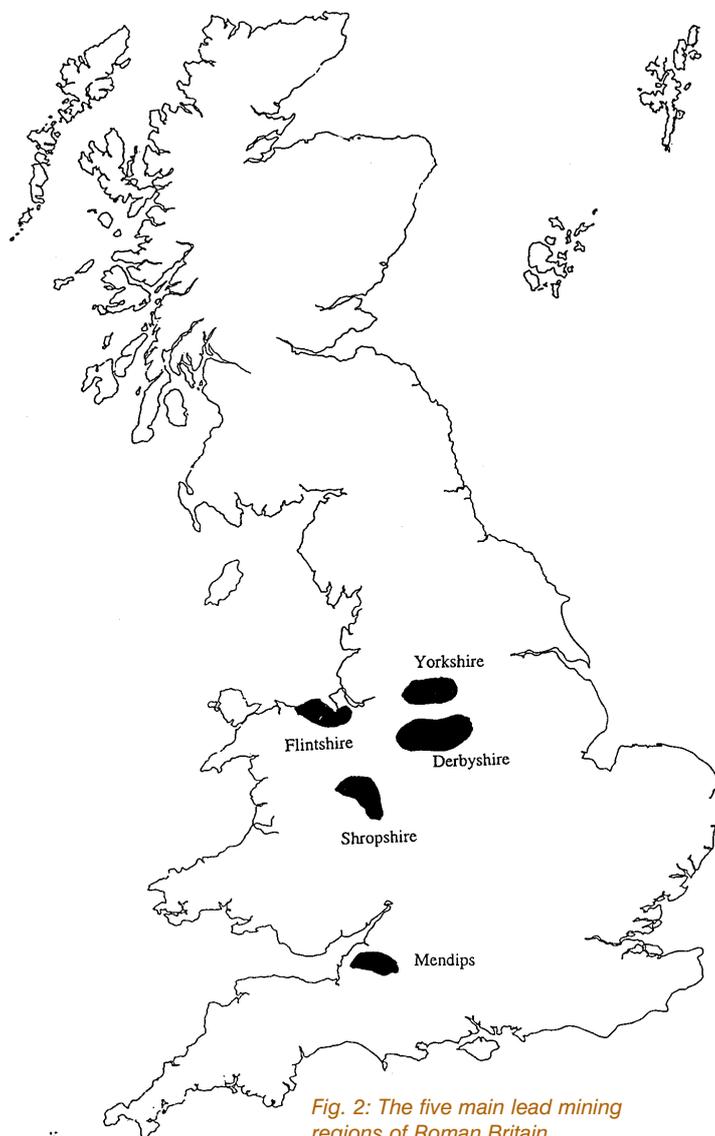
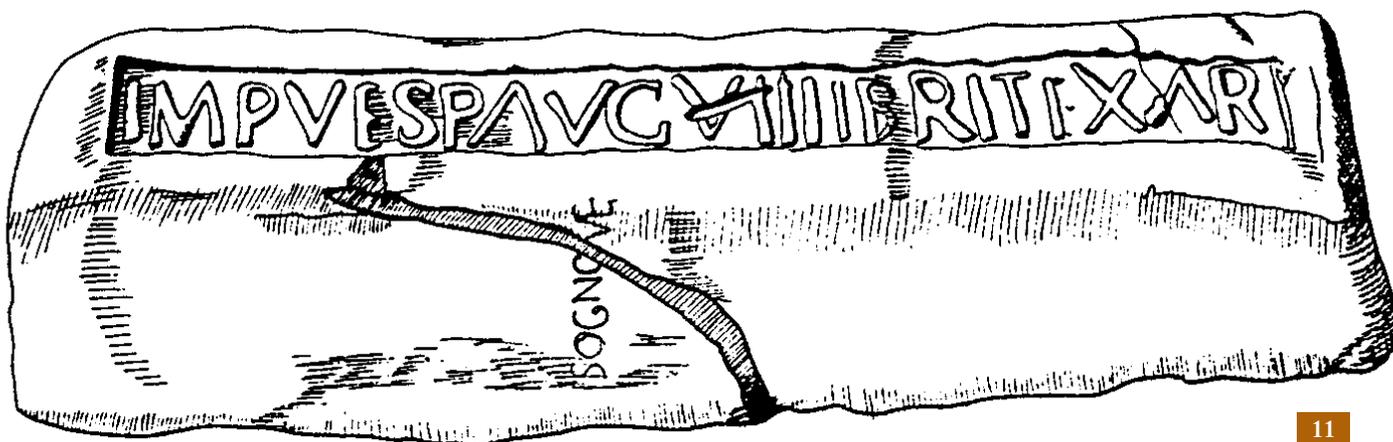


