New Discoveries at Rudna Glava — the earliest shaft-and-gallery copper mine in Eastern Europe

IAMS had planned to publish a monograph on the prehistoric mine workings of Rudna Glava, which are of major importance for the history of mining, in 1985. However, during the excavation in 1984 a new type of mine workings was discovered which made a re-assessment necessary. The final report, now scheduled for 1987, will include a full description of these earliest, incipient shaft-and-gallery mining systems, known only so far at Rudna Glava. We publish here a first communication from Professor Borislav Jovanović, the excavator, on his discoveries.

Rudna Glava is a now abandoned magnetite (iron ore) open cast mine in north-east Serbia (Yugoslavia) with early prehistoric workings partly preserved in the banks of the open cast. The first indications of the existence of any early eneolithic (Chalcolithic) mining activities at Rudna Glava were found in the provincial anthropological museum at Negotin. Here, a small votive altar decorated with deer-heads, typical of the early eneolithic Vinča culture, was published with the details: ‘originated from an old mine shaft at Rudna Glava, 12m. below the surface’. This most unusual find triggered off a series of excavations undertaken since 1968 by the Mining Museum of Bor and the Archaeological Institute of Belgrade University. The result was the discovery of numerous eneolithic (Chalcolithic) mine ‘shafts’.

The actual ‘shafts’ consisted of more or less vertical, trench-like or tubular oval veins (1.2–1.5m. in diameter, 16–20m. deep) of rich copper carbonates, mainly malachite and azurite, very similar to the chalcolithic copper mines at Chinnon, Huelva, Spain, excavated by an IAMS team led by Beno Rothenberg (IAMS Newsletter No. 2, 1981). These were not, however, shafts sunk into the rock in order to reach the ore veins below (as with later mines), but natural veins that had been followed and emptied by the prehistoric miners.

In order to reach the mineralized rock, the ancient miners had, in many instances, to clear a thick layer of surface soil, resulting in funnel-shaped shafts occurring above the actual mine workings. In these instances, platforms had been prepared to facilitate haulage from the underground workings.

More than 200 grooved mining picks, made of large, hard, river-borne pebbles were found in the workings. These belong to the earliest type of mining tools known to date and can be paralleled at Chinnon, Huelva; Timna, Israel, and Mt Gabriel in Ireland, etc. A number of antlers used as picks were also recovered from the shafts, these were a widely used implement in prehistoric flint mines.

Of particular importance for the history of mining and a major key for dating the Rudna Glava mines were the groups of pottery and votive altars found in situ in special storage areas in the underground workings. The votive altars were previously known from agricultural settlements of the later Vinča culture and noted for their unusual deer-head decoration. Here at Rudna Glava, apparently, they served not only as cult objects but also as mining lamps, the earliest examples known.

In sharp contrast to the many different pottery types known from the Vinča culture, those found inside the mine consisted mainly of amphorae and simple pots, essentially decorated utility ware appropriate for use in the workings. The pottery, backed by C14 dates, places the mines at the end of the Neolithic to early Eneolithic of the Central Balkans, producing a calibrated date of 4200–4000 B.C.

General view of the top of Mine Shaft 2N at Rudna Glava
Grooved pebble mining hammers from Mine Shaft 4A at Rudna Glava. Largest approx. 15 x 24 x 9.5cm

Small pottery votive altar with deer’s head, found in the shaft of Mine 2G, 2H. Ht 20cm

Pottery amphora with lug handles from Mine Shaft 6A at Rudna Glava. Ht 43.5cm

The excavators considered vertical trench-mining as the highest technological level reached in this earliest mining phase. As far as the date is concerned, the late Vinča phase must be considered as the earliest possible beginning for copper mining. It is the earliest post-neolithic period and copper mining must obviously lie on the threshold of eneolithic (Chalcolithic) times. In 1984, however, new discoveries made it necessary to revise some of our thinking regarding this earliest metal mining phase. Horizontal ‘galleries’ were found deep in some of the shafts. These horizontal workings followed rich copper impregnation in the soft rock conglomerate, so far 3.5m, long and 80cm wide. Presumably we are dealing here with an incipient shaft-and-gallery technology, the earliest of its kind found to date.

At the meeting point of the ‘shaft-and-gallery’, groups of pottery and grooved mining picks were found in situ. Amongst the pottery recovered were some finer quality, well-fired ceramic types, some having beautiful spiral decorations; similar sherds also occurred in the shafts and galleries — all being of the same early Vinča culture phase.

