THE ROMAN MINES AT RIOTINTO

By G. D. B. JONES

(Plates I–IV)

Although the name of Riotinto has become synonymous with mining throughout the world and the site was very clearly exploited in antiquity, the Roman mines have received relatively little archaeological attention at the analytical level. The reasons for this situation are complex, not least perhaps the impression amongst archaeologists that there now remains little or nothing from antiquity capable of examination. The two major expansions of large-scale open-cast mining by the old Riotinto Company have led to a general impression that modern mining has removed all worthwhile archaeological evidence.[1] Furthermore, in the last century a massive study by Rua Figueroa appeared at the time to offer a comprehensive survey of all that was known of ancient and more recent exploitation.[2] Following his work, interest revived with the discovery of the famous water-lifting wheel in the 1920s, a discovery the location of which was never precisely plotted but which attracted attention in the mining and archaeological journals of the time and led to several general survey articles of Roman mining in Andulusia that remain of importance.[3] Yet, in retrospect, those works remained firmly object-orientated in their scope. The same must ultimately be said of Oliver Davies' treatment of the site in the early thirties, where the absence of any overall plan and the overwhelming attention devoted to objects in the local museum of the time betray the difficulties of understanding the overall development of the site against a historical and technological background.[4] The same has remained true till recent years. The more startling discoveries such as water-lifting wheels and gallery frames have duly been incorporated in modern literature.[5] Then in the late sixties work began on Cerro Salomon and produced confirmation of the site's Punic origins.[6] These important excavations by Blanco and Luzon clearly take the origins of the site back to the seventh century B.C. and form the backdrop for the development of part of the mine.

Currently the Riotinto site falls within the area of the general survey of the Huelva Archaeo-Metallurgical Project, but the overall strategy of this important work rests on field survey and places its emphasis on little-exploited sites of prehistoric origin away from the major Roman extraction centres of Riotinto and Tarsis. Whether this extensive approach is the best available is doubtful for the Roman period for reasons that will emerge from this study. The site at Salomon itself will be destroyed by open-cast mining by the early 1980s; and it is important to emphasize the archaeological wealth that still awaits any study at all north of Salomon at Corta Lago. This area, where evidence of a Roman mining settlement measuring at least three-quarters of a kilometre across has been located, is due for open-cast development starting within the next quinquennium. In general, Riotinto appears to form the largest single mining site of antiquity and its archaeology still survives in places to a surprising extent; yet exploitation within the next few years will remove many key areas where major stratigraphic deposits still exist. Their potential is twofold: not only can they give us a history of the Punic and Roman exploitation, and indeed the Arabic, such as it may be, but they can also provide the raw material for understanding the evolution of the technological processes that affected mineral extraction. Indeed the actual minerals involved at this stage—gold, silver, copper—still remain in

[1] For example, the mine is not even mentioned in the survey of mineral resources in *CAH* XI, 493, although Riotinto is the largest source of silver, gold and copper in the south-western Spanish minefield.

[2] R. Rua Figueroa, *Ensayo sobre la História de las Minas de Rio Tinto* (Madrid, 1859).

→ T. A. Rickard, 'The Mining of the Romans in Spain', *JRS* 18 (1928), 129 ff.; *EMJ* 124 (1927), 13 ff.; R. E. Palmer, *TIMM* 36 (1926–7), 299 ff.

[4] O. Davies, *Roman Mines in Europe* (1934), esp. pp. 126 ff. There is evidence from Davies' notes (now in the possession of the author) that the working restrictions of the time prevented him from making any close analysis of the Corta Dehesa-Corta Lago area. The recent study by J. F. Healy, *Mining and Metallurgy in the Greek and Roman World* (1978), 9, 69 f., incorporates recent geological work.

[5] J. M. Blazquez, 'Explotaciones Mineras en Hispánia durante la República y el alto Império Romano: Problemas Económicos, Sociales y Técnicos', *Anuario de Historia económica y sócial* 2 (1969), 9 ff. for an excellent survey of the evidence. See also his survey, 'Economia de la Hispánia Romana Republicana: Minas, Agricultura, Ganaderia, Caza, Pesc y Salazones', *Hispánia, Revista Española de Historia* 33 (1973), 205 ff.

[6] A. Blanco and J. M. Luzón, *Antiquity* 43 (1969), 124 ff.

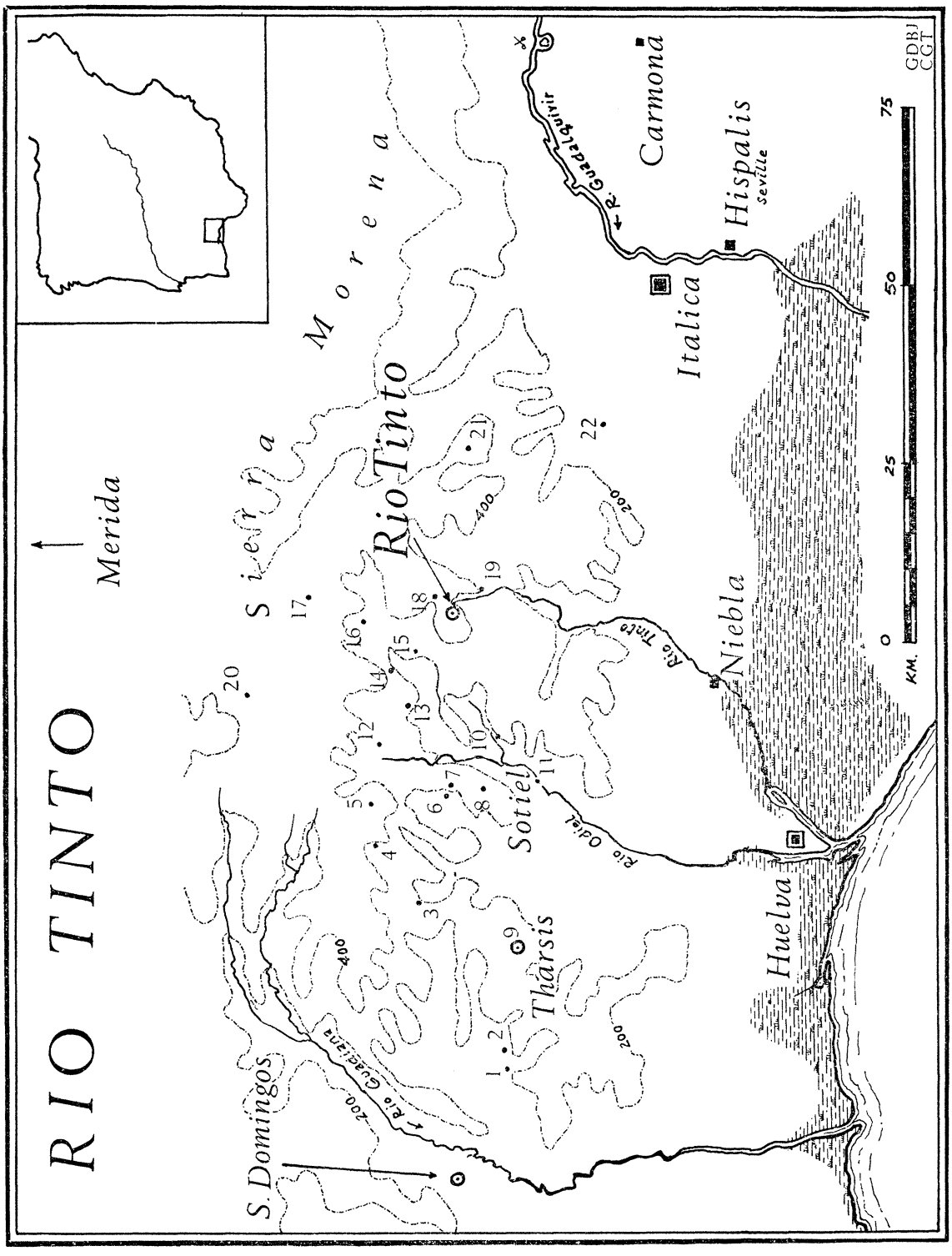


FIG. 1. RIOTINTO AND ITS ASSOCIATED MINING AREA.

The major sites after Rio Tinto are Tharsis, the S. Domingos mines west of the Guadiana and Sotiel Coronado. The prehistoric or Roman mining sites include those numbered on the map as follows 1. Cabezas 2. Herrerias 3. La Joya 4. San Telmo 5. Lomero Poyatas 6. Perrunal 7. Zarza 8. Calanas 9. Tharsis 10. Buitron 11. Sotiel Coronado 12. S. Miguel de la Mora 13. S. Miguel 14. Concepcion 15. Poderosa 16. Lo Soldato 17. Aracena 18. Pena 19. Rio Tinto 20. Maria Luisa 21. Castillo de las Guardas 22. Aznalcollar.

dispute on a site the metallurgical richness of which currently allows 38 per cent iron ore to be dumped from the copper pyrites. This article is a brief account of the mine as a whole. It attempts primarily to show how the mine developed, and to a lesser extent to describe the settlements and cemeteries in which the Roman miners worked and were buried. Moreover, it is suggested that the disruption of the mine in the last quarter of the second century A.D. had a major effect on the production of silver coinage. If this study, resulting from a four-week survey undertaken through the generosity of Riotinto Patino S.A.,[7] fulfils part of its purpose then it will have provided an outline history of the greatest single mining site currently known from the ancient world.

The Regional Background

In the Roman period the major links of the Riotinto site must have lain to the north and to the south-east towards Italica. Yet this may not have always been the case. Perhaps the most valuable result to emerge from the Archaeo-Metallurgical Project is the plotting of the location of a large number of predominantly copper-working sites that existed in Huelva Province in the Chalcolithic period. A glance at the map (Fig. 1) will show that these sites are principally related to the Rivers Tinto and Odiel. Further west the same kind of pattern is visible on the eastern side of the Rio Guadiana in the area of Minas de Santa Domingos. The axis of prehistoric communication, therefore, lay along the river flow, either north–south or north-east–south-west in the case of Riotinto. There is no doubt from the wealth of prehistoric material found that the town of Huelva represented an entrepôt for the metal-working industry in the early prehistoric period. This is quite clear from the considerable amount of 'P' type slag that has been located on the Cabeza del Esperanza, one of the seven headlands overlooking the present harbour at Huelva.[8] The importance of riverborne traffic should always be remembered. As late as the 1920s, for instance, it was common for boats of substantial tonnage to work upstream along the Rio Guadiana to the Minas de Santa Domingos. Similarly it was apparently possible for boats of shallow draft to sail up the Rio Odiel as far as the area of Sotiel Coronado. Likewise the discovery of the Riotinto deposits must be associated with the ease of traffic, possibly in part riverborne, along the valley of the Rio Tinto towards Narsis (Niebla). Clearly the conditions of the river have altered substantially since ancient times and boats could probably penetrate much further upstream than today. The Roman communications network represents an artificial creation linking the mine towards the centres of Italica and Hispalis (Seville) in the south-east and, though less clearly understood, to Merida in the north.

