

MINING IN THE LATER ROMAN EMPIRE AND BEYOND: CONTINUITY OR DISRUPTION?*

By J. C. EDMONDSON

One of the more tangible benefits that accrued to Rome from the conquest of an empire was the acquisition of significant mineral resources, significant because Italy, although rich in iron, could not provide a sufficient supply of the whole range of metals needed by the Roman state for coinage and by members of the élite for the luxury artefacts that helped to enhance their social status. Once Rome had gained control over metalliferous regions of the Mediterranean, Romans, and especially Italians, were not slow to become involved in mining overseas, while the state came to gain considerable revenue from the leasing of contracts for the right to exploit state-owned mineral resources. Recent archaeological work has done much to improve our understanding of the techniques of mining and processing of raw metals, while the study of ingots (found mainly in shipwrecks) has allowed some insight to be gained not only into ways in which metals were transported, but especially into the modes of administrative control of metal production.¹ Interest in general has centred on mining in the late Republic and early Empire; very little attention has been paid to its later history during either the later Roman Empire or the early medieval period.² Yet the need for metals of all types was just as, if not more, pressing during the late Empire. At all times iron remained the metal most in demand—for arms and armour, constructional and agricultural tools and building materials such as nails, hinges and fittings. Fortunately it was found in many parts of the Empire, usually in sufficient quantities to allow something approaching regional self-sufficiency.³ There were some large-scale iron-mining districts (for example, the Kentish Weald or, still more, in Noricum); these produced a considerable surplus to supply the Roman army. But more typically, iron was exploited on a much smaller scale, sometimes even at a domestic level of production.⁴ Since its supply was rarely problematic, iron will largely be excluded from the following discussion. Attention instead will focus on the precious metals, gold and silver, and, to a lesser extent, on copper and tin. These metals could only be obtained in certain regions of the Empire, and so greater official concern over their supply and closer central control over their production were necessary.

Gold, silver, copper and tin were the main metals required for coinage throughout the Roman period, with a greater emphasis on gold from the time of Constantine, when the coinage came to be centred on the gold *solidus*.⁵ Not all coins were minted from freshly-mined metal: many old coins were returned to the treasury in payment of taxes and were melted down to provide bullion for new issues.⁶ Furthermore, Constantine obtained unusual windfalls of gold not only when he

* This is a revised version of a paper given at the Institute of Classical Studies, London; I am grateful to the audience on that occasion and subsequently to Michael Crawford and the Editorial Committee of the *Journal* for their comments.

¹ For a survey of evidence on mining techniques see J. F. Healy, *Mining and Metallurgy in the Greek and Roman world* (1978), ch. 4; for the administration of Republican silver mines: J. S. Richardson, 'The Spanish mines and the development of provincial taxation in the second century B.C.', *JRS* 66 (1976), 139–52; for ingots: C. Domergue, 'Les Planii et leur activité industrielle en Espagne sous la république', *Mél. de la Casa de Velázquez* 1 (1965), 9–27; id., 'Les lingots de plomb romains du musée archéologique de Cartagène et du musée naval de Madrid', *Archivo español de arqueología* 39 (1966), 41–72.

² By 'later Empire' I mean the period from the accession of Diocletian in 284 to the end of Roman administrative control over the western provinces at the start of the fifth century.

³ Plin., *NH* 34. 41. 142.

⁴ For Kentish Weald see H. Cleere and D. Crossley, *The Iron Industry of the Weald* (1985); for Noricum: S. Dušanić, 'Aspects of Roman mining in Noricum, Pannonia, Dalmatia and Moesia Superior', *ANRW* II. 6 (1977), 52–94; for self-sufficiency: R. Hodges, 'The beginnings of the medieval iron industry in western Europe: craft specialization and the domestic mode of production' in *Medieval Iron in Society: papers presented at the symposium in Norberg, May 1985* (1985), 299–306, esp. 300–2.

⁵ M. H. Crawford, 'Finance, coinage and money from the Severans to Constantine', *ANRW* II. 2 (1975), 560–93, esp. 586 ff. for view that Diocletian stabilized the gold coinage by introducing the *solidus*, a reform for which Constantine is usually given the credit.

⁶ M. F. Hendy, *Studies in the Byzantine Monetary Economy, c. 300–1450* (1985), 386–97; A. H. M. Jones, *The Later Roman Empire: 284–602* (1964), 427–48 (for taxation and coinage), esp. 436.

gained control of his rivals' accumulated reserves, but especially when he confiscated treasures from the pagan temples.⁷ This gold was used to build, enlarge and adorn many Christian churches; in short, as Barnes has recently reiterated, it allowed Constantine to lay a solid foundation for the new Christian monarchy.⁸ But these sources of old metal may still not have been sufficient to mint the quantity of coins needed for the vastly increased state expenditure of the fourth century. The army and bureaucracy were much larger than under the Principate, while further gold was required to ensure the quiescence of the barbarians outside the frontiers of the Empire.⁹ Even though taxation in kind helped support some of this expenditure, the volume of coinage required was such that there must still have been a need for the mining of new metal in the late Empire.¹⁰ Indeed the very complexity of the bureaucratic structure of the office of the *comes sacrarum largitionum* (who controlled all aspects of revenue and expenditure in coin and precious metals) is evidence for the continued, centrally perceived concern over the flow of precious metals from the provinces to the imperial centre.¹¹

It is often assumed that there was a serious decline in mining productivity during the later Empire.¹² It is the aim of this paper to re-examine the various kinds of evidence (literary, legal, numismatic and archaeological) for mining, especially in Iberia, but also, to a lesser extent, in Gaul, Britain and the Balkans, to assess whether this supposed 'decline' was as serious as has been assumed. The results of recent archaeological work will, it is hoped, add a new dimension to the discussion. It will be suggested that mining did not cease, but that it underwent a restructuring or reorganization of production. Such a restructuring seems consistent with an overall decline in centrally controlled large-scale mining, but it also indicates that mining on a smaller scale still had a role to play within the local economies of the Empire. Evidence from later, better documented mining operations (especially in Spanish America) will be introduced to suggest possible reasons for such changes in Roman mining. Conclusions reached here on mining may also help to contribute to the more general debate as to the nature and scale of economic change in the later Empire. In the final section the chronological limits of the discussion will be extended, to allow some brief comments on the impact of the Germanic invasions of the fifth century on mining in Iberia and Gaul. This in turn should throw some light on the extent to which the loss of Roman political control over the western provinces led to significant economic change.

I. THE SOURCES AND THEIR LIMITATIONS

The sources of information about ancient mining present special problems of interpretation, which need outlining at the outset.

1. *Literary sources*

Literary sources for mining are limited in the quantity and quality of the information they provide. The most useful information comes from a chronologically limited span, covering the late first century B.C. and the first A.D.: Strabo (e.g. 3. 2. 8–10; 4. 6. 12; 14. 5. 28) and the elder Pliny (e.g. *NH* 33 and 34), who as procurator of Hispania Tarraconensis had first-hand experience of the large-scale gold mining operations in north-west Spain.¹³ Thereafter, the literary evidence becomes very

⁷ Hendy, 284–5.

⁸ T. D. Barnes, *Constantine and Eusebius* (1981), 49, 258.

⁹ For the general background see Jones, op. cit. (n. 6), 411–69 (finance), 563–606 (civil service), 607–86 (army); for gold and silver see K. S. Painter, 'Gold and silver in the Roman world' in W. A. Oddy (ed.), *Aspects of Early Metallurgy* (1977), 135–58.

¹⁰ Jones, op. cit. (n. 6), 433; Hendy, op. cit. (n. 6) unfortunately does not discuss fresh sources of bullion for minting.

¹¹ See C. E. King, 'The *sacrae largitiones*, revenues, expenditure and the production of coin' in C. E. King (ed.), *Imperial Revenue, Expenditure and Monetary Policy in the fourth century A.D.* (BAR International Series 76) (1980), 141–73.

¹² For Spain, see, for example, J. Arce, *El último siglo de la España romana (284–409)* (1982), 118–19; 123–4.

¹³ For a collection of literary references to mining, organized geographically, see *RE* Suppl. IV (1924), 111–24, s.v. 'Bergbau'.

sparse. Late pagan poets, for example, allude to fluvial gold, but there are dangers in using this evidence uncritically. The river Tagus is described as 'gold-bearing' in the works of no fewer than twenty-two Latin authors ranging from Catullus to Boethius.¹⁴ There is no doubting that gold was extracted from the Tagus, since archaeological traces of Roman alluvial workings have been discovered.¹⁵ But references to this gold in poems written in 371, 379, 395, 404 and 416 by Claudian, Prudentius or Rutilius Namatianus are scarcely sufficient to prove, as some scholars have claimed, that gold was still being extracted from the Tagus at these dates.¹⁶ 'Gold-bearing Tagus' had clearly become nothing more than a literary *topos*; it is worthless as historical proof of gold-working. Early Christian writers provide some more useful hints on mining regions operational in the third and fourth centuries A.D., when they discuss the condemnation of Christians to hard labour in, for example, gold and silver mines in Numidia, copper mines in Cyprus and Palestine and mines of unspecified type in Cilicia.¹⁷ Otherwise, only occasional, incidental reference is made to mines and metals.¹⁸ It is, therefore, dangerous to argue from the relative silence of the literary sources that mines (especially in the West) were not being worked, since the literary evidence is so partial in its concerns and so heavily weighted in favour of the eastern part of the Empire. In short, the literary evidence is not very helpful and can often prove a deluding guide to the location, nature and scale of late Roman mining.