Although the Vinča miners, with their primitive stone picks, followed the natural veins of rich minerals and did not actually cut shafts and galleries into the rock as such, Rudna Glava must now be considered to be the prototype of incipient underground shaft-and-gallery mining.

Borislav Jovanović, October 1985

Editorial

With this issue we introduce a new Editor and a slight variation in our page size to achieve more economic printing costs. We intend to feature more original articles and reports and also for them to carry the signatures of their distinguished authors. In an endeavour to keep our subscribers abreast of not only our own IAMS work we shall feature news items and articles on work under other direction that throws light on early metallurgy anywhere in the world. From time to time we hope to also include reviews of books of interest. This, together with our new feature, ‘News from the director’s desk’, will go a long way to keeping our readers up to date with developments in metallurgical studies.

P.A.C.
The Rio Tinto Enigma — no more

The ancient mine workings and slag heaps of Rio Tinto (south-west Spain) have often been described in the literature (Nash; Salkield; Avery; Rothenberg-Blanco) and some of its important ancient mining relics are exhibited in major museums of Spain and abroad, including the famous Roman water wheel shown in the British Museum. It was mainly the huge scale of these workings and the enormous slag heaps which made Rio Tinto unique in the world history of mining and metallurgy. These slag heaps were first surveyed and sampled in 1924, when the Rio Tinto Company issued its ‘Map of the Ancient Slag Heaps’, including chemical assays and an estimate of the quantity of slag in Rio Tinto: 15,300,000 tons of lead/silver slag and 1,000,000 tons of copper slag. These were astonishing figures and Rio Tinto was generally acknowledged as the largest metal producer of the ancient world, although some authors expressed their amazement that such a huge Imperial Roman production centre of silver should not be mentioned in classical literature.

The classification of the slags as copper or silver slag was based on the following criteria (Salkield 1970, p. 88): slag with more than 0.5% copper and little lead and silver was defined as copper slag; slag with more than 0.5% lead and some silver and little copper was labelled silver slag. Because of the huge quantities of lead/silver slag and because some lead ores had been found between the upper oxidized zone (‘Gossan’) and the massive pyritic ore body, it was concluded that early Rio Tinto was basically a lead/silver smelter.

The ancient silver and copper ores of Rio Tinto

The geologist David Williams (Royal School of Mines, London) revealed in 1950 that at Cerro Colorado (the main ore body of Rio Tinto) gold and silver ores were overlaying the pyrites and he called these ‘jerosites’. He estimated that from the Rio Tinto ore bodies about 2,000,000 tons of jerosites were extracted in ancient times. As it was also assumed that in ancient times only copper ores with 8–20% copper were smelted, the source of the copper ore was identified as the chalcolithic ores also contained in the same ‘secondary enrichment zone’ between the gossan and the massive pyrites.

The date and nature of the slag heaps of Rio Tinto, i.e., the kind of metal produced and at what periods, was frequently discussed in the literature and it became generally accepted that Bronze Age Tartessians began silver production in Rio Tinto on an industrial scale, enhanced soon afterwards by seaborne Phoenician metal-traders of the eighth to six centuries B.C. However, because the Romans remelted much of the earlier Phoenician slags, most of the black slag visible now at Rio Tinto was assumed to be Roman (Salkield, 1970, p. 93).

The Rio Tinto Enigma

Many basic questions remained unanswered:

1. The slags of Rio Tinto, especially the huge ancient slag build-up uncovered by the recent Corta Lago open pit operation, clearly showed very many undisturbed layers of slag on top of each other and many pre-Roman layers could be identified by finds of undoubtedly pre-Roman pottery. Archaeologically there could not have been any Roman resmelting of earlier slag — simply because these earlier slags were still in their original position below the Roman layers. But what was their date and when did it all start?

2. Modern geological surveys (D. Williams and others) showed that there were only about 3,000,000 tons of jerosite ores in the ore bodies of Rio Tinto, of which

Map of the ancient topography of Rio Tinto before the beginning of mining. The later slag dumps and the North Lode open cast mines are also marked on the map.
about 2,000,000 had been extracted in ancient times. It was estimated that about 4,500 kg. of slag were produced from 1,000 kg. of hornitic ores (Salkield, p. 92). How could 15,300,000 tons of slag be produced from only 2,000,000 tons of ore?