The road systems relate directly to the cemeteries that ringed the mining site in an arc to the north. So far five cemeteries have been located. A sixth lies well away from the mine proper and the imposing nature of the tombs, although only partially visible on the surface, clearly indicates an upper-class cemetery. Significantly, it lies well away from the mining area, which may explain its very different nature. The location is at Ventoso, a southward looking hill slope on the south-western flank of Nerva. Significantly perhaps,

[7] That this exercise in salvage archaeology was conducted is due to the initiative of the present mining company, Riotinto Patino S.A., which financed the project through the courtesy of Sr. Dn. Juán Eugenio Morera and other members of the management. My particular thanks are due to Sr. J. P. Hunt, the Company Secretary, and his family for organizing the logistics of the operation and making the stay so pleasant in a host of ways. The team consisted of my wife, Mrs. V. A. Jones, who acted as draftsman, and Messrs. P. Reynolds and P. Bennett, who kindly collated the tables in Appendix A; we are deeply grateful for all the help and attention received from the staff of the Riotinto Patino S.A. Company Office at Dehesa, notably those members who assisted the project from the Survey Office and made Company archives available. Thanks are also due to the labour force, mainly drawn from the village of La Dehesa.

On the archaeological side our most grateful thanks are due to Prof. A. Blanco who authorized the work and to the Curator of Huelva Museum. Our indebtedness to the pioneer work of Prof. Blanco and J. M. Luzón on Cerro Salomon will be apparent from the text.

On the metallurgical side Prof. R. H. Tylecote, who initiated the scheme, provided great support with his advice and technical assessments. We are also grateful to Mr. L. U. Salkeld, a former geologist at the mine, and Prof. R. N. Pryor for their help in a variety of ways.

Mr. J. Sharples, Keeper of Numismatics at the Melbourne Museum, Dr. Richard Reece and Mr. M. H. Crawford, very kindly provided information on coinage, while Prof. A. R. Birley, Mr. H. F. Cleere and Dr. G. P. Burton commented on various aspects of the text.

[8] Information from Prof. Tylecote.

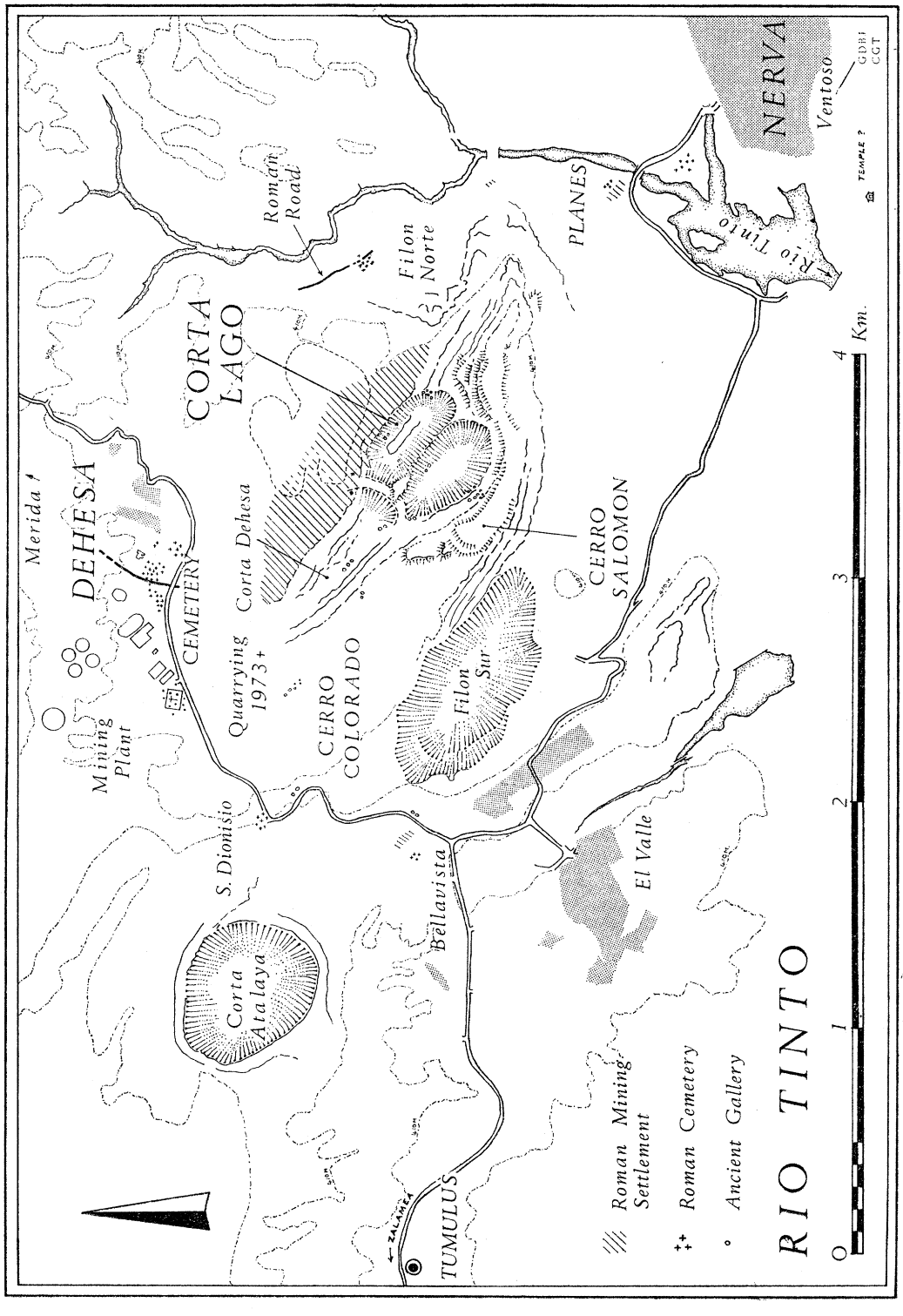


FIG. 2. THE CENTRAL MINING AREA OF RIOTINTO.

at no point is the mine of Riotinto visible from the cemetery area and its associated remains; it may be that this reflects social aspirations familiar enough in the modern world (Fig. 2).

The study of the roads in and out of Riotinto may not perhaps appear the most logical method of reconstructing the development of the mine. Yet it is possible to determine the nature and above all the development of the mine in the pre-Roman and Roman periods from a detailed examination of the surviving features, as has been done at the Dolaucothi gold mine in Wales. The remains of the roads are indicators of the locations of the Roman cemeteries. The presence of the dead implies the proximity of the living; their main settlement has been identified by the remains of clinker-built upstanding walls and floors that had lain previously unrecognized amongst the sixteen million tons of ancient slag ringing the northern edge of the mining area. The extent of the main Roman settlement, which lies some way from the previously known Hispano-Punic nucleus on Cerro Salomon, and is still to be seen, part destroyed, part still massively upstanding amid its clinker strait-jacket, makes it the largest Roman mining settlement yet known. The depth of the stratigraphy involved, spanning the Punic to the mid-imperial period, reflects the life of a settlement whose rapid decline, it will be argued, was caused by the Moorish incursions of the later second century. The story of discovery is best started with the rich and varied ore body underlying Riotinto.

The Geological Background

The mining area of Riotinto is the largest in the vast mining field extending between the Guadalquivir valley near Seville and Portugal, along a corridor measuring approximately 170 km wide. The main lode occurred along a north-west–south-east axis incorporating the peaks known as Cerro Salomon, Cerro Colorado (now substantially quarried away) and Cerro San Dionisio. The present quarrying operations are centred on developing a relatively new open-cast working known as the Corta Atalaya west of San Dionisio and the bench mining of Cerro Colorado, thus leaving Cerro Salomon, the site of the excavated Hispano-Punic settlement, the highest surviving feature of the ridge. The great burst of mining activity at the end of the nineteenth century, when the original parent company was formed, took place on the southern and south-eastern sides of the ridge between Mesa Pinos and Planes along the road to Nerva.[9] In the early years of this century modern exploitation developed along the north-eastern flank of the ridge. These workings at Corta Filon Sur, Planes, Corta Lago and Corta Dehesa ring the Riotinto ridge and the largest of the mining trenches, that of Corta Lago, represents a modern deepening of the great trench that was created by ancient mining along the Corta Dehesa–Corta Lago axis.

With modern mining came understanding of the ore bodies involved. It is thought that mineralization occurred in two stages, first when tufaceous sediments along the ridge were impregnated with copperless pyrite. This was followed by probable fracturing and the creation of chalcopyritic, or copper bearing, veins normally occurring vertically (Pl. I, 4). The dark brown or reddish material contained in these ore shoots is normally termed gossan. ' Thick mantles of gossan formerly overlay the massive deposits of pyrites, whilst the conspicuous reddish gossan crown of Cerro Colorado represents the oxidized remains of long vanished ore bodies . . . Over a wide area of Cerro Colorado the gossan, for a thickness of 25 m, contains the equivalent of more than 50 per cent iron together with 1·25 oz silver (42 gm Ag/m ton) and 1 dwt gold (1·7 gm Au/m ton).' [10] The recovery of gold and silver is far greater from underlying deposits that are relatively more accessible on the sides of the 2·5 km main ridge. These jarosites (silver and gold ore) do not appear until the bottom of the gossan, and the division is often marked by an earthy layer up to 1·5 m thick that is comparatively rich in gold, silver, lead, antimony and lesser elements.[11] This multicoloured earth band of jarositic ore was easily mistaken for clay and, ironically, in the first twenty years of modern mining, when efforts were concentrated on the massive pyrite of Corta Lago and Corta Filon Sur, it was jettisoned along with the overburden. It has

[9] For the history of the modern mine V. D. Avery, *Not on Queen Victoria's Birthday* (1974).

[10] D. Williams, *TIMM* 43 (1933–4), 593 ff.; ibid. 59 (1950), 63; 84 (1975), 73 ff.; R. N. Pryor, H. N. Rhoden and M. Villaon, *TIMM* 81 (1972), 143 ff. for the latest work on Cerro Colorado.

[11] D. Williams *et al.*, *TIMM* 84 (1975), 73 ff.