Fig. 2: The five main lead mining regions of Roman Britain.

known Roman legions (Elkington 1976) while at several mining sites including Prestatyn, Flintshire, forts contemporary with the mine workings have been discovered (Fry 1984). This phase reflects the need of the Army to maintain control of resources in newly conquered territory, lasting for only a few decades until civil rule was established.

The **Early Commercial** phase covers the late first and early second centuries AD, and reflects the increasing stability of the new province, with private companies (societates) and individuals (conductores) being granted mining rights by a

Fig. 1: A lead pig from the Mendip mining region found at Syde, Gloucestershire. Its inscription dates it to AD 79 while the SOCNOC marking identifies the company which produced it. Length 58.4 cm, weight 78.9 kg (de la Bedoyere 1989).



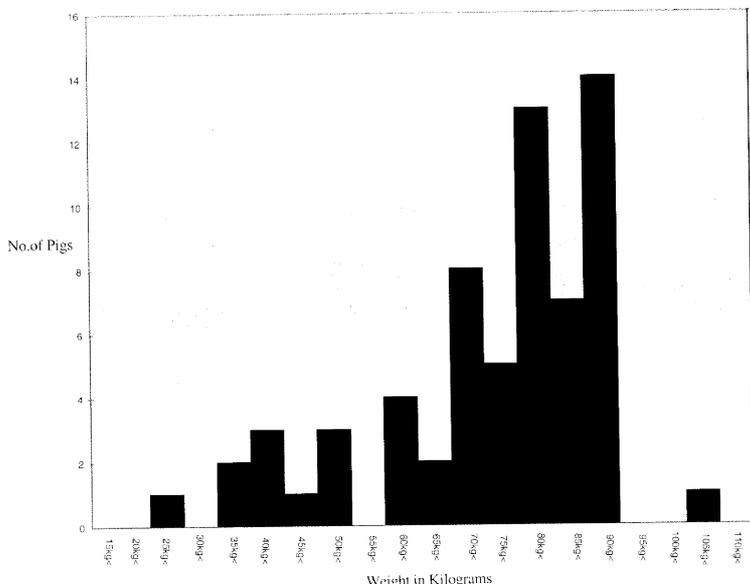


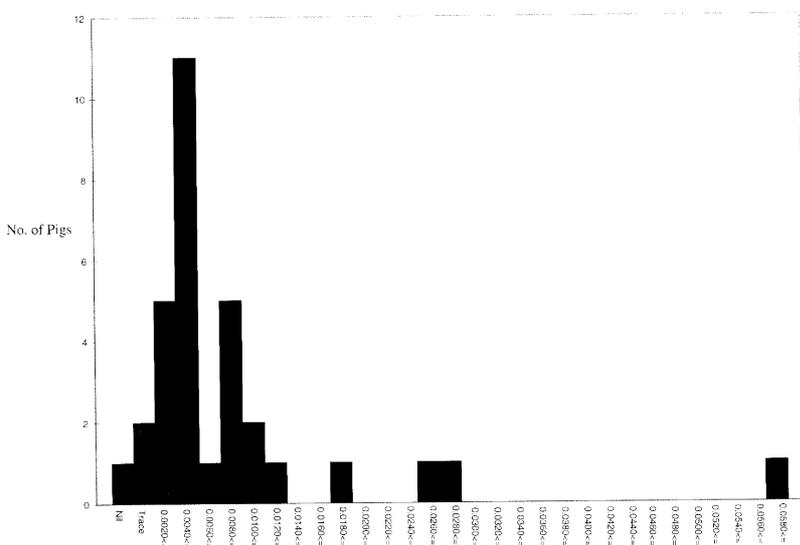
Fig. 3: Chart of weight distribution for Romano-British lead pigs.