2. *Legal sources*

Certain regulations in the *Theodosian Code* relate to gold mining, most promulgated between 365 and 392, but one dated to 424.¹⁹ Furthermore, a certain amount of information on the economy of the early medieval period can be gleaned from the law codes of the Visigoths, Franks and Burgundians, who wrested control of much of Spain and Gaul in the early fifth century.²⁰ But information contained in legal codes needs careful handling, since law is essentially prescriptive rather than descriptive; not all regulations laid down in a code of law would necessarily have been put into effect.²¹ Thus it is rash to assert that gold mining took place in the later fourth century merely because of its mention in the *Theodosian Code*. However, at least we may infer that there was some official concern over the gold supply; the emperors were attempting to increase, or encourage, gold production, though we cannot assume that they achieved it; on the contrary, those laws which laid down penalties for harbouring runaway miners or that which tied the sons of miners to the profession of their fathers clearly show that their attempts were not totally successful.²²

3. *Archaeological evidence*

Archaeological evidence, on the other hand, may allow greater precision on a number of issues: first, on the exact locations of Roman mining, secondly, on the precise periods in which a particular mine was operating, and thirdly, on the range of minerals extracted from any given mine. There are, however, also problems of interpretation here. First, the geographical range of mining. Some parts of the Roman

¹⁴ F. J. Fernández Nieto, "'Aurifer Tagus'", *Zephyrus* 21-2 (1970-1), 245-59; the *topos* still occurs in later Spanish literature: e.g. in the Prologue to Cervantes, *The Adventures of Don Quixote* (1604-14), (tr. J. M. Cohen, Penguin ed.), 28-9.

¹⁵ J. C. Edmondson, *Two Industries in Roman Lusitania: Mining and Garum Production* (BAR International Series 362) (1987), figs 3.3, 3.4, 3.5 and Appendix I (for references).

¹⁶ J. M. Blázquez, *Historia económica de la Hispania romana* (1978), 246-7; followed by C. R. Whittaker, 'Inflation and the economy in the fourth century A.D.' in King (ed.), op. cit. (n. 11), 1-22, esp. 5.

¹⁷ F. Millar, 'Condemnation to hard labour in the Roman Empire, from the Julio-Claudians to Constantine', *PBSR* 52 (1984), 124-47, esp. 137-43.

¹⁸ See, for example, O. Davies, *Roman Mines in Europe* (1935), 148 for a Byzantine ship unloading corn at Exeter in return for a cargo of tin, reported by Leontius, *Life of St John the Eleemosynary* 9. 30-1, an allusion to the operation of tin mines, presumably in Cornwall, in the sixth century.

¹⁹ Especially *CTh* 10. 19; for mining procurators: *CTh* 1. 32. 5.

²⁰ For example, P. D. King, *Law and Society in the Visigothic Kingdom* (1972), esp. ch. 7.

²¹ See briefly J. A. Crook, *Law and Life of Rome, 90 B.C.-A.D. 212* (1967), 7-13.

²² Runaway miners: *CTh* 10. 19. 5, 6 (both of 369), 10. 19. 7 (of 370 or 373); sons of miners tied to the profession of their fathers: *CTh* 10. 19. 15 (of 424).

Empire have received much more archaeological attention than others; and so it is difficult to assess the relative importance of mining in one area as opposed to another. North-west Spain provides a case in point. In 1935 Davies listed forty-four Roman mines here; but intensive field survey has allowed a recent gazetteer, published in 1984, to list no fewer than 231.²³ Our overall picture of mining must, therefore, be treated as only partial and may need to be altered significantly in the light of further archaeological fieldwork.

Secondly, many Roman mines owe their discovery merely to the fact that they were reopened and reworked in the nineteenth and twentieth centuries. Those mines that were exhausted in the Roman period, and so have not merited reopening, stand little chance of discovery. This bias towards mines later reopened tends to encourage the discovery only of the larger Roman mines with large ore-bodies. This in turn has created a rather imbalanced impression of Roman mining, in which a few large-scale mines dominate, completely overshadowing smaller mines, which may well have been a more widespread mode of exploiting minerals in the ancient world than is usually assumed. Furthermore, mining tends to be studied from a Romanocentric point of view, with emphasis placed on those large mines which were economically important to the Roman state. But if mining were to be viewed more from a provincial perspective and an attempt made to assess its importance to the local, or provincial, economy, then the smaller mines would take on a greater significance.

Thirdly, sites of alluvial mining are much more difficult to locate archaeologically than underground hard-rock mines with their interconnecting shafts and galleries, which are more likely to leave visible traces for the archaeologist to discover. This factor again is likely to have distorted our impression of the pattern of Roman mining, which may often have been much more varied than appears from the surviving archaeological evidence. Thus a recent survey of Roman tin mines in Brittany revealed some alluvial workings, some hard-rock mines; in short, a mixed pattern of mining, marked by a variety in the type and size of the mining operation. But it was only as a result of intensive field survey that this suggestive pattern emerged.²⁴

Fourthly, although the recent reactivation of a mine has often revealed traces of Roman exploitation, this can be a mixed blessing; for it tends to remove vital evidence not only for the exact period of Roman mining at the site, but also for the scale of Roman operations. With modern technology, the rate of mining is now substantially greater than it was fifty years ago; the faster the rate of mining, the less chance there is of discovering ancient features.²⁵ As for the scale of Roman exploitation, surviving slag heaps may be a deluding guide, since slag has often been resmelted either in antiquity or more recently. Thus a certain amount of the evidence for Roman operations has been removed, which means that estimates of Roman levels of productivity based upon it tend to be on the low side.²⁶

Finally, very few mines provide any detailed evidence for the chronological development of mining. Thus in a recent catalogue of over one hundred Roman mines from the province of Lusitania, only thirteen provided any archaeological criterion for dating.²⁷ Furthermore, clearly datable artefacts are very rarely found in mines themselves; often the only evidence for dating consists of pottery or coins found in connected settlements or burial grounds.²⁸ But it does not necessarily follow that a mine was operational for exactly the same period as the connected settlement or cemetery.

²³ Davies, *op. cit.* (n. 18), map II; D. G. Bird, 'Pliny and the gold mines of the north-west of the Iberian peninsula' in T. F. C. Blagg, R. F. J. Jones and S. J. Keay (eds), *Papers in Iberian Archaeology* (BAR International Series 193) (1984), I, 341–68, esp. 354 f.

²⁴ P. Galliou, 'Mines et métaux de l'ouest de la Gaule' in *Mines et fonderies antiques de la Gaule* (Table ronde du CNRS, Toulouse, 1980) (1982), 21–32, esp. 23.

²⁵ G. D. B. Jones, 'Roman mines at Rio Tinto', *JRS* 70 (1980), 146–65, esp. 158.

²⁶ For resmelting of silver and copper slag see the *Lex Metallii Vipascensis* (*CIL* II, 5181 = *FIRA* I, 105),

II, 46–56; at the silver mines of Laurium in Attica slag from the fifth and fourth centuries B.C. was resmelted in the third and fourth centuries A.D.: C. E. Conophagos, *Le Laurium antique et la technique grecque de la production de l'argent* (1980), 124–5. For an analysis of some ancient slags see L. U. Salkield, 'Ancient slags of the south-west of the Iberian peninsula' in *La Minería hispana e ibero-americana* (VI Congreso internacional de Minería) (1970), 85–98.

²⁷ Edmondson, *op. cit.* (n. 15), 40–2 and Table 3. 6; Appendix I for catalogue of mines.

²⁸ For example, as at Rio Tinto: see n. 25.

Ideally more field surveys should be undertaken in mining zones, to provide more detailed and precise pictures of Roman mining. In addition, aerial photography could be used more widely in such field surveys.²⁹ It would also be useful if more Roman coins and metal artefacts could be analysed spectrographically; this would allow the sources of metals to be traced with greater precision.³⁰ But despite these limitations archaeology does provide the most promising kind of evidence for Roman mining, and this study will rely heavily on it.

II. THE HISTORICAL DEVELOPMENT OF MINING: THE IBERIAN PENINSULA

Under the Principate the Iberian peninsula constituted the most productive mining area of the Roman Empire. The full range of minerals was available, and exploited: gold, silver, copper, lead, tin, iron, mercury, cinnabar, sulphur and zinc.³¹ In this section the archaeological evidence for mining in three chosen zones will be considered selectively, but in some detail, in an attempt to assess the historical development of mining in the later Empire. In particular I hope to establish, first, whether, and to what extent, mining declined, and, secondly, whether the way in which the mining was organized changed between the Principate and the late Empire. The history of mining in the post-Roman period in Iberia will be considered in the final section of this paper.