3. Since in the ancient smelting operation about one ton of charcoal was needed to produce one ton of slag, 40,000 tons of charcoal per annum, i.e. 110 tons of charcoal daily, would have been required over a period of about 400 years, to produce 15,300,000 tons of lead-silver slag. Salkield, investigating this problem (1970 p. 94), reached the conclusion that the Romans would have had to cut down 600,000 mature trees per annum — quite an impossible figure.

4. The Rio Tinto slags showed extremely low metal contents: 0.1–0.56% Pb in silver slag and 0.6–0.9% Cu in copper slag according to the R.T.M. assay in 1924 — as compared with ancient slag elsewhere: at Laurion, Greece, 10% Pb; in Sardinia up to 30% Pb; at Cartagena, Spain, 8–17% Pb; in Timna, Israel, 4% Cu in Bronze Age slag and up to 17% Cu in Chalcolithic slag. This surprising fact was often explained as the result of a highly advanced smelting technique known to the Romans and unknown to us (already suggested by Ramon Rua Figuerola in 1859).

Sorting out the archaeological history of the Rio Tinto slag heaps

Eight seasons of excavations in the slag heaps of Rio Tinto by the IAMS team, lead by Beno Rothenberg (IAMS Newsletters Nos. 1, 2, 3) produced a fascinating picture of its history. After initial prehistoric beginnings in the Chalcolithic Period (Early Copper Age of Spain, perhaps as early as the fourth millennium B.C.) proper industrial mining and silver production began next to a small spring on the northern slope of the huge Cerro Salomon, today the Corta Lago open cast mine. Here a 10-metre high slag section was exposed by modern mining and its more than one hundred superimposed slag layers could be dated by pottery and coins. Further systematic trial trenching over the entire slag area has shown the gradual growth, in almost perfect eccentric circles, of the smelting operations from a small Late Bronze Age (late second century B.C.) smelters’ habitation to the huge metal industry of Imperial Rome (into the second century A.D.). Moreover, two surprising new basic facts became clear during this archaeological survey which cast serious doubts on the previously commonly accepted concepts of Rio Tinto and its 15,300,000 tons of silver slag. The slag heaps were found to be of rather varying depth, i.e. from a very thin cover on originally high ground (see the original topography of the site above) to 15-metres and more of slags dumped into deep valleys. Further doubt arose when the first analyses of the slag samples from the Corta Lago Section became available (Rothenberg-Blanco, 1981, p. 105). Though the pre-Roman layers showed that only silver was produced during these periods, the Roman layers revealed that copper had, by Roman times, become a main product of the Rio Tinto workings. The Rio Tinto Enigma, though still rather confusing, began to crack, but it took several years of further investigation using modern research methods to finally sort things out.

A new look at the slag heaps of Rio Tinto, 1983–85

As a result of our archaeological investigations, the systematic survey in depth of the ancient slags had become imperative and this was carried out by Rio Tinto geologists, directed by Felix Garcia Palomero, in the course of their general re-investigation of the gossans of Rio Tinto. After three years of a computerized drilling programme, which covered the entire

---

Schematic section through the Cerro Colorado mineral bodies showing the location of the silver and copper ores extracted in antiquity.
slag area by a narrow net of drill-holes down into the bedrock below the slag layers, it became possible to define for the first time the real volume and composition of the entire slag build-up of Rio Tinto and to establish the different sources of the copper, silver and gold minerals used by the ancients to produce their metals and the slag heaps.

How much and what kind of slag?
The slag dumps of Rio Tinto, covering about 2500–200 metres, turned out to have an average thickness of six metres, which means a total volume of 6,000,000 tons instead of the previously (1924) estimated 16,000,000 tons of slag. This greatly reduced slag volume obviously lowered the estimated quantity of charcoal needed for the smelting operations to a far more reasonable figure.

Furthermore, the new survey found two basically different kinds of slag all over the slag heaps: a silver smelting slag with a very low copper (less than 300 p.p.m.) and a high lead (1.2%) content, and a slag with a very high copper content (more than 1000 p.p.m.), which was obviously the product of copper smelting.

Different sources of silver and copper
The schematic Cerro Colorado Section indicates a different location of the copper and the silver ores within the Rio Tinto ore body. The copper ores came only from the ‘secondary enrichment zone’ between the gossan and the massive sulphides (Section N.4) whilst the jerosite silver ores, with only low copper contents, came from the lower parts of the gossan, above the level of the copper concentration (Section N.6). The now well defined total volume of these ores corresponds very well with the 6,000,000 tons of copper and silver slag established by the new archaeological and geological survey.