Procurator Metallorum in exchange for a proportion of the revenue going to the state. Numerous lead pigs bearing company markings such as SOC LVT or the names of conductores such as G NIP[IVS] ASCAN[IVS] have been found indicating commercial exploitation in areas previously controlled by the army.

The period of **Hadrianic Construction** occurs at the start of the second quarter of the second century AD, with the construction of the massive frontier works in the north of Britain, and it seems likely that large quantities of lead would have been required for pipes, cisterns, bath linings and roofing in these new installations. From this period onwards, the names of societates and conductores are almost entirely absent and all the datable pigs from this period bear imperial markings.

The **Later Commercial** phase occurs in the second half of the second century and continues until the end of Roman Britain. Although a few lead pigs with imperial markings are known from this period onwards, it seems likely that the industry was allowed to fall more and more into private hands and was no longer producing large inscribed ingots (Frere 1987). The few late examples rarely bear any markings, but testify to the continued exploitation of this resource.

Fig. 4: Chart of silver distribution for Romano-British lead pigs



Weights

In addition to their use for dating the phases of exploitation, detailed examination of these lead pigs can show the extent to which standardisation of weights was practised within the industry. The presence of numeric markings on some examples has led to suggestions that a "standard weight" of 195 Roman librae (63.85 kg) existed and pigs which varied from that were marked to indicate the excess (Palmer & Ashworth 1956). Although this appears to have been the case with three of the four lead pigs found at Green Ore, Somerset, (Table 1) there is little evidence for its use in other parts of the country. Similarly, although numeric markings were found on a lead pig from Strageath Roman Fort, Perthshire which corresponded closely to its weight in librae - it was marked with CCX (210) and weighed 209.19 librae (Frere & Wilkes 1989) - only one other example found in Britain has any comparable relationship between its weight and the inscriptions on its surface.

Table 1: Relationships between Lead Pig weights and numeric inscription.

| Pig No. | Date | Weight (librae) | Marking | Different between weight and 195 librae "standard" |
|---------|---------|-----------------|-------------|--|
| M11 | AD69-79 | 258.97 | LXV (65) | +63.97 |
| M12 | AD69-79 | 273.63 | LXXIX (79) | +78.63 |
| M13 | AD69-79 | 262.33 | LXIIIX (68) | +67.33 |

(Data from Palmer & Ashworth 1956. Pig Numbers from Gardiner 1999). All weights are given in Roman librae. 1 libra = 327.45 g

As only 10% of all the known pigs bear such markings, and only half of the markings have any correlation with the weights of these objects, it is reasonable to conclude that there was no precise standardisation of weights, although some localised exceptions may have existed. Similarly, when the weights of the 64 lead pigs for which this information is known are plotted (Fig. 3), three modal peaks are visible, at 65-70 kg, 75-80 kg and 85-90 kg, although the exact meaning of these observed peaks is still uncertain. During the later periods of exploitation a broader range of weights are observed - particularly within individual mining regions - which may reflect a relaxation of state control but at no stage does there appear to be an enforced policy of standard weights.

Silver Content

Similarly, the question of whether a standard policy for the desilverisation of argentiferous lead existed can be explored through the analysis of Romano-British lead pigs. Thirty lead pigs from the Mendip and Derbyshire mining regions bear the inscription EX ARG, and it has long been a matter of debate whether these examples contained desilvered lead or whether the inscription simply - and perhaps optimistically - identified the object as "a product of the lead/silver works". Evidence from the 13 EX ARG marked examples for which analyses exist showed considerable variation in silver content, ranging from nil to 0.0564% (18oz 12dwt/ton), with the majority falling within the range of 0.002 - 0.01%. Of the 32 lead pigs - both with and without EX ARG - for which analyses are available (Fig. 4), 75% contained between nil and 0.012% (4oz/ton) silver. No appreciable variations were detected between those bearing EX ARG markings and those without, strongly suggesting that EX ARG is not indicative of desilverisation and that there is no clear pattern regarding this activity.