1. *Gold Mining in the North-west*

The north-west of the Iberian peninsula (Gallaecia and Asturia) was one of the richest gold fields known to the Romans, and its exploitation commenced soon after the final conquest of the area under Augustus. Gold was obtained in three different ways: from low-lying placer deposits of gold found in the silt or gravels of rivers, from higher-level alluvial terraces (where the gold-bearing gravels had been forced up from the bottom of the river valley into terraces by erosion) and from hard-rock mineral deposits of gold.³² Pliny talks of 20,000 lb. of gold accruing to the Roman state per year from Asturia, Gallaecia and Lusitania from alluvial terraces alone.³³ To this must be added gold obtained from hard-rock deposits and from placer-mining. According to a recent estimate one valley alone (the Duerna) produced 3,000 kg of gold per annum for 130 years; in total, it is estimated that the north-west provided approximately seven per cent of state revenue under the Flavians.³⁴ Pliny's mention of Lusitania is often overlooked, but serves to remind us of the substantial gold resources of the Tagus and its tributaries, which were administered fiscally as a separate unit from the mines of Asturia and Gallaecia, possibly under a special procurator.³⁵ The gold mines of the north-west were controlled by a special equestrian procurator of Asturia and Gallaecia, who was assisted by various imperial

²⁹ See, for example, C. Domergue and G. Hérail, 'L'utilisation de la photographie aérienne oblique en archéologie et géomorphologie minière: les mines d'or du nord-ouest de l'Espagne' in A. Bazzana and A. Humbert (eds), *Prospections aériennes: les paysages et leur histoire: cinq campagnes de la Casa de Velázquez en Espagne (1978-1982)* (1983), 89-103.

³⁰ See, for example, A. Hartmann, *Prähistorische Goldfunde aus Europa. Spektralanalytische Untersuchungen und deren Auswertung* (Studien zu den Anfängen der Metallurgie 3 and 5) (1970, 1982); for a brief introduction, D. Britton and E. E. Richards in D. Brothwell and E. Higgs (eds), *Science in Archaeology* (rev. ed., 1969), 603-13.

³¹ Blázquez, *op. cit.* (n. 16), 21-42, 85-98, 144-56, 242-52; *id.*, 'Fuentes literarias griegas y romanas referentes a las explotaciones mineras de la Hispania romana', in *La Minería hispana e iberoamericana* (1970), 117-50. We await with anticipation the publication of C. Domergue's valuable thesis, *Les mines de la*

península ibérique dans l'antiquité romaine (Université de Paris I, 1978).

³² For types see P. R. Lewis and G. D. B. Jones, 'Roman gold-mining in north-west Spain', *JRS* 60 (1970), 169-71, citing J. M. Maclaren, *Gold, its geological occurrence and geographical distribution* (1908).

³³ *NH* 33. 21. 78; for the *arrugia* technique of mining see C. Domergue, 'A propos de Pline, *Naturalis Historia*, 33, 70-78 et pour illustrer sa description des mines d'or romaines d'Espagne', *Archivo esp. de arqueología* 45-7 (1972-4), 499-528, esp. 506, 516-18.

³⁴ C. Domergue and G. Hérail, *Mines d'or romaines d'Espagne: le district de la Valduerna (León): étude géomorphologique et archéologique* (1978), 278.

³⁵ As yet there is no evidence for this post, but since no fewer than thirty-four mining sites have to date been discovered (see Edmondson, *op. cit.* (n. 15), Appendix 1), and since the silver and copper mines of Vipasca in the south of the province of Lusitania had their own procurator (e.g. *AE* 1933, 273), it seems a reasonable hypothesis.

freedmen *procuratores metallorum*, and a sizeable military contingent.³⁶ In other words, the mining of this region was too extensive to be supervised *inter alia* by the procurator of Hispania Tarraconensis, in whose province the region lay. Mining in this area was clearly large-scale in two senses: first, in the sense that certain mining sites were themselves large and required a complex organization of production;³⁷ and secondly, in the sense that the whole area, which included some large mines, but also many smaller operations, was organized fiscally as one large unit.

In general the period of greatest production was from the mid-first century A.D. to the start of the third century, as recent excavations and field survey in the Duerna valley and at El Caurel suggest.³⁸ Similarly, gold mines in northern Portugal (for example, Trêsminas and Jales) came into operation in the Augustan period, but the earliest pottery forms found in any abundance date to the third quarter of the first century A.D.; evidence is lacking for any exploitation after the start of the third century.³⁹ The phasing out of the procuratorship of Asturia and Gallaecia at the start of the third century is seen as further confirmation of a decline in mining productivity.⁴⁰ Thus, the consensus of scholarly opinion is that mining had effectively ceased by the mid-third century. However, excavations at some smaller sites, since they were conducted with a view to establishing a careful stratigraphy, provide more precise information on the historical development of Roman mining. It is worth briefly summarizing the evidence for two sites, Huerna⁴¹ and Corona de Quintanilla.⁴²

The mining settlement at Huerna reveals two main phases of occupation. The first ran from c. A.D. 45/50 to 70/5. Since its foundation date is too late for an indigenous hill-fort, the excavators conclude that Huerna must have been a settlement for indigenous people transplanted hither to work the mines. After a period of abandonment in the area excavated (although reference is made to the construction of new houses elsewhere in the settlement), a second phase of occupation ran from 150/60 until 190/200. The discovery of a hypocaust and the overall nature of the finds suggest a much more Romanized settlement; this has suggested that the site might have been the base of a Roman military unit involved in the local mining. But what precludes the hypothesis that this was still a native settlement for miners, by now more Romanized than their predecessors in the first century?

The settlement at Corona de Quintanilla, isolated and hence fortified by means of double ditches, has also revealed two phases of occupation. The first ran from A.D. 15/20 to 70, when the essentially local pottery types and the lack of imported wares and luxury items suggest a generally low level of prosperity. The excavators again suggest that this site was occupied by a group of natives, transplanted hither to work in the alluvial mining nearby. Again after a period of abandonment there was a second phase, dated to the fourth century and marked by the reconstruction of some houses; on the whole, little material was found in this second phase, suggesting resettlement only on a small scale. Four other similar types of settlement have been identified in the vicinity, with what little material discovered suggesting that they were occupied only in the first century A.D.

The small-scale and short-lived nature of these settlements suggests that it is imprecise to talk too loosely of a 'mining district', if by that term we imagine a large-

³⁶ For administration see A. Tranoy, *La Galice romaine: recherches sur le nord-ouest de la péninsule ibérique* (1981), 178–89; for military presence R. F. J. Jones, 'The Roman military occupation of north-west Spain', *JRS* 66 (1976), 45–66, esp. 60–2.

³⁷ As, for example, at Las Medulas in the Sil valley, with its three aqueduct systems, which brought sufficient water (estimated at c. 34 million litres per day) from a distance of at least twenty kilometres for the flushing of the ore from rock deposits: see Lewis and Jones, art. cit. (n. 32), 174–6, fig. 25 and pl. xx; more generally, C. Domergue, 'L'eau dans les mines d'or romaines du nord-ouest de l'Espagne' in P. Louis (ed.), *L'homme et l'eau en Méditerranée et au Proche Orient*. III. *L'eau dans les techniques* (Travaux de la Maison de l'Orient 11) (1986), 109–19.

³⁸ For the Duerna valley see n. 34; for El Caurel: J. M. Luzón Nogue and F. J. Sánchez Palencia, *El Caurel* (Exc. arq. en España 110) (1980).

³⁹ C. A. Ferreira de Almeida, 'Aspectos de mineração romana de ouro em Jales e Trêsminas (Tras-os-Montes)' in *XII Congresso Nacional de Arqueologia, Jaén, 1971* (1973), 553–62.

⁴⁰ C. Domergue, 'Introduction à l'étude des mines d'or dans le nord-ouest de la péninsule ibérique' in *Legio VII Gemina* (1970), 255–86, esp. 279; cf. Tranoy, op. cit. (n. 36), 184.

⁴¹ C. Domergue and T. Martin, *Minas de oro de la provincia de León*. II (Exc. arq. en España 94) (1977).