The new drilling programme also helped to solve the riddle of the extremely low metal content in the copper smelting slag, previously often assumed to be the result of a highly efficient Roman copper smelting process unknown to us. There can now be little doubt that the low metal content of the ancient slag of Rio Tinto is the result of a continuous strong leaching process, which brought about the removal of most of the copper and some of the silver and gold. The analyses of the bedrock below the slag showed some redeposited silver and (less) gold in its upper 2–4 metres, whilst the copper, due to its higher solubility in water, migrated to an even greater depth.

The Rio Tinto Enigma, repeatedly argued by several generations of investigators, has now been resolved through the strictly problem-related archaeo-metallurgical research methods developed over the years by IAMS.

The detailed report on the new Rio Tinto discoveries will shortly be published by Beno Rothenberg, F. Gracia Palomero and H. G. Bachmann.

Beno Rothenberg,
Felix Gracia Palomero

References

Rio Tinto Mining Museum

The major theme of this unique mining museum is the history of Rio Tinto and the development of the various metallurgical processes which are represented in the spoil heaps, slag heaps and installations, ancient and modern.

The Mining Museum of Rio Tinto is housed in the former Mine Hospital building in the village of Minas de Riotinto. It will tell the story of mining and metallurgy in Rio Tinto from very early prehistoric times and will present, in an integrated manner, two parallel major subjects:

1. The archaeological and industrial archaeological sites in Riotinto.
2. The developments of mining and metal production technology through the ages.
The story of Riotinto will, in fact, write a new history of Europe’s metallurgy of sulphide orebodies. Based on many years of exploration and excavation in the field and thorough metallurgical, analytical and experimental studies, we can today reconstruct the metal history of Riotinto on a sound scientific and archaeological basis. This will reflect the history of metallurgy, its techniques, problems, developments and achievements.

The present plan of the Museum contains the following sections, each to be housed in a separate room:

1 PREHISTORY: The earliest evidence for prehistoric production and use of copper and silver in Rio Tinto; the dolmen and early cist burials in Rio Tinto.

2 THE BEGINNING OF COPPER MINING AND SMELTING: Third millennium B.C. mineworkings, perhaps starting in the fourth millennium, the earliest copper smelting technology in Western Europe.

3 CORTE LAGO — FROM LATE BRONZE AGE TO THE ROMANS: Industrial mining and melting of silver, copper and iron.

4 THE ANCIENT METALLURGICAL PROCESSES: The development of silver, copper and iron smelting technology in ancient times in Riotinto.

5 THE ROMANS IN RIO TINTO: Mining, metal production and industrial organisation —
   Part 1 Roman mining
   Part 2 Roman building technology, metal working, pottery and glass. Cultural and social aspects of daily life
   Part 3 Excavations in Riotinto

6 GEOLOGY IN RIO TINTO:
   Part 1 Genesis of the orebodies
   Part 2 Mining potentials of the different orebodies with emphasis on ancient as well as modern technologies
   Part 3 Ores mined in various periods

7 THE BEGINNING OF MODERN COPPER PRODUCTION IN RIO TINTO: Sites, installations, technologies and people.

8 UNDERGROUND AND OPENCAST MINING:
   Part 1 Opencast mining: techniques; equipment; transport and people
   Part 2 Underground mining
   Part 3 The production of copper: Concentrator, smelter, products, flowsheet of processes

9 PRESENT AND FUTURE: Mining in Riotinto today and tomorrow; Opencast and underground; From ore to finished product; Flowsheets and Processes.

10 THE LIFELINE OF RIO TINTO: The history of the Riotinto railway and the mainline transport.

New members of the Scientific Committee, actively participating in current IAMS research projects:
Professor Antonio Arribas Palau,
University of Palma de Mallorca (Spain)
Dr Noel Gale,
University of Oxford
Dr Fernando Molina Gonzales,
University of Granada (Spain)

Additional copies of this Newsletter can be obtained from the IAMS Secretarial Office, Institute of Archaeology, University of London, 31–34 Gordon Square, London WC1H 0PY.
Telephone: 01–387–6052.
News from the director’s desk

The Iberian Archaeo-metallurgical Project, which grew out of the Huelva Project (1973–77) and its follow up, the Rio Tinto Archaeo-metallurgical Project (since 1977) (see IAMS Newsletter N.5, 1985) is about to begin work on a Corpus of Ancient Metallurgy of Southern Iberia. It is planned to include in this computerized corpus the southern Iberian metal objects found in stratigraphically well-defined culture-historic contexts and their typological and functional, analytical as well as metallographic data. The corpus will also comprise relevant literary references, comparisons and related information from the excavators’ documentation.