Transport and Origin

Examination of the find-spots of lead pigs has helped to identify the distribution patterns of these objects, and the routes along which they were transported. Of the pigs for which exact find-spots are known, 37% were found in or near navigable rivers while only 24% were in close proximity to known Roman roads. The benefits of water transport for

goods in the ancient world is already well known (Finlay 1985) while the presence in France of four lead pigs of probable Romano-British origin is a clear indication of cross-channel trade in these materials.

When the find-spots of lead pigs from each mining region are plotted on a map, it is possible to suggest a pattern of distribution from each (Fig. 5), although these must always be tentative given the very small sample of material on which they are based. However, it is reasonable to propose the following: The Mendip region mainly supplied the south-west of Britain from Gloucestershire, Hampshire and south Wales down to Cornwall, although finds of Mendip pigs from London (Hassall & Tomlin 1996) suggests that some other areas may also have been supplied, and some material may have been exported to the continent through Clausentum (Bitterne, Hants.). The Derbyshire ore-fields certainly supplied central and north-eastern Britain, probably the south-east and possibly East Anglia, while the presence of numerous lead pigs around the port of Petuaria (Brough-on-Humber) suggests that this was a probable point from which they were exported or transported by sea to other parts of the province.

Yorkshire, for which only four lead pigs are known, probably supplied northern Britain and - because of its location - may have provided much of the material used during the Hadrianic phase of exploitation, although its distribution to other areas remains uncertain. The Shropshire region - which has only three known lead pigs - probably supplied central Wales and the West Midlands, but this cannot be confirmed due to the absence of archaeological evidence. The Flintshire region appears to have supplied north Wales, Cheshire, Staffordshire and Merseyside, while a cargo of some 20 pigs found on a shipwreck in the River Mersey suggest that some seaborne distribution was undertaken from this ore-field although again the precise distribution is uncertain.

It is possible that a more accurate pattern of distribution could be constructed if a large-scale programme of lead-isotope analysis was undertaken, using samples from all the extant Romano-British lead pigs and relating the results to the analyses of lead ore from Britain and Ireland compiled by B.M. Rohl in 1996. (The ratios of different isotopes within the metal vary according to the area in which it originated, and this can be detected and assessed using Mass Spectrometry). If successful, such a study would enable the extant pigs to be assigned to one of the known ore fields and improve our knowledge of the distribution patterns of these objects.

One lead-isotope analysis which can be compared to this list was conducted by N.H. Gale on a lead pig from Strageath, Perthshire (Frere & Wilkes 1989). The analysis was as follows:

| | |
|---|---------|
| Ratio of Pb ²⁰⁸ to Pb ²⁰⁶ : | 2.09109 |
|---|---------|

| | |
|---|---------|
| Ratio of Pb ²⁰⁷ to Pb ²⁰⁶ : | 0.85350 |
|---|---------|

| | |
|---|--------|
| Ratio of Pb ²⁰⁶ to Pb ²⁰⁴ : | 18.233 |
|---|--------|

When this is compared to Rohl's listing of British and Irish galena ores, the closest match is from Wanlockhead in the Southern Uplands of Scotland :

| | |
|---|--------------------|
| Ratio of Pb ²⁰⁸ to Pb ²⁰⁶ : | 2.09176 (+0.00067) |
|---|--------------------|

| | |
|---|-----------------------|
| Ratio of Pb ²⁰⁷ to Pb ²⁰⁶ : | 0.85350 (Exact Match) |
|---|-----------------------|

| | |
|---|-----------------|
| Ratio of Pb ²⁰⁶ to Pb ²⁰⁴ : | 18.230 (-0.003) |
|---|-----------------|

Although unexpected (having no evidence of Roman mining) and lying some 110 km south of Strageath, Wanlockhead is only 5 km from the main Roman road into Scotland (Margary road 77). It is also close to the Flavian/Antonine fort of Crawford, suggesting that if mining was carried out there, the Roman infrastructure to supervise the operation and transport the product north was easily accessible.