⁴² C. Domergue and P. Sillères, *Minas de oro romanas de la provincia de León*. I. *La Corona de Quintanilla* (Exc. arq. en España 93) (1977).

scale operation centred in one particular area. Attention is attracted to the large mines and impressive large-scale alluvial workings (e.g. Las Medulas), but the contribution of smaller units of production, consisting of groups of miners operating a small open-cast working or even just panning for gold, should not be ignored. Gold mining in the north-west was scattered over a number of different locations, and marked by a diversity of modes of production. This mixed pattern of mining may have been similar to that found in the tin-mining region of Roman Brittany or that which prevailed in nineteenth-century tin and copper mining in Cornwall and Devon.⁴³

But the archaeological evidence for settlement in mining zones in the fourth century is also overlooked, as at Corona de la Quintanilla, or as with the isolated finds of late Roman coins in settlements near mines (for example, those of Constantine from Poço dos Romanos, Valongo, northern Portugal).⁴⁴ The natural hypothesis would be that the mines were still in operation, even if at a reduced scale from that of the early Empire.⁴⁵ Furthermore, Corona de Quintanilla is just one example of the reoccupation of sites known as 'mesas' in the north-west. There is, however, enormous controversy over the exact nature of these 'mesas': were they just settlement sites or did they form part of the mining techniques?⁴⁶ Even if they are just settlements, their reoccupation would suggest some mining in the locality in the fourth century, since there was very little other economic reason for settlement here. Thus they possibly provide evidence for some small-scale prospecting, as a response to the emperors' efforts to encourage gold mining in the second half of the fourth century.⁴⁷

2. *Silver and Copper Mining in the Iberian Pyrites Zone*

This mining zone had come into the Roman sphere of interest a hundred years before the gold mines of the north-west, but its exploitation during the late Republic tends to get overlooked in favour of the New Carthage silver mines prominent in the literary sources.⁴⁸

First, Rio Tinto. Pottery finds suggest that these silver, copper and, possibly, gold mines were most active from the Flavian period to the third quarter of the second century. A decline sets in after A.D. 160–70. This has been plausibly attributed to the Moorish invasions of the 170s, which caused the temporary loss of Roman administrative control over southern parts of Baetica and Lusitania.⁴⁹ But there is also some trace of later activity at Rio Tinto; a small settlement was constructed in the third century on the top of slag heaps, while an inscription dated to the early fourth century and some coins of Theodosius (379–95) and Honorius (395–425) have also been found.⁵⁰

The Tharsis copper, and possibly sulphur, mines were at their greatest extent of production under Trajan. They seem to have experienced problems in the third century, but coins dated to as late as 350 have been discovered. In this later period there is much fragmented evidence of Roman mineworking, but no record of continuous exploitation at any single working. The collapse of mining, however, seems not to have taken place until the Visigothic invasions, which caused such a break in production that the mines became flooded and drainage adits and galleries were irretrievably blocked.⁵¹

⁴³ For Brittany, see n. 24; for Cornwall and Devon: R. Samuel (ed.), *Miners, Quarrymen and Saltworkers* (1977), 17–18.

⁴⁴ D. F. de Almeida, 'Minas de ouro na Gallaecia portuguesa' in *Legio VII Gemina*, 287–301, esp. 290–1.

⁴⁵ But see the sceptical remarks of Arce, *op. cit.* (n. 12), 123.

⁴⁶ For their function in mining itself see Bird, *art. cit.* (n. 23), 353 ff.; cf. C. Domergue, 'Mines d'or romaines du nord-ouest de l'Espagne: Les "Coronas": technique d'exploitation ou habitats?', *ibid.*, 11, 370–83 (arguing that they were simply settlements).

⁴⁷ See above p. 86 and n. 22.

⁴⁸ Diod. Sic. 5. 36; Strabo 3. 2. 10; Richardson, *art. cit.* (n. 1). For Roman Republican coinhoards from silver mines see M. H. Crawford, *Roman Republican*

Coinhoards (1969), nos 186, 196 (Sierra Morena), 194 (Rio Tinto), 181 (El Centenillo).

⁴⁹ In general B. Rothenberg and A. Blanco Freijeiro, *Studies in Mining and Metallurgy in South-West Spain* (1981), 96–114; D. Avery, *Not on Queen Victoria's Birthday: the story of the Rio Tinto mines* (1974), 419–27 and, especially, Jones, *art. cit.* (n. 25).

⁵⁰ For settlement see J. M. Luzón Nogue and D. Ruiz Mata, 'El poblado minero de Riotinto', *Habis* 1 (1970), 125–38, esp. 136–7; for coins: Avery, *op. cit.* (n. 49), 427; for fifth-century pottery and coins: Rothenberg and Blanco Freijeiro, *op. cit.* (n. 49), 114; inscription: *CIL* 11, 957.

⁵¹ S. G. Checkland, *The Mines of Tharsis: Roman, French and British Enterprise in Spain* (1967), esp. 54–6.

Finally, Vipasca (modern Aljustrel, Portugal). These important silver, copper and, possibly, gold and iron mines, were worked in the Bronze Age and then from the second half of the second century B.C., with slag surviving in large quantity from the latter part of the first century B.C. onwards.⁵² Finds from an associated cemetery and the mining settlement can mostly be dated to the second and third centuries A.D., but there is some material from the first and fourth centuries.⁵³

3. *Tin Mining in Lusitania and Gallaecia*

The evidence for tin mining suggests that it was scattered at many different sites; there seems to have been nothing approaching a large-scale district.⁵⁴ Some mines were distinctly short-lived: for example, the valley of the Maçainhas (Castelo Branco, Portugal) was clearly worked by the Romans, since a 'substantial quantity' of Roman coins, all dated to the first half of the first century A.D., was dredged during renewed operations earlier this century. Once the valley was exhausted for the methods in use, attention seems to have shifted to other sites.⁵⁵ However, there is some indication that tin was still being extracted in this general region in the fourth century, since in this period a Roman military garrison reoccupied an abandoned Iron Age hill-fort at Las Merchanas (Lumbrales, Salamanca) and engaged in the smelting of tin, until the site was abandoned at the start of the fifth century during the Germanic invasions. That a Roman military presence was needed to supervise mining in the area seems a plausible hypothesis.⁵⁶

4. *Conclusion*

The conclusion to be drawn from the archaeological evidence is traditional, but seems consistent: namely that the apogee of large-scale mining of gold, silver and tin in the Iberian peninsula occurred during the first and second centuries A.D. Thereafter the mines do not seem to have operated on quite such the same scale; there was a decline in production. But what is often overlooked is that the mines did not go out of production altogether. There is evidence, no matter how scant, that at most of the larger sites some mining still took place in the later Empire, if only on a much reduced scale. Furthermore, the role of smaller mines with a relatively short working-span (i.e. less than fifty years) in the overall pattern of mining in both the early and the late Empire has consistently been ignored. Many smaller mines may well have operated in the later Empire, but because of their size and type they have left no archaeological trace of their exploitation. Thus not only the scale, but also the pattern of mining changed during the third century. Under the Principate a mixture of large- and small-scale mines had prevailed; but during the later Empire large mines as such were no longer feasible and so small-scale mining came to form the dominant mode of production.

III. OTHER SOURCES OF PRECIOUS METAL IN THE ROMAN EMPIRE

The Iberian peninsula was not the only source of metals for the Romans; and it does not follow that just because Iberian mines had undergone some transformation, mines in other parts of the Roman Empire also saw changes. Although Dacia, the next most important source of gold after north-west Spain, was lost to Rome in 270, evidence does exist for gold mining elsewhere in the Roman Empire.⁵⁷ The

⁵² In general see C. Domergue, *La mine antique d'Aljustrel (Portugal) et les tables de bronze de Vipasca* (1983).

⁵³ J. and A. Alarcão, 'O espólio da necrópole luso-romana de Valdoca (Aljustrel)', *Conimbriga* 5 (1966), 7-104; for settlement: R. Parreira, 'O salvamento arqueológico de Vipasca: nota preliminar sobre a campanha de escavações de 1981', *Arquivo de Beja*, série II, 1 (1984), 135-44.

⁵⁴ For refs. to Lusitanian tin mines see Edmondson,

op. cit. (n. 15), 223, 225-30, 236-41; for Galicia: Tranoy, op. cit. (n. 36), 220-1.

⁵⁵ J. C. Allan, *Considerations on the Antiquity of Mining in the Iberian peninsula* (1970), 28-9.

⁵⁶ Blázquez, op. cit. (n. 16), 245-6; J. Maluquer de Motes, 'Excavaciones arqueológicas en el castro de "Las Merchanas" (Lumbrales, Salamanca)', *Pyrenae* 4 (1968), 101-28.

⁵⁷ S. Mrozek, 'Die Goldbergwerke im römischen Dazien', *ANRW* II, 6 (1977), 95-109.