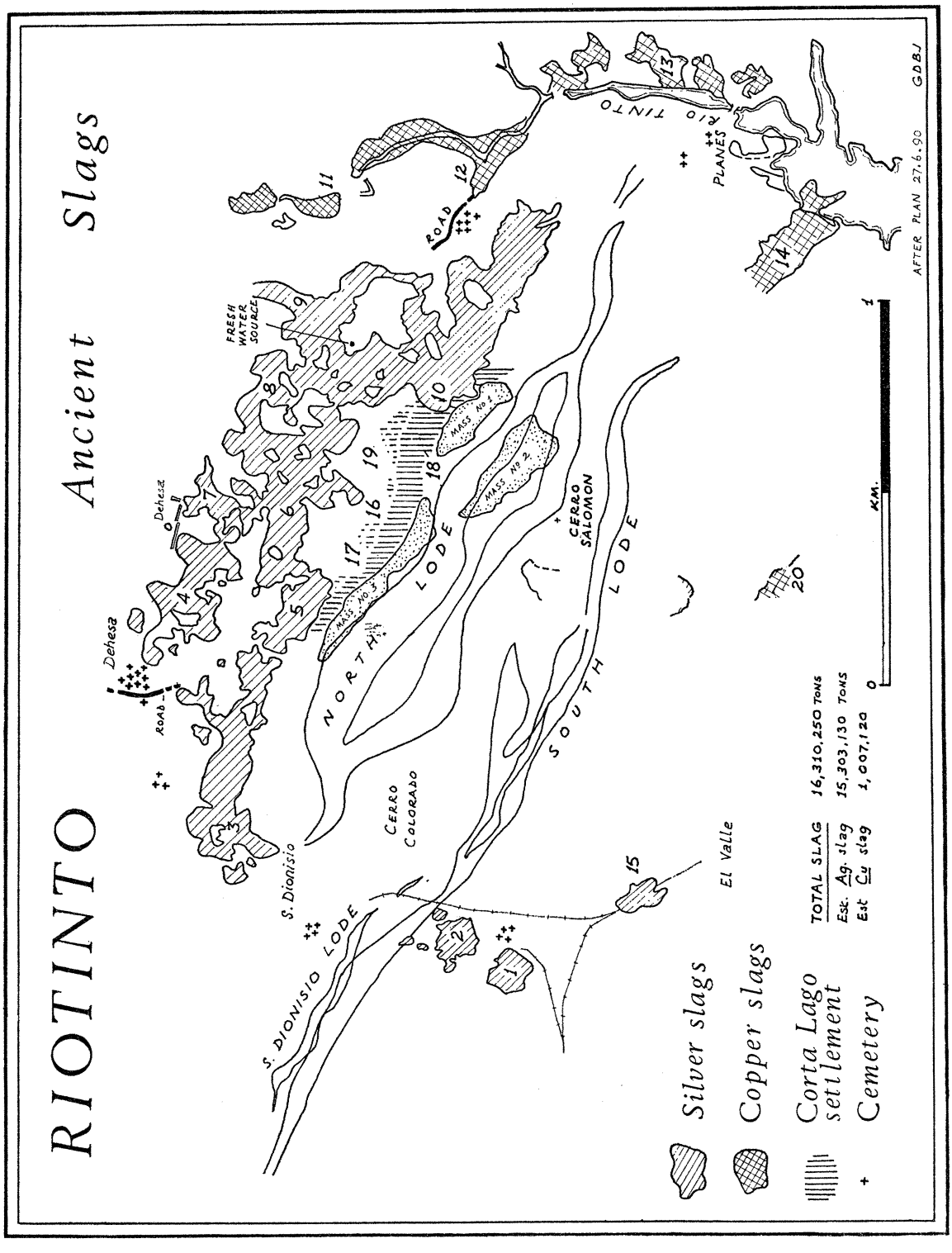


FIG. 3. THE ANCIENT SLAGS.

been estimated that originally some three million tons of this ore existed and that approximately two million tons may have been extracted in antiquity. The jarosite could contain from 166 to 3,110 gm Ag/m ton and 7·7–41 per cent FeO. The ancient slag dumps around the mines contain some sixteen million tons of what seems to be principally a non-copper slag of the fayalite variety. What kind of mineral extraction was therefore involved? An early bloomery process might mean that iron production took place, and certainly this would be possible from the enriched gossan. The current consensus, however, amongst metallurgists and mining engineers is that the principal operation involved was the extraction of silver from the jarositic earths with their high recovery rates.[12] The extraction of silver might involve an alkaline flux in dissolving silver in lead and, although the lead content of the jarosite is normally less than 34 per cent, when concentrated it should have been sufficient for the purpose; otherwise lead would have had to be introduced. Some experts, however, doubt whether there existed a need for either a flux or lead, thanks to the richness of jarosite in potash. In any case, others agree that the plumbo-jarosite was sufficient to provide enough lead from which the silver could be extracted by cupellation.[13] Certainly the 1890 survey supports the emphasis on silver production by estimating that fifteen million tons derived from silver slags and that the remaining one million tons related to copper smelting in the Planes area. This important document, produced by the British mining engineers in charge at the time, is an analysis of the slags visible at the end of the last century and is reproduced partly in Fig. 3 and in Appendix B.

The Early Development of the Mines

That silver was indeed the main pre-occupation of the Hispano-Punic miners was comprehensively demonstrated by the important excavations by Blanco and Luzón on the crest of Cerro Salomon.[14] The slag samples examined in the Riotinto laboratories showed consistently high levels of silver comparable with the highest levels known to-day. This confirms the tradition that in a number of places actual mineral veins were visible in the pockets of jarositic earths, one of which was apparently excavated in antiquity and formed the large cave from which sprang the headwaters of the Rio Tinto. The name of the river derived, of course, from the red-brown colour of its waters. The position of the pre-Roman settlement on Cerro Salomon was perhaps conditioned in part by the defensive advantages of a hilltop site, in part by a windy location to assist smelting. While the recovery of a pre-Roman settlement marked a major step forward in our understanding of the mine's development, there is perhaps a tendency to treat it as an isolated phenomenon. The reality is somewhat different. The recovery of seventh- to sixth-century B.C. pottery associated with smelting hearths cut into the bedrock porphyry on the northern face of Corta Lago (Fig. 4), buried beneath four metres of superimposed Roman remains, shows that the pre-Roman exploitation of the mines was on a considerably greater scale than has previously been believed. Archaeologically too the discovery at the base of the Corta Lago section is important for any future work; it means that, while the Cerro Salomon site was a rare survival without substantial overlay (but one destined for total destruction in the current mining development), there are substantial prehistoric levels awaiting eventual examination beneath the massive Roman overlay.

The new evidence for the scale of pre-Roman Riotinto suggests that its importance should somehow be reflected in other ways. This is not the place to discuss the arguments relating to Tartessos, but the apparent absence of prehistoric monuments at Riotinto can now be rectified by recording the discovery of a major tumulus, or similar feature, on the western side of the mining area overlooking Corta Atalaya. The crest of a small hill on the southern side of the road to Zalamea was crowned by a monument the scale of which was

[12] L. U. Salkeld, 'Ancient Slags in the South-West of the Iberian Peninsula', *La Mineria Hispánica e Ibero-Americana* 1 (1970); J. C. Allan, *Bull. Hist. Metallurgy Group* 2 (1968), 47 ff.; cf. idem, *Considerations on the Antiquity of Mining in the Iberian Peninsula*, R. Anth. Inst. Occas. Paper 27 (1970).

[13] Jarosite is chemically $K_2SO4.3Fe_2SO_6H_2O$. Perhaps one of the most important elements in the argument is contained in the 1890 map of the slag deposits which draws a careful distinction between the great majority of silver slags (around Corta Lago) and the minority of copper slags (from the Planes area). The figures support the developmental scheme for the Roman mine set out in this paper and are printed in Appendix B.

[14] A. Blanco and J. M. Luzón, op. cit. (n. 6), 127 ff.

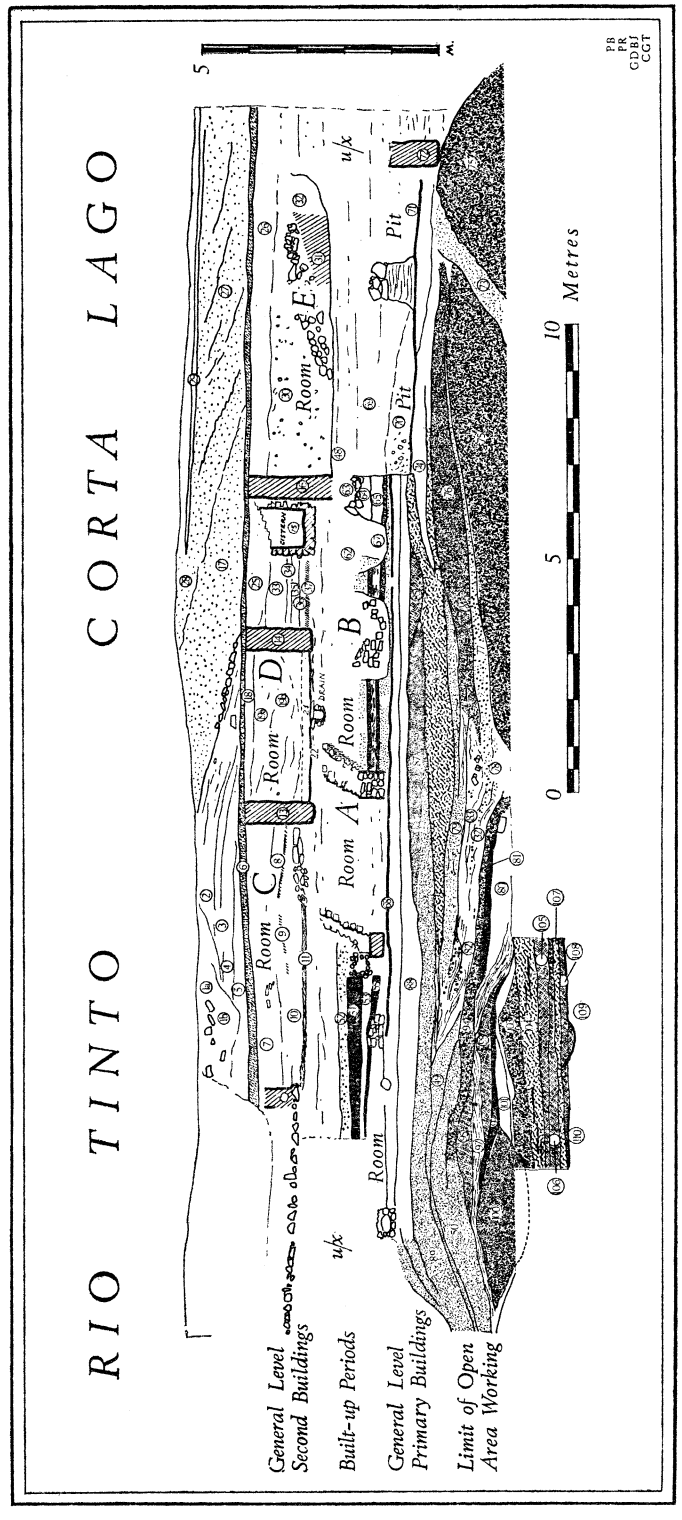


FIG. 4. THE CLEANED SECTION.