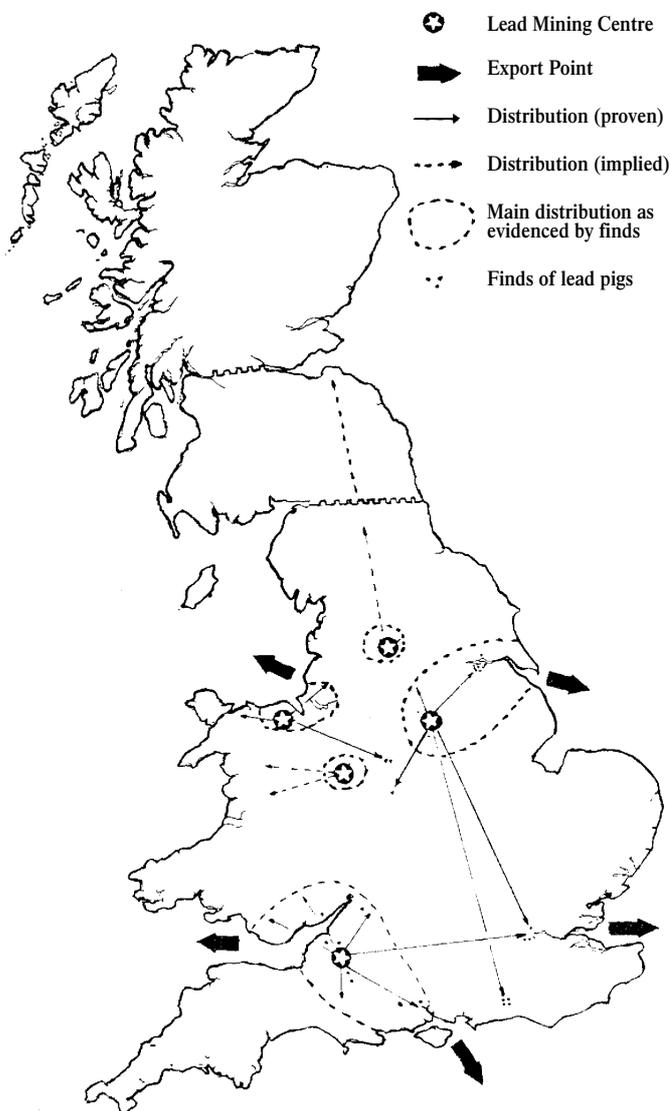


Fig. 5: A map of proposed distribution patterns of the main lead mining regions of Roman Britain.

It is hoped that, with appropriate funding and co-operation from museums and collections, a sampling programme for lead-isotope analysis may be undertaken in order to further elucidate the sources of supply and patterns of distribution of this material in Roman Britain.

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The Early Islamic crucible steel industry at Merv

St John Simpson, London

In 1993 dramatic new evidence for early crucible steel production was discovered at the ancient city of Merv in the Central Asian state of Turkmenistan. The preliminary analyses of archaeometallurgical remains from an Early Islamic workshop at this site were first reported in this Newsletter (Merkel, Feuerbach and Griffiths 1995). These remains are the subject of doctoral research by Ann Feuerbach at the Institute of Archaeology, University College London. Further preliminary analyses of the archaeometallurgical and other finds and the excavations themselves have been published (Feuerbach, Merkel and Griffiths 1997, 1998; Feuerbach, Griffiths and Merkel in press; Herrmann, Kurbansakhatov and Simpson *et al.* 1997, 10-13). The purpose of this short report is to update readers of IAMS and place the excavated remains into a wider context.