In contrast to most existing catalogues of metal finds, which usually do not include the most basic scientific data imperative for archaeo-metallurgical research, the Iberian Corpus will comprise the full range of metallurgical information (much of which will have to be created by our group), including relevant information on ore bodies and mine workings, smelting and metalworking sites and installations.

The Southern Iberia Metallurgical Corpus is planned as a collaborative project involving Spanish and English archaeologists, scientists and research associates of IAMS, and will be based mainly on detailed research by Spanish senior archaeologists and the analytical and metallographic facilities of IAMS research associates. The British Museum Research Laboratory, which has been a major partner in the Iberian Project since its beginnings in Rio Tinto (especially through the participation of Paul Craddock in the fieldwork as well as in the laboratory), has already started detailed metallurgical studies of samples taken from Early Copper and Bronze Age stratified metal objects from excavations in the Almeria and Granada Provinces, as well as from stratifiedArgaric and Phoenician metal finds from the Malaga Province (excavated by W. Schubart, German School of Archaeology, Madrid).

A group of IAMS associates will also take part in excavations, where extracate metallurgical finds are expected; some sites in Almeria and Granada, currently being excavated by Antonio Arribus and Fernando Molina, have already been ear-marked for 1986.

Rio Tinto remains the centre of our archaeo-metallurgical work in Spain. Besides the continuation of our excavations (reported in this Newsletter), in 1986 we shall begin systematic extractive metallurgical research into the ancient smelting processes of copper, gold and silver, based mainly on the materials from IAMS excavations of the ancient workings of Rio Tinto. The huge slag build-up around the mine workings of Rio Tinto (today huge open pits), dated from the Late Bronze Age to Roman times, present a unique opportunity for extractive metallurgical research on stratified and well-dated smelting debris. It is hoped that well-coordinated research by the IAMS associates involved in the Iberian Project will create theoretical and experimental models of the ancient extractive processes.

A first publication on material science research of Rio Tinto samples, which may well serve as a model for future work on smelting debris, has recently been published by the British Museum:


With this issue of the Newsletter we say farewell to Arthur Wilson who has acted as our Editor as well as a Trustee for many years. We accept his resignation with regret and take the opportunity of thanking him for all that he has done for IAMS.

Many of our subscribers, supporters and friends have been very patient with us over the gap that has occurred in our publication schedule for the Newsletter. As will be seen elsewhere in this issue, we welcome a new Editor and look forward to more frequent issues with current information on IAMS and allied projects. All these things cost money and we welcome the continuing generous donations and support from our subscribers.

IAMS Trustee honoured

Sir Sigmund Sternberg KCSG JP

The Pope has granted a signal honour to IAMS Trustee Sir Sigmund Sternberg. His Holiness has conferred the rank of Knight Commander of the Order of St Gregory upon Sir Sigmund. This is the highest Order of Papal Knighthood that can be conferred upon a layman, only three other Pontifical Orders of Knighthood stand higher than the Order of St Gregory, and they are only conferred upon Heads of State.

For a non-Catholic Christian to receive the Order is unusual, for it to be conferred upon a member of the Jewish faith is not unique, but it is highly exceptional. It seems that the only other Jewish recipient of this high honour was the late Lord Lever of Ardwick. Sir Sigmund is Chairman of the International Council of Christians and Jews and was responsible for arranging the historic meeting between the Pope and British members of the Council in 1981. A man of many commitments, not least as a valued Trustee of IAMS, we offer Sir Sigmund our warmest congratulations on this historic and well-merited honour which he has received.
Review


This is a marvellous work covering an area where there has been a crying need for a good comprehensive synthesis. Now we have one.

The study of metallurgy in Africa has hitherto been a very lopsided affair. Certain regions have been well surveyed, others of equal importance have been neglected either through inaccessibility or just lack of interest. Again, certain subjects such as iron smelting, or the analysis of metalwork, (particularly West African, Nigerian, especially Benin bronzes) seem to have been exhaustively studied, but other topics of equal interest have attracted almost no attention. One thinks of Africa as somewhere where early metallurgy has been little studied. What became apparent to this reviewer was the huge amount of work that has been done in the past and, so far, little used. Few works seem to have taken a genuinely Pan-African view. This book should go a long way to remedy this state of affairs.