so large as to obscure its artificial nature (Pl. I, 2).[15] Hill wash has done much to hide the break of slope but a contour survey kindly conducted by the Riotinto Patino S.A. surveyors brings out the nature of the remains as a massive circular tumulus at least 55 m across the base. Its artificial nature is emphasized by the flat top measuring 32 m across. A ring of stones on the south-eastern side and several other features hint at structures below. Provisionally the remains are classed as a tumulus; what is clear, however, is that the size of the monument, which hindered recognition of its character before 1975, is of an order greater than the normal *dolmen* of the Huelva province, an indication perhaps of the importance of those buried within the monument.[16]

The Roman Mines

(*a*) *The Dehesa Cemetery*

The initial purpose of the 1975 excavations lay in the clearance and display of the Dehesa Roman Cemetery, much of which was already known to have been considerably destroyed by the crushing plant to the south and the gold concentration plant to the north. The remainder of the cemetery survived on a small crest immediately west of the offices of Riotinto Patino S.A., through whose initiative the clearance of the cemetery and other features was effected. Within the area contained by the present boundary (Fig. 5) some 290 graves were identified and over a hundred excavated. Although the graves have been heavily robbed, the results offer an interesting picture from southern Spain, showing two mausolea of the well-to-do cut through the earlier, humbler cremation burials of the mining community that must have contained a very large slave element in the first and second centuries A.D. The cemetery was prepared by the author and his team for permanent display by the removal of all topsoil across considerable areas, thus leaving the rock-cut graves easily visible. The graves nearly all followed the same pattern, being cremation burials cut in the bedrock and normally at least half a metre square. The larger, more elaborate versions (Pl. IV, 1) contained a countersunk *loculus* cut in the floor to hold an ossuary. It is clear that many of the graves were distinguished by massive semi-cylindrical capstones, which served both as a deterrent to interference and a way of identifying the deceased. Rectangular blocks were chiselled into semi-cylindrical shapes, but on one side a small recess was created with two lateral grooves. Into this was slipped a thin inscribed slab with the name of the deceased; the weight of the gossan capstone would then keep it in position within the recess. The capstones were shaped in a variety of forms with either arched or flat tops surmounted by a roughly carved miniature pediment or portico. Some of the best examples can be found in the new church at El Valle (Pl. IV, 4).

The major exception to this type was the remains of a tower or pedestal tomb (Tomb 1) on the crest of the hill. Its foundation (4·1 m by 3·5 m) were cut through the remains of the earlier tombs (19, 20). Seven gossan blocks survive from the floor of the sub-foundations and make it clear that any funerary cist must have been incorporated higher up in the structure, though whether it took the form of a tower or a pedestal tomb must remain uncertain. The large dimensions suggest that the latter was the more probable form and find ready parallels in North Africa, in contrast with both the Punic-style *hypogea* attested at Carmona east of Seville and the more Italianized tombs known at Merida to the north.[17] The other major structure (Tomb 111) lay to the south-east and was comparable in size (3·6 m by 3·4 m), although almost completely robbed. The rock-cut construction trenches marking the exterior of the tomb (Pl. IV, 3) left a central pillar of bedrock in the centre in which possible traces of a funerary niche remained. The tomb faced east into a road cutting, and its rock-cut western side had been revetted by a low wall of gossan blocks. The date of the cemetery is not in doubt. Although the tombs had been severely robbed, some time ago in most cases, finds of samian indicate that it existed in the Flavian-Antonine periods. The grave goods follow a familiar pattern with *amphorae*, glass and samian vessels and some coarse wares, principally flagons, buried with the cremated remains.

[15] Detailed publication forthcoming.

[16] For an up-to-date summary of the prehistoric evidence see *Huelva: Prehistória y Antigueddd* (1974), with a summary of the evidence for Romanization by J. M. Luzón (pp. 271 ff.).

[17] The recent detailed publication of the Carmona tombs has not been available to the writer; for Merida, see M. Almagro, *Guida di Merida* (1965).

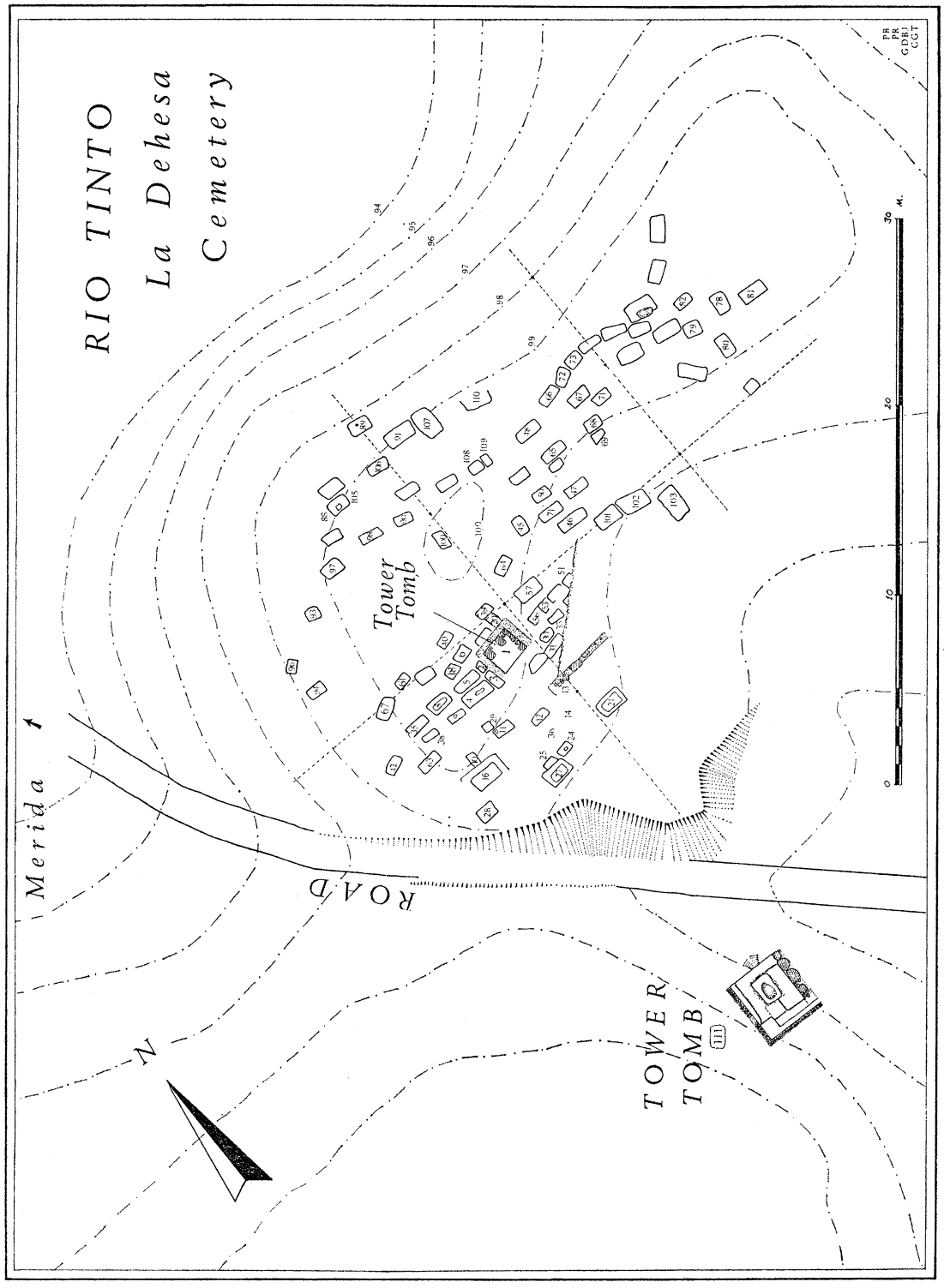


FIG. 5. THE DEHESA CEMETERY.

(*b*) *The Other Cemeteries and the Roman Slag Deposits*

Cemeteries, of course, are normally directly related to settlements and lie alongside roads radiating from settlements. In the case of the Dehesa cemetery it has already been noticed that the larger tower tomb faced east on to a road cutting that led north towards Merida. Another road cutting and associated Roman cemetery was located at Filon Norte; the road in question climbed to the northern edge of Corta Lago. As the survey expanded, four other cemeteries were located at Nerva, Planes, Bella Vista and San Dionisio. With the exception of Ventoso (well to the south-east on the route to Italica, p. 148), the six cemeteries ring the mining area. Their position provides an indication of the major roads radiating from the Roman mining areas and, more important, an indication of the relative size of the associated mining settlements. Despite its extremely damaged state, the Dehesa cemetery, which may originally have been linked to the San Dionisio cemetery (the main processing plants now split the two), was by far the largest of those identified and points to the major Roman settlement having lain along the northern edge of the Corta Dehesa/Corta Lago trench. At this point another piece of evidence comes into play. At the time the modern mine was first established, a map was drawn up by British mining engineers (in 1890) to show the location and extent of the ancient slag deposits, much of which was removed to provide ballast for the railway to the coast. The map shows that an estimated sixteen million tons of slag lay around the mine area and that the main concentration occurred along the northern edge of Corta Dehesa and Corta Lago. As already stated, the map, redrawn in Fig. 3, also gave detailed estimates and analyses of the slag in each area, and the gaps in the slags can now be shown to correlate with the presence of settlement, roads and cemeteries.

(*c*) *The Roman Mining Town*

This was the situation in 1975 when work began on material stored in the abandoned Corta Dehesa mine offices. These finds, deriving initially from a collection of random discoveries made during very extensive bulldozing in 1973 and 1974, were so great in number that, although unfortunately not derived from any recorded stratigraphic context, they arguably form one of the most important pottery groups currently available from Andalusia. The material was sorted, and the glass and *terra sigillata* deposited in Huelva Museum. The latter was of particular interest in dating the overall occupation period of the Roman settlement and contained considerable quantities of *terra sigillata Hispanica*, which is now known to have been produced around Andujar (Prov. Jaën).