The ancient city of Merv is situated in the heart of the fertile alluvial delta created by the river Murghab that flows north from Afghanistan. Surrounded on all sides by steppe and desert, this delta resembles a huge oasis that has been continuously occupied since the 3rd millennium BC. During the 5th or 6th century BC a city was founded on the site known today as Erk-Kala; this became the citadel of the sprawling Hellenistic city of Antioch Margiana, occupied thereafter for a thousand years throughout the Parthian and Sasanian periods and surviving today as the deserted city-site of Gyaur-Kala. The ruins of Merv were described by 19th century British and Russian travellers and explorers, and first excavated in 1890. Later Soviet archaeologists based in Tashkent made some significant discoveries between the late 1940s and 1980s, including the western-most known ancient Buddhist monastery and richly decorated houses in the nearby medieval city-site of Sultan-Kala.

The Soviet teams also paid particular attention to the investigation of industrial areas or so-called "craftsmen quarters". Extensive fired brick and pottery-producing areas were identified within and to the south of Gyaur-Kala, and immediately outside the west wall of Sultan-Kala. All of the published remains date to the 8th century AD or later; the single so-called "Parthian" pottery kiln identified in YuTAKE Trench 5 on a low mound in the north-east corner of Gyaur-Kala was later recognised to be an Early Islamic construction on an earlier part of the site (Zaurova 1958). Similar Sasanian and earlier industrial suburbs must have existed to support the ancient city of Merv but these appear to have been either buried below later occupation in Sultan-Kala or destroyed in agricultural redevelopment. Nevertheless, the identified remains offer important insights into developments of medieval technology at an important urban centre on the interface of Iran and Central Asia.

In AD 651 the last Sasanian king, Yazdigird III, was murdered a short distance outside the city-walls of Merv to which he had been refused entry by the governor. An Arab army entered the city soon afterwards and Merv became a military headquarters for the Arab conquest of Central Asia. Large numbers of people from Iraq and Transoxiana settled in the vicinity and a very large mosque with a spiral minaret of the same type as at Samarra and Abu Dulaf was constructed at the town of Khurmuzfarrah [present-day Kishman-tepe West or Uly Kishman], on the main road leading north from Merv to Khorezm. At Merv itself, Arabic ostraca from a Late Sasanian building on the summit of the citadel, and sporadic finds of Arab-Sasanian bronze coins from other trenches suggest a continuing administration within the 7th or 8th centuries yet by the 9th century most of Erk-Kala and Gyaur-Kala appear to have been abandoned in favour of new locations

closer to the Razik canal that ran along the western side of Gyaur-Kala. One possible reason for this urban drift was social tension between Muslim immigrants and the indigenous population, probably exacerbated by the relative difficulty of gaining access or fresh water.

The previously inhabited areas of Gyaur-Kala now became extramural industrial suburbs. Surface surveys and detailed observation of the micro-topography suggest that the new industrial activity was based in separate workshops, some clustered near tracks running between the east and west gates or from the centre of the site to the position of the south gate; other workshops were separated by large open spaces. Many, if not all, of these workshops were engaged in pyrotechnology. Although there is little evidence for the organisation of the industry, two distinct types of pottery kiln have been excavated. One consists of a deep subterranean firepit, square in plan, with a perforated grate supported on transverse arches; the firing-chambers do not survive. Two examples of this type have been excavated by the International Merv Project (Herrmann, Kurbansakhatov and Simpson *et al.* 1999, 13-15, pl. III). The second type is smaller and consists of a circular kiln, between 2.1-2.9 m across, heated by means of a flue leading from an external firepit. Associated pottery and coins recovered by Soviet teams suggest an 8th century date for this type (Zaurova 1958).

In 1993 the first remains of crucible-steel furnaces were found in the same industrial quarter. The plan of these somewhat resembles that of the second type of kiln found by the Soviet teams, suggesting a common technological source. A total of four crucible-steel furnaces have now been excavated, constructed with clay walls reinforced along the inside with reused fragments of vitrified crucible. The floors of the furnaces were sunk below the level of the surrounding deposit; the tops were destroyed but they are likely to have been domed originally. Each had a single ceramic tuyere, with a diameter of c. 8 cm, that entered the base of the furnace through the centre of the floor; the opposite end of the tuyere was presumably attached to a bellows placed within a pit (Fig. X). In one case, the collapsed remains of a mudbrick shield wall was found along one side of the bellows-pit where it had probably served to protect the operator from the heat of the nearby furnace as the exit flues for the furnaces were at ground level. Charcoal residues from nearby refuse pits suggests that a combination of high-calorie narrow roundwood, particularly imported pistachio but also members of the *Chenopodiaceae* and other species, was employed (Gale forthcoming).