Theodosian Code refers to gold miners in the eastern part of the Empire (Illyricum, Macedonia, Thrace, Pontus and Asia) in the later fourth century.⁵⁸ It also contains regulations for the appointment of *procuratores metallorum* from among the curial class of Macedonia, inland Dacia, Moesia and Dardania,⁵⁹ and finally, it makes general reference to *metallarii* in Italy and Gaul.⁶⁰

Some confirmation of this legal evidence is provided by archaeology. First, the western Empire. In Britain the Dolaucothi gold mines were worked intensively from soon after the conquest under Claudius until the Antonine period, but numismatic evidence again suggests that some, if spasmodic, exploitation took place at least as late as the reign of Gratian (375–83).⁶¹ Some more precise information is available from Gaul. Roman coin hoards dated to the start of the fourth and the start of the fifth century have been found in settlements attached to gold mines of the Limousin. These mines were also still operational under the Merovingians.⁶²

As for the East, some mining also took place in regions famous for their metals in earlier periods. In the silver mining zone of the Laurium in Attica, late Roman mining lamps, datable to the fifth and sixth centuries, have been found in a mine at Thorikos; taken together with the evidence for the resmelting of slag, this suggests some mining activity in what had been a large and flourishing mining district. If anything, mining may well have restarted here, since during the reign of Augustus the mines were out of operation.⁶³ Roman material is also reported from the copper mines of Kandanos in western Crete and from the gold mines on Thasos, but again it does not allow any precise conclusions on exact chronology to be drawn.⁶⁴ As for the Balkans, Pliny talks of discoveries of gold in Dalmatia during the reign of Nero, while archaeological evidence exists for gold mining (both hard-rock and alluvial workings) in central Bosnia, but unfortunately does not provide any precise dating criteria. However, in western Bosnia numismatic evidence suggests that iron, lead and copper were exploited in the third and fourth centuries, while in eastern Bosnia the argentiferous lead mines of the Drina valley have provided epigraphic evidence for their continued operation in the later third century.⁶⁵ Thus Dalmatia is one area where mining (possibly including gold mining) continued into the later Roman Empire.

A final example is revealing not only of the general problems of mining in the later Roman Empire, but also of some possible responses to these problems. Large-scale exploitation of fluvial gold had taken place in Serbia in Roman Dalmatia from the reign of Hadrian; it had led to the growth of major settlements to support the mining operations, as often occurs in remote mining areas.⁶⁶ Mining seems to have ceased, however, during the political upheavals and Gothic invasions of the mid-third century, as is suggested by the discovery of two coin hoards, dated to the 230s and 240s. There was, however, some renaissance of gold mining in the fourth century, but on a much smaller scale, and at a different site: excavations have revealed gold mining and smelting at Kraku'lu Yordan, a small site surrounded by a fortification, eloquent testimony to the perceived threat of barbarian incursions in an area close to the frontier of the Empire. Its abandonment at the end of the fourth century has been

⁵⁸ *CTh* 10. 19. 7 of 370 or 373; 10. 19. 12 of 392.

⁵⁹ *CTh* 1. 32. 5 of 386.

⁶⁰ 10. 19. 9 of 378, advising the prefects of these two regions to arrest those miners who had escaped to Sardinia.

⁶¹ In general on Dolaucothi P. R. Lewis and G. D. B. Jones, 'The Dolaucothi gold mines. 1. The surface evidence', *Anty* 49 (1969), 244–72; for coins: G. C. Boon, 'Aperçu sur la production des métaux non ferreux dans la Bretagne romaine', *Apulum* 9 (1971), 453–503, esp. 502.

⁶² G. Tamain, 'L'or des Lemovices' in F. Braemer and G. Deicha (eds), *Les ressources minérales et l'histoire de leur exploitation (colloque à Grenoble, avril 1983)* (1986), 119–31, esp. 128.

⁶³ S. A. Butcher, 'Late Roman lamps in a mine

gallery in Thorikos', *MIGRA* 5 (1982), 137–48; for slag see n. 26; for lack of mining under Augustus: Strabo 9. 1. 23.

⁶⁴ Kandanos: I. F. Sanders, *Roman Crete: an archaeological survey and gazetteer of late Hellenistic, Roman and early Byzantine Crete* (1982), 33, 171; Thasos: J. de Courtills, T. Koželj and A. Müller, 'Des mines d'or à Thasos', *BCH* 106 (1982), 409–17, esp. 417. I owe this point to Simon Price.

⁶⁵ Plin., *NH* 33. 21. 67; M. Zaninović, 'The economy of Roman Dalmatia', *ANRW* II, 6 (1977), 767–809, esp. 796–8. The inscription is *CIL* III, 12736 of 274.

⁶⁶ As, for example, in later Spanish silver mining in Mexico: D. A. Brading, *Mines and Merchants in Bourbon Mexico 1763–1810* (1971), 7.

attributed to a fire, but was this fire the cause or the symptom of the end of operations here?⁶⁷

Thus, mining was still indeed practised in the later Roman Empire, but, I would suggest, under a different mode of exploitation. The operation of large-scale mining districts had for various reasons become impractical in a changed economic world.⁶⁸ Mining did not cease, but there was now more emphasis on smaller-scale exploitation, less directly controlled by the state. But, before discussing such structural changes in the organization of mining, I shall first consider some factors which help to explain the decline of large-scale mining districts.

IV. THE DECLINE OF LARGE MINING DISTRICTS

Comparative evidence from later, better-documented mining operations may help to suggest some reasons for the decline of larger Roman mining districts. The most relevant factors will be discussed under three headings: technological, socio-economic and socio-political.

1. *Technological factors*

(a) Ore exhaustion and the Law of Diminishing Returns

An obvious and immediate reason for the closure of a mine would have been the exhaustion of the ore-body. Thus in Colombia gold was obtained from alluvial workings along the river Cauca from 1576, but in 1685 production simply ceased and was transferred elsewhere because of the exhaustion of the ore-bearing gravels.⁶⁹ Similarly the gold mines of Mt Tmolus in Asia Minor were by the reign of Augustus exhausted of ore, while certain tin mines in Lusitania went out of production for this same reason.⁷⁰

But recent work on mining in south-west England and in Spanish America raises another connected factor that may also have caused the closure of Roman mines. In nineteenth-century Cornish and Devonian copper mining there were considerable technological drawbacks to the exploitation of the deeper veins of ore: it proved very difficult to dig deep enough shafts and then to keep them adequately ventilated and drained. As a result, the exploitation of deeper veins of ore was more labour intensive: one ton of open-cast copper could be produced by ten men, whereas the same amount of copper from deeper deposits required the labour of fifteen.⁷¹ Similarly in Spanish silver mining in Mexico and Peru something akin to the Law of Diminishing Returns clearly obtained. The higher grade ores existed nearer the surface, and were thus accessible by means of open-cast workings; these ores were also easier to smelt. Conversely, the deeper deposits were of lesser quality, were more difficult to extract and required significantly more mercury for their smelting by the process of amalgamation. Once mining shafts reached a certain depth, it was no longer economic to keep them in operation.⁷² Although it would be rash to credit the Romans with too sophisticated, modernist economic concepts, the 'Law of Diminishing Returns' seems simple enough to be applicable to Roman mining and may help to explain the decline of previously prosperous mines in the later Empire. Thus the large-scale Roman mining of silver in the Iberian Pyrites Belt would have initially been concerned with the higher quality, more accessible ores, as had certainly been the case in the pre-Roman mining operations.⁷³ Also for the extraction of gold, open-cast mining would

⁶⁷ M. R. Werner, 'The archaeological evidence for gold smelting at Kraku'lu Jordan, Yugoslavia, in the late Roman period' in P. T. Craddock and M. J. Hughes (eds), *Furnaces and Smelting Technology in Antiquity* (British Museum Occasional Paper 48) (1985), 219-27.

⁶⁸ See below, pp. 97-9.

⁶⁹ A. Twinam, *Miners, Merchants and Farmers in Colonial Colombia* (1982), 16-17.

⁷⁰ Mt Tmolus: Strabo 13. 1. 23; Lusitanian tin: see above, p. 91 and n. 54.

⁷¹ Samuel, op. cit. (n. 43), 34.

⁷² D. A. Brading and H. E. Cross, 'Colonial silver mining: Mexico and Peru', *Hispanic American Historical Review* 52 (1972), 545-79, esp. 554-5.

⁷³ A. Blanco Freijeiro and J. M. Luzón Nogue, 'Pre-Roman silver miners at Riotinto', *Antiquity* 43 (1969), 124-31; Rothenberg and Blanco Freijeiro, op. cit. (n. 49), 173.

have required less effort and would have provided more return on investment. Many of the large mines may have been abandoned, when because of technical problems the exploitation of lesser-quality ore simply became less profitable, or even impractical. It would have been more sensible to transfer expertise and attention elsewhere.⁷⁴

(b) The problem of drainage and flooding

All mines are liable to flooding. Once flooded, it is very difficult to put them back into operation. Evidence from Cornish and Devonian copper mining suggests that small mines were especially vulnerable, since their size made investment in sophisticated drainage machinery uneconomic.⁷⁵ Effective drainage machinery was essential in deeper underground mines. Drainage problems caused many Colombian underground mines to go out of operation in the sixteenth and seventeenth centuries,⁷⁶ and this seems also to have been the reason for the closure of the Tharsis mines in southern Spain under the Visigoths.⁷⁷ The Romans were clearly aware of the problems and at certain mines did install relatively sophisticated drainage machinery, to allow them to exploit deeper deposits.⁷⁸ But if mining operations ceased, shafts quickly became flooded, and Roman drainage methods, although adequate for keeping an operational mine relatively free of water, could not clear a substantial amount of water once it had accumulated after a break in production.⁷⁹ Again, it would have been more economical of effort to move the location of extraction, to open a new shaft rather than try to reactivate an old one. But the opening of new shafts involved expenses and efforts that may further have hindered the re-establishment of large mining districts, if there had been a break in production.