The quantities of pottery recovered, however, prompted more detailed examination of the surviving areas alongside the northern edge of the Corta Dehesa-Corta Lago trench. The upper end of the former has been infilled by the present mining scheme and so for convenience the area is termed Corta Lago overall. It was found that, while much of the estimated sixteen million tons of ancient slag dumps were refuse tips pure and simple, remains of actual buildings constructed with slag walls and floors extended for approximately three-quarters of a kilometre along the north edge of Corta Lago.[18] The difficulty in recognition occurred because the actual buildings had been constructed with the same materials that also composed the adjoining slag dumps. With growing experience it became possible to analyse the remains of buildings that survived in places to heights of 1·5 m along what is in effect a continuous archaeological section. In this way two sample sections were recorded, one in as much detail as labour allowed, the second completely down to bedrock, at the northernmost edge of Corta Lago. The latter showed prehistoric exploitations beginning in the seventh to sixth century B.C., when the decomposed porphyry bedrock was pitted with a number of primitive smelting hollows. Above this extended some 1·5 m of stratified deposits intermixed with silting, until pottery evidence led to the identification of the late second to first century B.C. levels. These relate to the initial period of Roman exploitation after the collapse of the Carthaginian hold on southern Spain in 206 B.C. The site then continues as an open working area until the early first century A.D., when the

[18] The siting of the mining settlement is in principal the same as that at Charterhouse-on-Mendip, i.e. on higher ground away from the ore body (*Britannia* 2 (1971), 278), and *Rescue Archaeology*, ed. P. A. Rahtz (1974), 137 ff.

first level of buildings could be recognized in section. A further range of buildings occupied to some point in the later second century was superimposed on the primary structures. As the sectional drawing (Fig. 4) shows, the standing remains, when cleaned down and stratigraphically analysed, have been exceptionally well preserved by the rapidly rising levels of accumulated slag and the superimposition of structures upon others that were levelled and infilled rather than demolished in the usual way. The results are described in detail in the following section.

(*d*) *The Corta Lago Section*

The all-important evidence of the development of the Corta Lago mining settlement was obtained by clearing down of one of the mining benches that pre-date the Second World War. These benches were cut when Corta Lago was developed as a major open-cast mine by bench excavation in the 1930s. The width of the benches is some 12–15 m on average, which normally means that the internal face has been cut back to a height of between 6 and 8 m. In April 1975, as part of the exploratory programme of work on the site, it was decided that a careful cleaning of the face of the mining bench would reveal the total history of the site, if only sufficient attention were paid to the stratigraphic minutiae that have largely escaped attention in the past. The section vindicated this approach. It provided evidence for the development of pre-Roman exploitation away from the presumed nucleus of Corta Salomon, and also provided evidence for pre-Roman open-cast working on a substantial scale somewhat to the west. Most important perhaps in terms of potential and as yet unrealized archaeology, it revealed the existence almost anywhere in this mining settlement of an intricate, and because of the nature of the gossan clinker, very fast accumulating stratigraphic sequence through the early Imperial period. This is something that has hitherto remained unexploited on any Roman site in southern Spain. For instance, the levels from the nearby city of Italica are not remotely comparable in depth.

The fortunate feature of this work was that the existing level of the bench floor had not completely removed the archaeological levels. By cleaning down the available un-exposed face of the bench it was possible to realize (see below) that the existing mining floor was approximately on the level of the second or first century B.C. exploitation. To deal with the excavation in ascending chronological order, therefore, we may note the results of the partial mechanical clearance that isolated features in the bedrock. The decomposed porphyry forming the bedrock at this point was found to contain three shallow furnaces (109, 110 and 111) each containing quantities of charcoal and clinker of the 'P' type, that is with a high quartzite content visible to the eye. All three pits contained considerable quantities of coarse pottery with a red/brown fabric. All the fragments, however, were body sherds; but fortunately a more diagnostic type was recovered from Furnace 109. There, wall fragments of a vessel of Hispano-Punic type dating to the seventh to sixth century B.C. were located. A number of parallel forms were located at Cerro Salomon to the south. The first levels were covered by a deposit of silt (108). Beneath this lay alternating layers of charcoal and more silt/clay material (1–7, 106, 105). The principal layer was formed by 104, comprising a mixture of charcoal, gossan, clinker and silt. All these levels, like 103 above, contained more or less elements of *scoria* or clinker, often as in the case of level 104 derived from finely crushed gossan. The difficulty with these levels is that their dating can only be relative. The fundamental historical question lies in whether they stem from a steady and relatively continuous exploitation from the seventh to sixth century down to the end of Punic domination, or are to be assigned to the Roman period.

The latter is made less likely by the evidence from Pit 100. It is at this level that the evidence of *scoria* deposits is on the whole of a larger scale. Significantly Pit 100 yielded a base of a Campanian black-glazed vessel, or equivalent, assignable to the late second century or first half of the first century B.C. Although the imprecision of the pottery dating is unfortunate, it nevertheless provides a key piece of evidence in building up a picture of the development of the earlier stratigraphic levels on the site. By this stage one must assume that it represents Roman Republican exploitation. To judge from the volume of slag being produced, the quantitative scale of production was greater, reflecting either increased technological efficiency in extraction or greatly increased exploitation—or conceivably a

combination of both. At this stage working was still, in this particular area, conducted in the open air. Levels 80 to 100 represent the accumulation of a variety of *scoria* dumps and other working processes that form a complete contrast with what followed. The latter part of the site's existence is taken up with what can be interpreted as two periods of *scoria*-built structures both surviving to some 1·5 m in height, and both destroyed in a final period of abandonment that requires detailed discussion.

The first structural period was clearly more directly involved in technological processes than the second. The evidence for this comes from levels 39 and 40 on the western side of Room A. A substantial level of charcoal (40) was kept by a gossan dump (39), hence the presence of an adjustment working area. The same is not true of Room A. This remained an occupied area until its final demolition when it was unceremoniously filled with *scoria* rubble, following the standard pattern now apparent on this site. In Room B to the east, however, rising floor levels indicated a considerable degree of accumulation within the room itself. Although the stratigraphy is rendered difficult by the presence of a right-angle junction (67), compressed clay floor levels survive on the western side. Like its companion, the room was ultimately filled with *scoria* debris on demolition. What happened to the east is more obscure. Two pits, some 3 and 2 m wide respectively, were gradually allowed to accumulate a fill of crushed gossan and other clay features. The adjacent wall to the east does not have a clear structural rôle, and it may well be that the pits stood in the open while the wall belonged to structures that ran eastwards. The pottery from this area produced a general run of first century wares.

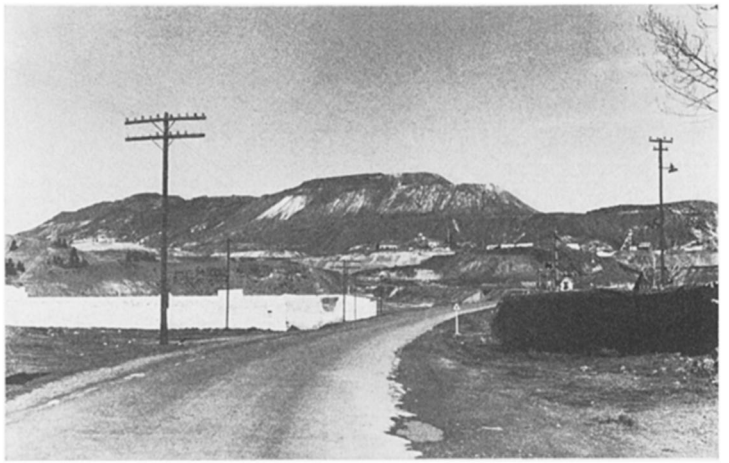
More interest perhaps attaches to the remains of the more substantial building that was superimposed over the remains. Three rooms were identified in the section (C, D, E). The latter two were separated by a small, apparently open space with a cistern (15). The set of buildings had undergone roughly the same kind of history. There was little indication that metal processing was actually carried out within the structure. The fact is argued from the absence of charcoal and the limited amount of gossan and *scoria* in the interiors, which were filled mainly with rising floor levels and ultimately with rubble. The floor of Room C was made up of a gossan dump (11) on which rested a dusty accumulation of gossan and small chips (10). A similar but better built floor (21) existed in Room D. Beneath it a square-bottomed drain was revealed in the section. Level 37 carried the foundation stratigraphy across into the cistern (15) and so to Room E. From the chronological point of view the significant element was the recovery of late-second-century A.D. coarse wares together with fragments of African Red Slip Ware of the same period. This terminus is, it is suggested in the following pages, one of considerable significance. There was no further construction on the site. Destruction/dereliction layer 6 was sealed by a gradual accumulation of hill wash (2–5, 17, 27–9) until the present day.

(*e*) *Technology and Trade*

At certain levels the technological details of the Roman mineral exploitation at Riotinto (and some other Spanish sites) are well recorded. This obscures the fact that recording principally occurred fifty or so years ago, while at Riotinto there is currently no system for recording the remains of galleries and other features brought to light by an extraction rate of 45,000 tons of ore per day. Thus when the rate of destruction is at its greatest there is least record of what is being destroyed. The mining of the early years of this century was an altogether slower process and led to the recognition, and in some cases conservation, of features such as the famous water-lifting wheel (an exact replica of which was built by carpenters at the time of its discovery), ropes, buckets, pit props and a quantity of ancient mining tools.[19] As so often, the discovery of such common features, inevitably to be found on any mining site, has obscured the question of the mine's overall development, the elements of which have already been suggested above, and the question of the technological levels attained in the extraction and processing of the wide variety of metals present at Riotinto.

For this reason, therefore, the casual finds from the Corta Lago mining settlement are of especial interest. The absence of water on any large scale meant that the development

[19] Palmer, op. cit. (n. 3).