It has always been recognised that Africa never had a true Bronze Age, when copper alloys were used exclusively for tools and weapons, but passed straight from the Stone Age to the Iron Age. However, until recently it was possible for people to believe, not only that Africa never had a Bronze Age, but that copper or other non-ferrous metals were never produced at all on any scale until the arrival of the Arabs or Europeans. This is demonstrably not so. From all over Africa have come independent reports from mining engineers, archaeologists, etc., of copper working often on a considerable scale and of great age. In Central and Southern Africa these date back to the beginning of our era, in West Africa considerably earlier. In all this early exploitation of metal there is no evidence whatever for a non-African presence. Indeed, the effect of Arab and European contact was largely to destroy the indigenous copper industry by competition with imports.

This book has brought together all this evidence and critically evaluated it. The case for metal production has changed from being no more than a strong suspicion in a number of unrelated areas to being an incontrovertible fact over most of Black Africa where copper occurs. It does appear that copper and its alloys was never used extensively for either tools or weapons, but it did have tremendous decorative and ritual importance that meant it was always in great demand. Gold, by contrast, was little valued and there is little evidence for production before contact with the world outside.

The main thesis of the book is the great importance of copper, which extended well beyond being merely decorative. A chief’s wife might carry many kilos of copper bracelets, collars and bangles not just as ornament but as a valuable expression of his wealth and influence. The production and exchange of copper was of local economic importance long before non-African traders entered the field and considerable stockpiles of ingots, as well as ornamental metalwork, were built up. African chiefs were anxious to augment their stockpiles of copper from Arab and European traders who in turn were interested in Africa’s gold. Thus much of the momentus of African trade was generated by a deep desire on both sides to acquire metals which were to be put to no utilitarian purpose, but in whose mere possession and display resided wealth, respect and ultimately power.

The book is well planned to cover all aspects of the subject from the extraction to ritual significance over all of Black Africa. The ore sources and early mines are treated in great detail, as is the evidence for a variety of smelting techniques, including some very valuable ethnographic evidence collected over half a century ago when the last of the African smiths engaged in copper smelting were still alive. The alloying and metalworking are similarly extensively covered. In all, about a third of the book is devoted to technical subjects. One must praise the author, primarily a historian, for the excellence of what she has written on metallurgical subjects. Clearly she has studied early metallurgy in great depth and her judicious use of extensive sources, her informed evaluation of some papers, for example, on the contentious use of metal analyses as a means to provenancing or dating artifacts, are remarkably well balanced. The book continues with a superb discussion of the copper trade in Africa right through to the nineteenth century and finally the role of copper in African society is evaluated leading to the conclusion that copper was indeed ‘The Red Gold of Africa’.

P. T. Craddock

Institute for Archaeo-Metallurgical Studies

Director Professor Beno Rothenberg
Institute of Archaeology, University of London

Trustees
R. J. L. Altham
Professor J. D. Evans
Nigel Lion
D. Rafael Benjumes Cabeza de Vaca (Spain)
Sir Ronald Prain OBE
Robert Rice
Professor Beno Rothenberg
Sir Sigmund Sternberg KCSG, JP
Simon D. Strauss (USA)
Professor R. F. Tylecote
Casimir Prinz Wittgenstein (Germany)

Scientific Committee
Professor A. Arribas Palau
Universidad de Palma de Mallorca
Professor H.-G. Bachmann
Institute of Archaeology, University of London;
J. W. Goethe-Universitat, Frankfurt/M
Dr Paul Craddock
British Museum Research Laboratory
Professor J. D. Evans
Institute of Archaeology, University of London
Dr N. H. Gale
University of Oxford
Dr F. Molina Gonzalez
Universidad de Granada
Robert Price
Rio Rino Finance & Exploration Ltd
Dr Nigel Seeley
Institute of Archaeology, University of London
Professor C. T. Shaw
Royal School of Mines, Imperial College of Science and Technology, London
Professor R. F. Tylecote
Institute of Archaeology, University of London
Professor P. Wincierz
Metallgesellschaft A/F, Frankfurt/M; Clausthal Universität

Editor Peter A. Clayton