(c) Supplies for smelting

Enormous quantities of charcoal were required to smelt raw ore into usable metal.⁸⁰ Over the years this will have caused substantial deforestation around the mines and, as local sources became exhausted, increasing problems of supply from outside the mining zone. Thus, if obtaining a sufficient supply of charcoal became a serious problem, this would also have caused a decline in production at, or the closure of, large-scale mining districts. That this caused official concern in the later Empire is reflected in the fact that charcoal was one of the commodities levied in kind from decurions, one of the *sordida munera*.⁸¹ Other commodities were needed for the smelting of silver: salt and, if smelting by the process of amalgamation was used, mercury. If the supply of either dried up, silver production on a large scale became impractical. Mercury was mined in Roman Spain at Almaden, relatively close to the silver mines of the Sierra Morena.⁸² Almaden was still the major source of mercury for the smelting of silver from Spain's Mexican mines in the seventeenth century. The Spanish crown operated a monopoly, and when it suddenly diverted half the mercury supplies away from Mexico in the 1630s, this caused considerable disruption to silver production there.⁸³ Thus mines were tied into a much wider economic network; if they were cut off from the supply of vital raw materials, they could not continue to function effectively.

⁷⁴ See below Section IV. 3 (a).

⁷⁵ Samuel, op. cit. (n. 43), 20-1.

⁷⁶ For example, the Buritica mine, where production dwindled after 1620: Twinam, op. cit. (n. 69), 16-17.

⁷⁷ See above, p. 90 and n. 51.

⁷⁸ Thus remains of water-wheel systems have been found in the mines of São Domingos (Portugal), Tharsis and Rio Tinto, Archimedean screws at Mina Santa Barbara (Posadas) and Sotiel Coronada, and a bronze water pump also at Sotiel Coronada: J. M. Luzón

Nogue, 'Los sistemas de desagüe en minas romanas del suroeste peninsular', *Archivo español de arqueología* 41 (1968), 101-20.

⁷⁹ I am grateful to Prof. J. Wilkes for pointing this out in discussion.

⁸⁰ For some rough orders of magnitude for three mines in the Iberian Pyrites zone see Edmondson, op. cit. (n. 15), 77-81.

⁸¹ *CTh* 11. 16. 15 (A.D. 382), 11. 16. 18 (A.D. 390).

⁸² Plin., *NH* 33. 40. 118-21.

⁸³ Brading, op. cit. (n. 66), 11.

2. *Socio-economic factors*

(a) Capital

Substantial investment of capital was needed to prospect for, extract and process mineral deposits.⁸⁴ The landed aristocracy were those most likely to have had the necessary capital to invest in mining contracts or to start up small mining operations on their own estates, if these were blessed with mineral resources. Thus, landed wealth and the exploitation of minerals were closely interconnected.⁸⁵ Similarly, levels of silver production in Peru fluctuated sharply in the late eighteenth and early nineteenth centuries in part because of the fluctuating availability of capital for investment in mining operations.⁸⁶ Thus mining can only flourish in a given area, if the local economy in general is in a relatively stable and prosperous state. If there are general economic problems, caused, for example, by warfare or brigandage, this is likely to lead to a decline in mining productivity.

(b) The problem of labour

Mining is a labour-intensive operation and so considerable attention has to be paid to the labour supply. Some Spanish silver mines in Mexico were located in isolated regions and hence required the transfer of native peoples to the mines to provide labour.⁸⁷ Similarly, in the early Principate peoples were transported some distance to work in mines.⁸⁸ Furthermore, it is often claimed that slaves formed a substantial part of the labour force, especially in large state-controlled mining districts; but their role can be, and perhaps has been, exaggerated. In Spanish mines there seems rather to have been a mixed work-force of slave, freed and free, while a labour contract from the Dacian gold mines clearly concerns a freeborn, indigenous, if illiterate worker.⁸⁹ In addition, the presence of convict labour (*damnati ad metalla*) has to be admitted.⁹⁰ That there was a shortage of mining labour in the later Roman Empire is suggested by those legal measures taken by Roman emperors at the end of the fourth century not only to stem the flow of runaway miners, but also to tie the sons of miners to the profession of their fathers.⁹¹ But significantly this was not a problem restricted to mining; rather it reflects a general trend in the economy and society of the later Roman Empire.⁹² Thus changes in the organization of mining might well be caused by more wide-ranging social and economic changes and problems. In other words, mining must always be viewed in the context of the economy as a whole.

3. *Socio-political factors*

(a) Shifts in the focus of metal production?

The Devon copper mines suddenly declined in 1850 after being one of the largest production areas in the world; this has been attributed to the pressures of foreign competition, which made mining in Devon unprofitable.⁹³ Such a shift of emphasis from one mining zone to another may also have occurred in the Roman period. Strabo reports that the gold mines of Cisalpine Gaul were in his day not being worked on the same scale as previously, because the mines of Transalpine Gaul and Iberia were

⁸⁴ For a graphic survey of the costs of mining see K. Hopkins, 'Economic growth and towns in classical antiquity' in P. Abrams and E. A. Wrigley (eds), *Towns in Societies* (1978), 35-77, esp. 55-7.

⁸⁵ See further Edmondson, op. cit. (n. 15), 71-85; for a similar connection in classical Attica, see R. G. Osborne, *Demos: the discovery of classical Attika* (1985), 111-26.

⁸⁶ J. R. Fisher, *Silver Mines and Silver Miners in Colonial Peru 1776-1824* (1977), 121.

⁸⁷ For example in the Taxco and Pachuca mines, but compare the wage labour system at Zacatecas: Brading, op. cit. (n. 66), 8.

⁸⁸ For example, certain Dalmatians were transferred to Moesia Superior to work in the mines: Dušanić, art.

cit. (n. 4), 93.

⁸⁹ For inscriptions from some Lusitanian mines, Edmondson, op. cit. (n. 15), 62-4, 83-5; the Lex Metalli Vipascensis (*CIL* II, 5181 = *FIRA* I, 105) refers to freeborn *conductores* and *coloni*, to freedmen and to slaves, and even makes mention of freeborn hired labourers (*mercenarii*); for Dacia: A. Berger, 'A labor contract of A.D. 164', *CPh* 43 (1948), 231-42.

⁹⁰ Millar, art. cit. (n. 17), 137-43.

⁹¹ See n. 22 for refs.

⁹² For example, A. H. M. Jones, 'The Roman colnate', *Past and Present* 13 (1958), 1-13; E. A. Thompson, 'Peasant revolts in late Roman Gaul and Spain', *Past and Present* 2 (1952), 11-23.

⁹³ Samuel, op. cit. (n. 43), 3-4.

more profitable.⁹⁴ Similarly, the copper mines of the Seronais in the Pyrenees were suddenly abandoned at the turn of the first century B.C.; this may have been because they could not compete with the more extensive copper mines of the Iberian Pyrites Belt.⁹⁵

This raises the question of whether the Roman government could encourage mining in one zone of the Empire at the expense of others. To return to copper production, there were so many copper mines concentrated in a relatively restricted area of southern Iberia that it made administrative sense for the Romans to encourage copper mining here rather than elsewhere. Such a cluster of mines could all be served by the same substructures: the same pool of technical expertise, the same centrally-located smelting-works and the same mechanisms and facilities for the transport of processed ore. Thus, in an area of concentrated mining 'economies of scale' could be practised. The creation of large-scale mining districts must have caused considerable effort, as well as considerable dislocation in the local society: it involved the construction of roads to the mines, the establishment of military detachments and possibly the (forced and/or voluntary) transfer of extra manpower into the mining zone. Such forced transfer of personnel may have served as a means of social control over a recently subjugated people; it would have split up and removed from a given region any likely sources of resistance to Roman rule. Mines also functioned in a penal capacity; condemned criminals could be transferred from 'non-mining' to 'mining' provinces.⁹⁶ Rome would not have wanted to lose these valuable methods of social control; and so once a large-scale mining district had been established, it would have been in Rome's interests to give it every official encouragement.