(1)

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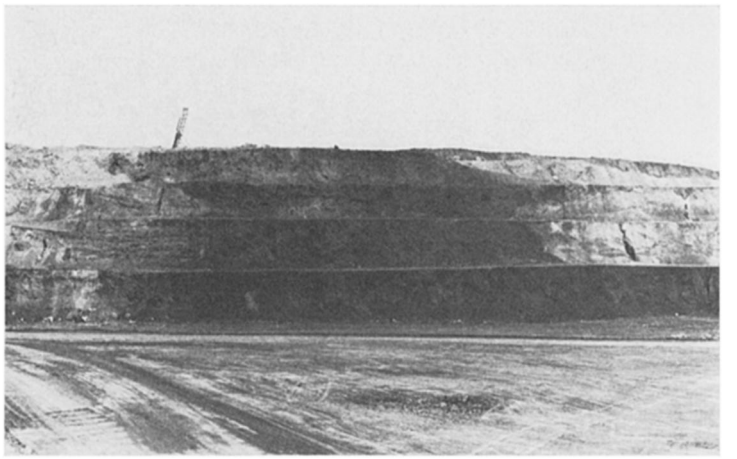


(4)

(1) A GENERAL VIEW OF RIOTINTO FROM THE SOUTH-EAST, WHERE MOST OF THE NINETEENTH CENTURY EXPLOITATION OCCURRED. CERRO SALOMON, THE PUNIC SETTLEMENT, LIES ON THE HIGHEST POINT OF THE RIDGE, THE CREST OF WHICH HAS BEEN QUARRIED AWAY TO THE RIGHT. (2) EVIDENCE OF THE IMPORTANCE OF RIOTINTO IN THE PREHISTORIC PERIOD COMES FROM THIS MASSIVE TUMULUS 2 KM. WEST OF THE MODERN VILLAGE OF RIOTINTO. (3) AN AERIAL VIEW OF THE GREAT MINING TRENCH OF CORTA DEHESA, CORTA SALOMON AND CORTA LAGO SEEN FROM THE EAST. THE PUNIC SETTLEMENT OF CERRO SALOMON IS MARKED AT A, THE EXCAVATION SITE ON THE EDGE OF CORTA LAGO AT B. (4) MODERN (1975) MINING ON THE NORTHERN SIDE OF CERRO COLORADO. THE DARKER AREA MARKS A MAJOR VEIN OF GOSSAN PRINCIPALLY CONTAINING COPPER. THE ANCIENT GALLERIES ARE CLEARLY VISIBLE.

GENERAL VIEW OF CORTA LAGO FROM THE WEST. THE DOWNTURNED ARROWS MARK THE POSITION OF ANCIENT ADITS, THE UPTURNED ARROW THE EXCAVATION SITE IN THE MINING SETTLEMENT.

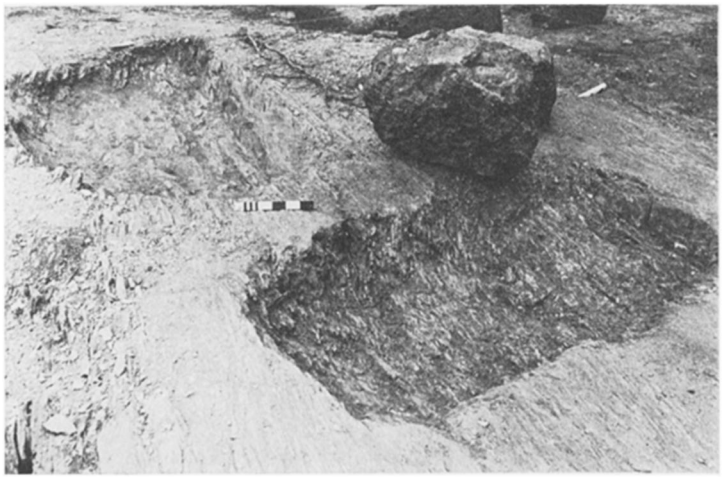
(1)

(2)

(3)

(1) A SECTION PARTLY CLEANED ACROSS THE UPPER EDGE OF THE CORTA LAGO FACE. THE FIGURE STANDS BESIDE ONE OF TWO WALLS OF THE UPPER ROMAN BUILDING (SEE FIG. 4). NOTE THE LEVELS OF DUMPED *SCORIAE* FROM THE LATE REPUBLICAN PERIOD ACROSS THE BOTTOM OF THE PHOTO. (2) A DETAILED VIEW OF THE WALLS OF CISTERN 15 SHOWN ON THE RIGHT OF PL. III (1). (3) THE DEHESA CEMETERY: A GENERAL VIEW OF THE ROCK-CUT TOMBS WITH THE ROBBED FOUNDATIONS OF THE TOWER TOMB CUT THROUGH EARLIER CREMATION BURIALS.

(1)



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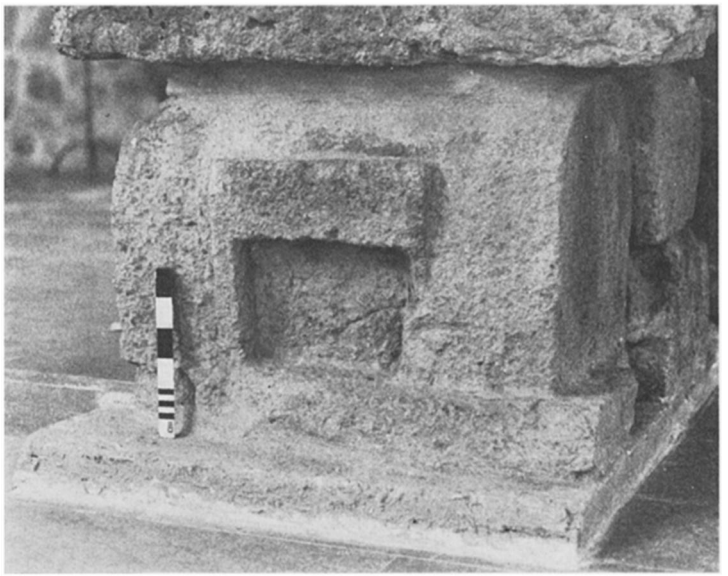


(4)

(1) GRAVE A27 CUT THROUGH THE SIDE OF GRAVE A25. NOTE THE WELL DEFINED *LOCULUS* OF THE FORMER GRAVE. (2) A TYPICAL PAIR OF ROBBED OUT BURIALS WITH THE BROKEN FRAGMENT OF A GOSSAN TOMBSTONE ALONGSIDE. (3) THE ROBBED FOUNDATION TRENCH OF THE LARGER TOWER TOMB ON THE SOUTH-WESTERN SIDE OF THE DEHESA CEMETERY. NOTE THE STEPPED FOUNDATION TRENCH AND THE OUTER RETAINING WALL. (4) TWO TOMBSTONES INCORPORATED IN THE ALTAR OF THE NEW CHURCH, RIOTINTO.

of water-driven crushing machinery, as attested at the Dolaucothi gold mine, for instance, could not occur. Instead the extraction of ore from the *matrix* involved was at a relatively primitive level. Several examples of pounders and mortars were recovered from the edge of the Corta Lago workings and further examples occurred on the edge of Corta Dehesa. All the evidence so far obtainable confirms the conclusions emphasized by Blanco and Luzón [20] for the pre-Roman period, that smelting was conducted throughout antiquity in relatively small furnaces. The debate about the actual processes in gold, and more especially silver and copper extraction, is still far from settled; its scientific nature renders it outside the scope of this article. Moreover, it is shortly to be the subject of a separate study by Professor R. H. Tylecote, who conducted experiments with an experimental furnace at Riotinto in 1975. It is, however, worth expanding slightly on Blazquez's excellent summary of the mining installations recorded in the adits by noting certain aspects of the ancillary industries that supplied the mines. Intriguingly, one of the commonest finds from the Corta Lago settlement is that of loom weights, but weights with a difference in that they are substantially bigger than normal textile loomweights. The reason is that they were principally used in the production of ropes, an essential commodity in the mining process. The production of specialist ceramics is also attested in a variety of ways. Refractory bricks were produced, again in slightly differing sizes. One highly unusual find comprised the nozzle of a double tuyere, implying a relatively developed form of bellows.

On the ceramic side the demand for mining lamps must have been great. The overall similarity of the majority of the lamps points to a single source of local production and the stamps indicate that the main producer was L.I.R., Lucius Iulius Reburrinus, whose tombstone was recently found at the Dehesa cemetery.[21] Other stamps on a very similar basal layout read C.T.M., but these are very much in the minority. The spread of the coarse pottery industry is further shown by the development of a local *mortarium* production. Four of the five fabrics appear to derive from the same source and at the same time can be correlated with one of the principal lamp fabrics. The demand for better-class wares was met by the import of *terra sigillata*, further analysed in Appendix A.

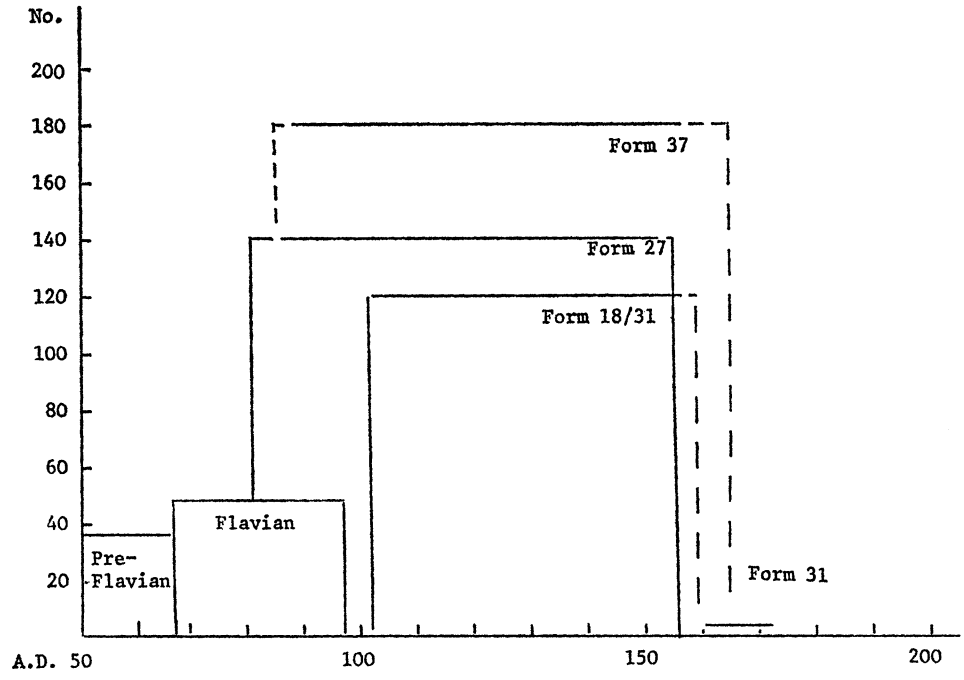
The interest of these finer wares is twofold. In the first place it enables us to see the proportion of the market (*c.* 8 per cent) won by the producers of imitation samian, *terra sigillata Hispanica*, from the production centres around Jaën further east along the valley of the Guadalquivir.[22] Although comparable in fabric quality with normal samian, *terra sigillata Hispanica* achieved a relatively low penetration of this part of the Baetican market, despite the shortness of the supply route from the source of manufacture. This must reflect the success of the marketing techniques of the parent industry and sets the apparent failure of the attempted Romano-British samian industry into context. More important perhaps is the way in which the samian evidence allows us to determine the lifespan of the Corta Lago settlement. The histogram shown as Fig. 6, b, represents an analysis of the samian recovered largely from the bulldozed levels of the settlement. It shows that the site was principally active from the Flavian period to the third quarter of the second century. The starting date, of course, tallies neatly with the evidence for the development of the Dehesa cemetery. Yet it is the abrupt end of the life-cycle of the site that is of particular interest. The histogram shows a steep decline in the presence of samian after A.D. 160–70 and after that there is very little evidence of the presence of later types. In particular the near absence of Form 31, the commonest form of the late Antonine period, is significant. Unless this represents abrupt changes in the character or efficiency of the samian industry (and there appears to be no evidence for this), then the downturn must be reflected in a steep decline in the Corta Lago mining settlement itself at the time.