After each firing the upper part of the furnace was partly dismantled in order to gain access to the contents. Examination of broken crucibles found within nearby refuse pits provides a glimpse of the firing process. The crucibles were made of a high refractory clay that was thrown on the wheel to produce a flat-based cylinder c. 20 cm high with a diameter of 8 cm. These were covered with a circular perforated lid, 8 cm across, sealed with wet clay and placed on top of separate circular pads of refractory clay positioned on the furnace floor. It is estimated that a single furnace would have held some twenty crucibles during a single firing. Refiring experiments indicate that the furnaces were fired at temperatures of up to 1500 °C, fusing the crucibles to their lids and pads and necessitating force to extract the small steel ingots within. The presence of cast iron droplets and steel prills within the glassy slag adhering to the crucible walls is interpreted as evidence for a co-fusion process as described by the contemporary writer al-Biruni; these ingots were either sold or re-



Merv, Turkmenistan: view of half-sectioned circular crucible steel furnace with pottery tuyere at the base; 1 metre scale.

worked locally. The small quantity of steel produced within each firing underlines the high relative value of the final product. The furnaces were used repeatedly, although relined each time. The refractory properties of the vitrified clay was clearly recognised as broken furnace wall and crucibles were deliberately recycled within the construction or crushed as grog for adding to new crucibles. The latter proves the co-existence of this workshop with a local ceramic industry.

Each of the excavated furnaces lay within an open space at the rear of a mudbrick workshop with rooms arranged around a paved courtyard. The stratigraphy suggests a relatively short span of occupation, possibly no more than a generation, before the workshop was abandoned or relocated to a different spot. Associated slip-painted bowls belong to the earliest tradition of local glazed wares in this region; glassware paralleled from Nishapur, splashed wares and turquoise glazed wares support a 9th or early 10th century date for the complex. Other finds include jet gaming-pieces decorated with dotted circles, presumably imported from Tus in north-east Iran, which boasted a jet industry at this period, and fragmentary chlorite cooking pots, again imported from north-east Iran.

The discovery of a crucible steel industry at Merv confirms contemporary Early Islamic written sources. This evidence suggests that Khurasan was the second most important Iranian province for the manufacture of iron and steel, the towns of Herat, Tus, Nishapur and Ghur being specifically mentioned as manufacturing centres for iron arms, armour, knives and needles whereas a locksmithing industry is attested from Merv (Allan 1995). Specialised products were therefore available in some centres and iron ingots and finished goods were widely traded; steel was particularly valued for its hardness and strength: uses include swords, daggers, maces, axe-heads, spear and arrow heads and armour (Allan 1979). This pattern of production was developed from the Sasanian period, if not earlier. The 3rd century author Zosimus of Alexandria described the production of crucible steel through direct carburisation as an Indian technique that had been exploited by the Persians. Iron and steel-workers and a variety of steel weapons are attested in Middle Persian (Pahlavi) sources, and the manufacture of sword-blades from crucible steel is now confirmed by analysis of an unpatterned Late

Sasanian sword in the British Museum (Lang, Craddock and Simpson 1998).

The archaeological evidence for an Early Islamic crucible steel industry at Merv has added considerably to our understanding of early medieval ferrous technology. It is likely that the design of the excavated furnaces is traditional to this region and that earlier forebears will eventually be discovered in Iran or Central Asia. Technological continuity from the Sasanian to Early Islamic periods is also suggested by archaeobotanical evidence for a cotton industry at Merv and the gradual evolution of plainware ceramic forms from 5th or 6th century types to those used in the 9th century. However, the importance of local regional trade in ingots, fuel and possibly the technology itself should not be under-estimated and further surprises probably still lie in store.

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