Another hint of central control may be discerned in Rome's imposition of something akin to quota restrictions on the mining of British lead in the first century A.D.⁹⁷ Roman mining in Gaul and especially Spain had commenced well before that in Britain, and so possibly this measure was designed to encourage mining regions where the necessary organization of production had already taken place. Furthermore, output was possibly lessened at the Rio Tinto mines in the later second century A.D. to allow more effort in the gold fields of the north-west, while the Dolaucothi gold mines seem to have declined as soon as the Dacian gold mines came into the Roman sphere of exploitation under Trajan.⁹⁸

To allow such shifts, the central administration in Rome could transfer skilled personnel from one mining zone to another. Thus 'mining experts' appear as procurators in several mining zones in succession.⁹⁹ Asturians from northern Spain (an area of considerable gold mining, as we have seen) were transplanted to Dolaucothi in Wales, presumably to help with the initiation of gold mining there.¹⁰⁰ Although again I do not want to attribute too sophisticated a level of economic thinking to the Romans, the central administration may well have engaged in some broad-term financial planning, at least to the extent that it would know that state expenditure was likely to be high, for example, to fund military campaigns. It was, therefore, clearly in Rome's interest to have some knowledge of, and control over, levels of production in each of the major gold and silver mining regions. This would allow production to be increased or lowered according to expected state expenditure.¹⁰¹

⁹⁴ 5. 1. 12.

⁹⁵ C. Dubois and J. Guilbaut, 'Antiques mines de cuivre du Seronais (Pyrénées ariégeoises)' in *Mines et fonderies antiques de la Gaule* (1982), 95-123, esp. 116.

⁹⁶ *Dig.* 48. 19. 8. 4; F. Millar, art. cit. (n. 17).

⁹⁷ Plin., *NH* 34. 49. 164: 'black lead which we use for pipes and sheets is mined with considerable effort in Spain and throughout the Gallic provinces, but in Britain it is found just below the surface of the ground in such abundance that there is a law prohibiting the production of more than a certain amount.'

⁹⁸ Jones, art. cit. (n. 25), 162-3.

⁹⁹ For example, C. Iulius Silvanus held procuratorships in Gaul, north-west Spain and then Dalmatia, all mining zones: Tranoy, op. cit. (n. 36), 183-4; or

Saturninus, procurator in north-west Spain and then Vipasca: P. le Roux, 'Procurator affranchi in Hispania: Saturninus et l'activité minière', *MDAI(M)* 26 (1985), 218-33.

¹⁰⁰ G. D. B. Jones, 'Britain, bullion and the balance of payment', lecture delivered to Roman Society, London, June 1986. Interestingly this same pattern of migration (from Asturia to Brecon) was replicated in the early twentieth century, but in the context of coal mining: personal information from the Abercrave Outdoor Centre, Brecon.

¹⁰¹ For some thoughts E. lo Cascio, 'State and coinage in the late Republic and early Empire', *JRS* 71 (1981), 76-86.

(b) The problem of security and the role of the army

All large-scale mining operations in the early Empire required a substantial military presence, not only to protect the valuable resource being extracted and to keep watch over the labour force, but also to provide technological expertise and assistance.¹⁰² In the later Roman Empire more and more military manpower was required by the emperors to deal with internal and external threats to their power (for example, pretenders, peasant revolts or barbarian incursions).¹⁰³ To what extent could the state afford to have large numbers of soldiers tied up in the supervision of large mining districts in times of general insecurity?

Furthermore, security was a necessary concomitant of mining. At various mining sites insecurity can be shown to have caused a break in production. At the Vipasca mines in southern Portugal a statue with commemorative inscription was set up in honour of a procurator who is styled *restitutor metallorum*.¹⁰⁴ His title suggests that production had been interrupted. The inscription can be dated to 146, 173 or 235, depending on which consular name is restored in the last line. Moorish raids into the south of Lusitania and Baetica are attested for the 170s.¹⁰⁵ If these raids affected Vipasca, the title *restitutor metallorum* would be appropriate in 173. After this restitution mining did continue, as grave goods from a cemetery in the mining zone and other material from the mines suggest.¹⁰⁶ These raids have also been seen as a possible cause of reduced output at Rio Tinto.¹⁰⁷ In general, to allow mining to continue in troubled times, special measures had to be taken. Two types of response seem plausible: either there had to be a major shift in the location of mining—that is, those mines in troubled areas had to be closed down and mines elsewhere activated or re-activated; or a restructuring of mining in the troubled location had to be put into effect: mines had to be fortified and/or a change in the organization of production (from large- to small-scale) had to take place, as happened, for example, in the gold mining region of Serbia.¹⁰⁸ Mines were often located in remote areas, not easily defensible. In the face of barbarian raids, they may well have had to be quickly abandoned in favour of more defensible sites. A hint of the problems is provided by a statute of 386, which sought to ensure that mining procurators, drawn from the curial class, should complete their term of office, on pain of losing their status as *perfectissimi*, rather than 'flee in the face of the barbarian invasions'.¹⁰⁹ This provides further confirmation not only of the general insecurity of the period, but also of the need to abandon mines at such times, especially large mining districts, which were supervised by individual procurators. If production was concentrated in just one place, this would have made it an obvious target during barbarian invasions. But if mining in a given zone was broken up into many smaller units of production, this would have spread the risk of losing output; some mines may have had to close, but others could have continued in production.

V. THE RESTRUCTURING OF MINING IN THE LATER ROMAN EMPIRE

Under the Principate mining did not consist solely of state-run districts. For although the Emperor came to own many, if not most, gold and silver mines, he did not necessarily own them all.¹¹⁰ *A fortiori* there will have been yet more privately owned tin, copper and iron mines.¹¹¹ Even where the Emperor did own mines, he sometimes chose not to exploit them directly, but leased the rights of exploitation to

¹⁰² For example, Jones, art. cit. (n. 36).

¹⁰³ C. R. Whittaker, 'Trade and frontiers of the Roman Empire' in P. Garnsey and C. R. Whittaker (eds), *Trade and Famine in Classical Antiquity* (Camb. Phil. Soc., Suppl. Vol. 8) (1983), 118.

¹⁰⁴ J. d'Encarnaçao, *Inscrições romanas do Conventus Pacensis* (1984), no. 121; E. Cuq, *NRHDRFE* (1908), 306–10; L. Wickert, *Sitz. der Preuss. Akad. der Wissen.* (1931), 835–9.

¹⁰⁵ SHA, *M.Ant.* 21. 1; 22. 11; cf. *ILS* 1327, 1354, 1354a.

¹⁰⁶ See above p. 90 and n. 53.

¹⁰⁷ Jones, art. cit. (n. 25), 162.

¹⁰⁸ See pp. 92–3 and n. 67.

¹⁰⁹ *CTh* 1. 32. 5.

¹¹⁰ Crook, op. cit. (n. 21), 161–2; F. Millar, *The Emperor in the Roman World* (1977), 181–5.

¹¹¹ On private mines see further G. Negri, *Diritto minerario romano. 1. Studi esegetici sul regime delle cave private nel pensiero dei giuristi classici* (1985). I owe this reference to Michael Crawford.

contractors (as at Vipasca). Thus mining consisted of a mixture of state and private operations.

What was the impact of these two different modes of production on the local economy and society and what administrative implications did both modes have for the Roman state? Mining, where it was organized as a state-run district, was in one sense divorced from the local economy, in that mines were administered independently of the local city, while labour and skilled personnel might be brought in from far outside the mining area. But in another sense mining was still closely integrated into the local economy; for the large communities of miners and ancillary workers that grew up around mines created a substantial demand for food and other supplies to be produced in, or imported into, the mining region. On the positive side, new economic opportunities arose in the area; that is, large mines caused considerable 'economic growth' in their surrounding hinterland.¹¹² On the negative side, these mining districts required the Roman state to provide substantial administrative and financial support, especially when they were being established. Furthermore, some Roman mines were located in difficult terrain and would have been inaccessible in winter.¹¹³ A large-scale operation is unlikely to have developed here; how, for example, could the labour force be kept occupied in the off-season?

On the other hand, mining on a smaller scale was more clearly integrated into the existing, agriculturally based, economic pattern of the area. For it was often only landowners who could afford the capital investment needed either to exploit mineral resources on their own estates or to lease a contract to operate shafts in imperially-owned mining districts.¹¹⁴ Furthermore, landowners had a ready source of labour in their agricultural workers (whether slaves or *coloni*), who could be used in smaller-scale mining in slack periods of the agricultural year. Such a symbiosis between mining and agriculture also prevailed in colonial Peru.¹¹⁵ This mode of production required much less centralized control or economic support from Rome; if the state was beset with financial pressures and preferred not to tie up too many administrators and soldiers in mining, it was a much more economical means of organizing metal production.

In the later Empire there seems to have been a similar mixture of state and privately owned mines. For privately owned mines, there is clear evidence in the law codes. The Roman state levied a special payment (the *praestatio auraria*, *aeraria* and *ferraria*) from owners of metalliferous land.¹¹⁶ This suggests that these landowners were acquiring wealth from the exploitation of these minerals on their estates. Furthermore, the increased levels of various kinds of taxation in the later Empire provided a major stimulus to the private exploitation of mineral resources by provincial landowners.¹¹⁷ Thus a regulation of 424 states that with government permission a landowner could pay his taxes not in coin or kind, but commuted into metal (gold, copper or iron).¹¹⁸ This might involve the surrender of metal in the form of plate or treasures; but if a landowner had such metals in the subsoil of his land, might he not have exploited them to help pay his taxes to Rome?