As the following pages suggest, this is in fact confirmed by a limited amount of pottery recovered from the stratigraphic sequence revealed in the Corta Lago section (Fig. 4), and it may be argued that the production of Riotinto was heavily affected by the Moorish invasions of Baetica and parts of Lusitania under Marcus Aurelius. This is not to say,

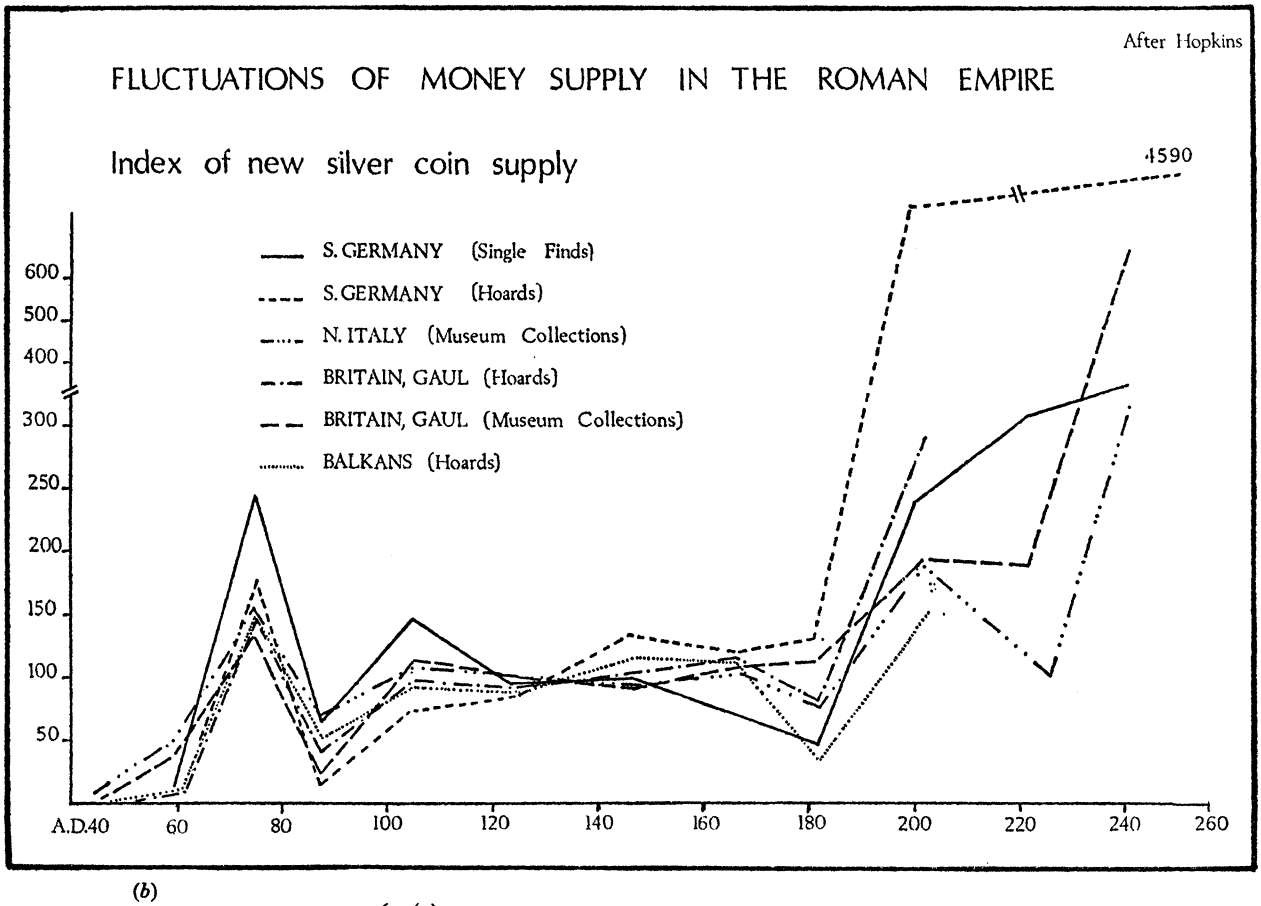
[20] See n. 14.

[21] J. M. Luzón, op. cit. (n. 16), 299; cf. Luzón and D. Ruiz, 'El Poblado Minero romano de Rio Tinto', *Habis* 1 (1970).

[22] M. A. Mezquiriz, *Terra Sigillata Hispanica* (1961); M. Soto-Major, 'Andujar (Jaën), Centro de Producción y Explotación de Sigillata', *Noticiario Arqueológico Hispánico* 1 (1972), 263 ff.



(*a*)



(*b*)

FIG. 6. (*a*) HISTOGRAM OF DATED TERRA SIGILLATA FORMS.
(*b*) EVIDENCE FOR FLUCTUATIONS OF MONEY SUPPLY.

of course, that the mine collapsed completely. Although, for example, Septimius Severus took repressive measures against parts of the Spanish provinces, it would have been nonsensical to shut down the largest mineral-producing centre in Andalusia. Likewise there is evidence of late occupation from Rua Figueroa's list of coins recovered from Riotinto but, from what evidence there is, it appears that most of the late examples derive from the south-eastern corner of the mining area. The growth of the huge Corta Lago mining settlement was a phenomenon of the Flavian-Antonine periods. It became the largest mining settlement of the complex, clearly indicating the main focus of early and middle imperial mineral extraction. The sudden collapse of the mining settlement arguably making the largest bullion contribution from the western Empire must, it is argued on the following pages, have made a recognizable impact on the pattern of coin production in the period concerned.

(*f*) *Historical Implications: Riotinto and the Bullion Supply*

The previous sections complete an initial analysis of possibly the most important source of bullion in the early Empire. It would be difficult to believe that the fortunes of Riotinto were not in some way mirrored in the production of silver coinage by the state. A number of points seem to be significant and merit further consideration by numismatists who normally have to work in a vacuum in which evidence for the raw supply of metal is unavailable. As we have seen, the very substantial evidence available from the Corta Lago workings during the Roman period carries a clear chronological message. The evidence from the half-kilometre area of clearance down to bedrock provides a statistical sample which is set out in histogram form in Fig. 6, b and shows a very marked drop in the presence of samian, whether the usual fabrics or *terra sigillata Hispanica*, in the third quarter of the second century. The paucity of late types confirms that this is unlikely to be simply a reflection of the production patterns of the samian industry itself. This evidence should therefore most logically reflect the history of Riotinto and is further confirmed by two other pieces of evidence. In the first place the life of the Dehesa cemetery does not extend as far as the end of the second century, although the extent of grave robbing makes the terminus uncertain; far more specific is the evidence from the Corta Lago section outlined on the previous pages. As Fig. 4 shows, the settlement levels which could be paralleled at most points along the face are truncated at the level of houses that produced material, in the form of African red slipped ware, from the period *c.* A.D. 170–80. Above the houses there is no further indication of settlement and, although it would perhaps be possible to argue for a substantial transfer of settlement, this is a difficult and illogical argument because the mineral source below the settlement was not worked out. Moreover the super-incumbent stratigraphy comprised sedimentary deposits formed over the demolished buildings, a clear implication that the mine and its production was greatly reduced, if not altogether halted. Inevitably, therefore, one looks for some major reason, or reasons, for this fundamental change in the exploitation of the site.

Exhaustion of the timber supply to produce charcoal for smelting must always be borne in mind,[23] but there is considerable evidence of another kind to suggest great

[23] Wood supply, either as timber or charcoal, was a major issue in any kind of mining on the scale of Riotinto and it is unfortunate that there is no reliable comparative material from which to work, although some comparative evidence can be deduced from sixteenth and seventeenth century mining in the Harz Mountains of Saxony. Whilst timber was obviously required for pit props, drainage wheels (on which see most recently G. Weisberger, 'Das römische Wasserheberad aus Rio Tinto in Spanien im British Museum London', *Zeitschrift für Kunst und Kultur im Bergbau* 2–3 (1979), 37 ff.) and timber buildings, the greatest demand must have been for charcoal. J. C. Allan (op. cit. (n. 12)) has argued that fifty tons of silver slag produced each day would have required about two acres to be cut each day. If this approximation is accepted as realistic, then allowing slightly over one hundred trees to the acre, roughly 730 acres would be consumed each year to supply charcoal. A forty-year regrowth cycle would therefore assume the cutting of over 29,000 acres, or about 44 square miles, i.e. a plantation of less than seven by seven miles (L. U. Salkeld, op. cit. (n. 12), 94). Against these rough estimates, however, several imponderables have to be weighed. The lightness of charcoal allows considerable quantities to be imported from a distance on horseback. Whole trees need not necessarily be destroyed in the charcoal-making process. We have very little idea of the forest cover in antiquity; Strabo III. 3. 3 mentions 'lofty trees' south of the Baetis, whereas the present countryside around Riotinto is relatively denuded of larger trees (save in recent afforestation), but contains extensive patches of scrub woodland.

I am grateful for discussion with J. S. Bromwich and S. J. S. Hughes on these and related points.

disturbance and a loss of Roman administrative control over areas of southern Spain and some adjacent regions in the 170s. In A.D. 171 there was a Moorish invasion of Baetica and parts of other Spanish provinces. In the circumstances Septimius Severus (who had gone to Africa to settle his father's affairs) found himself transferred from the quaestorship of Baetica to that of Sardinia.[24] Clearly under the circumstances there was much adjustment of the civilian administration to cope with the insurgents,[25] and C. Aufidius Victorinus was placed in charge of a twin command combining Baetica and Hispania Citerior.[26] Further indications of these *ad hoc* arrangements derive from the *cursus* of P. Cornelius Anullinus who was proconsul of Baetica and legate of VII Gemina,[27] as well as L. Iulius Vehilius Gratus Iulianus who was placed in charge of a vexillation fighting the Moorish insurgents.[28] The involvement of the former can be dated to the early 170s, and a literary reference to the latter half of the decade, claiming success against the insurgents, implies that by that stage the south-eastern troubles were particularly affecting Lusitania,[29] on the borders of which Riotinto was situated. This receives graphic support from an inscription relating, it is now known, to events datable to *c.* A.D. 177, when C. Vallius Maximianus relieved the town of Singilia Barba from *diutina obsidione et bello Maurorum.*[30] It goes without saying, of course, both that a walled town presented insurgents with a far greater problem than an exposed mining site and that Riotinto as the known source of gold and silver, as well as copper, was a natural focus for Moorish attention. Indeed, a second inscription relating to Maximianus, from Italica north of Seville, suggests that the area of the city was involved in fighting at this stage.[31] In view of the dating evidence from Corta Lago, with its hiatus towards the end of the third quarter of the second century, there is a strong possibility that production at the Riotinto mine was seriously interrupted. Furthermore, a mining settlement with a large disaffected slave labour force would be a natural focus of unrest; although the Spartacus-like revolt of Maternus under Commodus may not have affected areas this far south in Spain, his insurrection seems to have been led by disaffected slaves.

If this suggestion were correct, then it should be possible to corroborate it by an assessment of the numismatic evidence for the period of Marcus Aurelius in comparison with that of Commodus. Attention has normally been focused on the changes in coin production under Septimius Severus, notably the debasement of the *denarius* and a severe decrease in the production of all bronze denominations. These changes have been seen as reflecting the impact of the Civil Wars of A.D. 193–7 and deliberate policy stemming from hostility to the senate and its fiscal rôle.[32] The latter suggestion in particular reflects a highly centrist view of monetary policy and it is also worth considering the possibility that debasement of coinage does not necessarily coincide with increased coin production, an assumption that historians and numismatists tend to make. The picture may be far more complicated than that and greater attention should surely be paid to bullion supplies, particularly when probably the major source in the western Empire is involved. On a lesser scale, for instance, the end of military control at the British gold mine at Dolaucothi can now be dated to the Trajanic period, precisely the time when the far greater bullion resources of Dacia were first being tapped.[33]

Although the issues are far from simple, the case for arguing that disruption at Riotinto had a recognizable effect on coin production bears examination. Once this is accepted as a possibility, our concentration with hindsight on the radical changes of the Severan regime

[24] *HA, M. Antoninus* 21. 1; *HA, Septimius Severus* 2. 4. For a full review of previous literature and an assessment, cf. H. G. Pflaum, *Carrières procuratoriennes* (1960–1), no. 221.

[25] *HA, M. Antoninus* 22. 9.

[26] G. Alföldy, *Fasti Hispanienses* (1969), 38 ff.

[27] *ILS* 1139; cf. G. Alföldy, op. cit., 122.

[28] *ILS* 1327, reviewed by Pflaum, op. cit., no. 180.

[29] *HA, M. Antoninus* 22. 11. This area would have included the *Vispasca* (Aljustrel) mines in south-eastern Portugal. Reference there in an inscription to a *restitutor metallorum*, apparently dating to this period or shortly after, may be related to this period of instability and the present argument, see J. M. Blazquez, *Hispania desde el Año 138 al 235* (1974), 7.

[30] Inscription now at Antequera (Baetica) near the valley of the Genil (*Singilis*), a tributary of the Guadalquivir; *ILS* 1354a, the date of the procuratorship previously thought to be Severan can now be shown by new evidence from Morocco to date to A.D. 177, cf. Pflaum, *Carrières procuratoriennes* III, 985, no. 221.

[31] *ILS* 1354.

[32] H. Mattingly, *BMCRE* v, xxii.

[33] G. D. B. Jones and J. H. Little, 'Excavations at Pumpsaint', *Carmarthenshire Ant.* 9 (1973), 3 ff.; 10 (1974), 3 ff.

has perhaps rather masked the fact that the reign of Commodus displays changes in coin production that anticipate some of the modifications better known under Severus. As stated, there are at least two issues involved, the debasement of the metal content and the volume of coinage produced. The latter, as recent discussion suggests, fell substantially, for whatever reason, under Commodus,[34] as shown in the accompanying graph (Fig. 7). In Germany and Britain recorded Commodan *denarii* show drops of 65 per cent and 50 per cent respectively from previous levels. In Italy and France, where the effects of hoarding are included in the calculations, the figure is slightly lower at 47 per cent. Nonetheless the sudden drop is clear; the interpretation less so. The mint only produced in new coin each year a fraction of what the Emperor needed to disburse; this in turn must have been largely determined by fiscal needs, notably payment of the army, with debasement the effect of prolonged shortage of silver. Shortage of silver from a normally prolific mine might lead to the retention of old coinage in circulation for longer than usual, instead of its being melted down and re-struck. Longer term interruption of silver supply might lead to debasement. The issue is clearly complex.

The fall in the number of *denarii* produced by approximately half was hardly the result of chance. Centrist arguments might be broadened, indeed inverted, to consider the sources of silver bullion. At Riotinto there is strong evidence to link the Moorish incursions of the 170s with a breakdown in silver and copper production that had drastic effects, notably on the production of silver coinage throughout the 180s. Can such effects be deduced from the history of a single mine, albeit probably the largest in antiquity? Concentration on the decline of Riotinto should not obscure its expansion in the Flavian period. The samian histograms, notably the very low percentage of Form 29, also demonstrate the rapid development of the site in the last quarter of the first century, when it is generally agreed that Vespasian greatly increased the issue of silver coinage. And, if Riotinto declined as sharply as suggested, one must also ask whether this decline is mirrored by development elsewhere, to make good the shortfall and support the expansion of silver coinage under Severus and his immediate successors. Unfortunately none of the evidence currently available from the Dacian mines, which appear to relate primarily to gold production, or from the argentiferous lead mines of Britain lends itself to this kind of historical precision. What is remarkable occurs in Spain, and apparently in another metal, gold. The mines along the Rio Duerna lay, like the other mines of Asturias, under the control of the procurator at Astorga, backed by the presence of a legion nearby at Léon. Epigraphic evidence from Astorga has recently been joined by archaeological evidence from mining settlements along the Duerna valley to show that *c.* A.D. 180 the mines underwent a sudden, renewed burst of activity.[35] Was this a response to events in southern Spain? And was gold bullion replacing silver? These intriguing questions show not only the need for further consideration by numismatists of metal supply at the provincial level but also more archaeological analysis of the historical development of key mines throughout the Empire.

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[34] I am grateful to Professor K. Hopkins for permission to reproduce his graph. For a recent study of the problem see D. R. Walker, *The metrology of the Roman silver coinage* I. *From Augustus to Domitian* (B.A.R. suppl. series, 5) (1976). The following discussion has benefited greatly from the advice of Mr. M. H. Crawford, Dr. R. Reece and Mr. J. A. Sharples.

[35] For the Rio Duerna mines see D. G. Bird and R. F. J. Jones, 'Roman Mines in North-West Spain II: the Rio Duerna', *JRS* 62 (1972), 59 ff., esp. 74. The epigraphic evidence is further discussed by the latter author → 'The Roman Military Occupation of North-West Spain', *JRS* 66 (1976), 45 ff., particularly inscriptions from Villalis and Luyego in the Rio Duerna; at the latter, higher up the valley, activity is attested in June 181 (*AE* 1967, 230). The epigraphic evidence now appears to be very well supported by the recent excavations at La Corona de Quintanilla and Huerna, both mining settlements along the Duerna, see C. Domergue and T. Martin, *Minas de Oro Romanas de la Provincia de León* I (Excavaciones Arqueológicas en España, 93) and C. Domergue and P. Sillieres, *Minas de Oro Romanas de la Provincia de León* II (Excavaciones Arqueológicas en España, 94). Both sites show second-century occupation but in the latter case the evidence for a fresh burst of operations in the last quarter of the second century is particularly clear from both numismatic and samian evidence (p. 19).

APPENDIX A

Terra sigillata

Form	Number	Percentage
20	1	0·2
24/25	35	5·9
27	139	23·5
29	7	1·2
18/31R	11	1·8
18/31	111	18·7
18	24	4·1
30	3	0·5
15/17	41	6·9
37	132	22·2
37R	2	0·3
Ritterling 13	1	0·2
35	10	1·7
34	2	0·3
31	1	0·2
33	5	0·6
36	8	1·3
78	1	0·2
85	1	0·2
Unidentified	10	1·7
Total	593	91·7%

Terra sigillata Hispanica

Form	Number	Percentage
Jug. 68	1	0·2
37	34	5·8
Jug. 67	2	0·3
M.37·3	1	0·2
15/17	1	0·2
Ritterling 8	1	0·2
29	4	0·7
DR. 20	1	0·2
Hermet 13	1	0.2
Unidentified	2	0·3
Total	48	8·3%

The material is now deposited in Huelva Museum

APPENDIX B: TABLE ANALYSING THE 1890 SURVEY OF ANCIENT SLAG HEAPS SURVIVING AT RIOTINTO

Metric tons of visible slag	Reference No.	Gold per ton	Silver per ton			Copper %	Lead %	Slag
		grains	oz	dwt	grs			
49,410	1	·3 5	1	15	0	0·16	0·42	Ag
108,000	2	·376	2	0	4	0·15	0·56	Ag
288,000	3	·376	2	4	0	0·15	0·48	Ag
1,411,000	4	·3 5	1	13	14	0·15	0·36	Ag
1,080,000	5	·376	2	3	9	0·16	0·47	Ag
2,004,480	6	·3 5	2	13	0	0·12	0·52	Ag
693,900	7	·2 3	1	10	0	0·10	0·56	Ag
3,388,500	8	·2 3	1	13	5	0·12	0·40	Ag
1,512,000	9	·2 3	1	14	9	0·12	0·23	Ag
388,800	10	·2 3	1	17	19	0·21	0·10	Ag
89,280	11	trace	0	2	9	0·63	trace	Cu
230,400	12	trace	0	3	22	0·53	trace	Cu
370,440	13	trace	0	3	16	0·75	trace	Cu
316,800	14	trace	0	1	22	0·90	trace	Cu
50,040	15	·3 5	1	14	9	0·15	0·16	Ag
748,800	16	·24 4	3	1	0	0·18		Ag
1,209,600	17	·24 4	1	17	10	0·21		Ag
1,110,600	18	·3 5	1	12	10	0·07		Ag
1,260,000	19	·2 3	1	4	10	0·07		Ag
200	20	trace	0	2	0	0·77		Cu
16,000,000 total			15,303,130 total			1,007,120 total		