The appointment of *procuratores metallorum* and the role of the *comes sacrarum largitionum* demonstrate that state-owned mines still existed.¹¹⁹ But what was different from the Principate was that the state preferred to involve private individuals in the running of its larger mining districts. For, first, it leased out to landowners the right to exploit state-owned gold mines or alluvial workings on payment of the *metallicus canon*;¹²⁰ and secondly, it allowed them to exploit state-

¹¹² For the effects of silver mines on local economy in later Mexican mines see Brading, *op. cit.* (n. 66), 6-7.

¹¹³ For example, F. J. Sánchez Palencia, 'Prospecciones en las explotaciones auríferas del noroeste de España (cuena de los ríos Eria y Sierra del Tereno)', *Noticiario arq. hispánico* 8 (1980), 212-49, esp. 238.

¹¹⁴ See above p. 95 and n. 85.

¹¹⁵ N. Long and B. Roberts, *Miners, Peasants and Entrepreneurs: regional development in the central high-*

lands of Peru (1984), 26-31.

¹¹⁶ *CTh* 11. 20. 6 (A.D. 430).

¹¹⁷ On taxes see in general Jones, *op. cit.* (n. 6), 462-9.

¹¹⁸ *CTh* 11. 21. 3 (A.D. 424).

¹¹⁹ For procurators: *CTh* 1. 32. 5; for *comes sacrarum largitionum*: Jones, *op. cit.* (n. 6), 369-70; King, *art. cit.* (n. 11).

¹²⁰ *CTh* 10. 19. 3, 4, 12, dated respectively to 365, 367 and 392.

owned *metallica loca*, on condition that certain levels of production were maintained.¹²¹ The implication of these regulations is that the central government wanted to avoid as much as possible the administrative effort involved in running mining districts directly, and so devolved responsibility on to the provincial aristocracy. Such a mode of organization seems consistent with the archaeological evidence from mining districts, discussed in Sections II and III. Mining in the later Empire was marked not only by a reduced scale of output, but also by a much greater prevalence of small-scale units of production.

VI. INTO THE DARK AGES: MINING IN THE EARLY MEDIEVAL PERIOD

In the final part of this paper I shall consider briefly and provisionally the evidence for mining in the Iberian peninsula and Gaul after the Romans had lost political control over these areas at the start of the fifth century. There is much that is speculative, but at least a clarification of the main problems may serve to stimulate discussion. In short, did the end of Roman political control bring about a collapse of the mining that seems to have been practised in the fourth century; or was there continuity of mining into the early medieval period?

It is first necessary to assess whether the demand for metals was as high under the Goths as it had been under the Romans. The end of Roman political control did not spell the end of urban life, which continued to be stimulated by the growth of the Christian church.¹²² Thus there was still a need for iron and lead for building materials and, more significantly, iron was still required for arms, armour, military equipment and agricultural tools.¹²³ As for precious metals, the royal courts, the church and the local élite constituted a sizeable market for luxury products, especially silver plate and worked gold.¹²⁴ In addition, gold, and to a lesser extent silver, were still needed for coinage. For the Visigoths, Sueves and Franks continued to mint gold coins modelled on the Roman *solidus*; indeed the earlier issues bore the head of Roman emperors. The primary function of these coinages seems to have been symbolic: that is, they helped to legitimate the power of the kings and advertised their role as inheritors of the Roman Empire.¹²⁵ What is less clearcut is the extent to which coinage continued to function as a general medium of exchange. The various Germanic law codes lay down various fines expressed in terms of *solidi*.¹²⁶ But the extent to which these legal prescriptions represent actual practice is uncertain, since the codes were substantially modelled on late Roman law codes and so may just be imitating their Roman predecessors. Taxes were also fixed in monetary terms.¹²⁷ But it does not necessarily follow that just because taxes were paid in money, a general monetary economy was still in place. Numismatic evidence from Conimbriga (Condeixa-a-Velha, Portugal) suggests that a monetary economy had not been totally abandoned after the Germanic invasions, but that some (essentially bronze) coins continued to circulate, but now alongside other media of exchange such as iron bars. Furthermore, those coins in circulation were not recently minted; most of the coins found in levels of the mid-fifth century were issues of the period 335 to 361.¹²⁸ The question, therefore, of the extent of coin circulation in the post-Roman period is clearly problematic, but in general it appears that coinage was used, although on a much smaller scale than it had been in the later Roman Empire. Coin hoards have been found, but wealth was increasingly hoarded in the form not of coins, but of silver

¹²¹ *CTh* 10. 19. 13 (A.D. 393).

¹²² For example, see R. Collins, 'Mérida and Toledo, 550-585' in E. James (ed.), *Visigothic Spain: new approaches* (1980), 189-219.

¹²³ E. Salin and A. France-Lanour, *Rhin et Orient. II Le fer à l'époque mérovingienne* (1943).

¹²⁴ Gregory of Tours, *HF* is full of references to wealth held in silver plate and gold: e.g. 6. 28; 6. 45; 9. 34; see in general J. P. C. Kent and K. S. Painter, *Wealth of the Roman World: gold and silver A.D. 300-700* (1977).

¹²⁵ P. Grierson and M. Blackburn, *Medieval Euro-*

pean Coinage. I. The Early Middle Ages (5th to 10th centuries) (1986).

¹²⁶ King, *op. cit.* (n. 20), 191-2; see *Lex Visig.* 7. 6 for measures against counterfeiters.

¹²⁷ As shown, for example, in a Visigothic fiscal document from Barcino (Barcelona), dated to 592; those wanting to pay their taxes in kind had to arrange the necessary commutation with the local tax officials: see King, *op. cit.* (n. 20), 69-70.

¹²⁸ I. Pereira, J.-P. Bost, J. Hiernard, *Fouilles de Conimbriga. III. Les monnaies* (1974), 303-4. I am grateful to Michael Crawford for his comments here.

plate or gold treasure.¹²⁹ There was, therefore, still a need for fresh gold and silver, in part for the Germanic coinages, but more so as a means of storing wealth. But were these precious metals still being mined in the West?

Isidore of Seville provides a starting point, his prodigious output itself testimony to the survival of Roman culture in the Iberian peninsula after the loss of Roman political control. He refers on four occasions to alluvial gold workings in the Iberian peninsula.¹³⁰ However, Isidore was steeped in that Roman literary tradition which, in eulogizing the wealth of Iberia, gave much prominence to its mineral resources. His phraseology at these crucial points bears too many similarities to that of Pliny the Elder to give his testimony any independent value as evidence for continued mining in the Visigothic period.¹³¹ Thus again the literary evidence does not get us very far.

As for the legal sources, the Germanic law codes make reference to condemnation to the mines as a judicial penalty; they also contain measures to deter itinerant gold panners from interfering with landed property adjacent to their gold workings.¹³² But the problem remains as to whether these laws refer to contemporary practice, or whether they merely ape earlier Roman codes; thus again they can provide little unambiguous information.

Archaeological evidence for mining is also scant. Very occasionally Germanic coins have been found in Roman mines: for example, some late sixth-century Merovingian coins at the tin mines of Abbaretz-Nozay (Loire Atlantique) or Visigothic coins at the silver mines at Sotiel Coronada in the Iberian Pyrites Belt.¹³³ It is obviously controversial whether these finds necessarily indicate that the mines themselves were still operational; but unless an alternative reason for the continued occupation of these mining zones can be suggested, it seems best to attribute this to continued interest in the mines. In addition to coins, one would expect to find some Visigothic pottery at mining sites, if they were operational in this period. But unfortunately typologies of Visigothic pottery are not yet well defined, and so it is doubtful whether Visigothic sherds have always been recognized and recorded as Visigothic; the prevalence of a wide variety of local pottery types further complicates their accurate identification. But most of all, if mining consisted of small-scale operations at a number of isolated sites, then these mines are unlikely to be represented in the archaeological record for the reasons outlined in Section 1. 3.

The location of the Suevic, Visigothic and Merovingian mints in Iberia and Gaul further suggests that some mining for silver and especially gold did continue after the end of Roman rule. The earliest known Germanic coins were those minted by the Suevic king Rechiarius (448–56).¹³⁴ The Sueves occupied the north-west of the Iberian peninsula, an area that during both the Principate and the late Empire saw a high level of gold mining (see above, Section II).¹³⁵ Although there is as yet no archaeological confirmation of gold mining here under the Sueves, that they minted their coins from locally mined gold seems very likely.¹³⁶ After the Visigoths seized control of Suevic territory in 585, they located roughly half of their mints (thirty-eight out of seventy-nine) in this remote corner of the Iberian peninsula, to take advantage again, it would appear, of the local availability of fresh bullion.¹³⁷ Similarly in France during the seventh century sixty-nine Frankish mints operated in the

¹²⁹ X. Barral i Altet, *La circulation des monnaies suèves et visigothiques: contribution à l'histoire économique du royaume visigot* (Beihefte der *Francia* 4) (1976), 71–2. For a general survey, L. Garcia de Valdeavellano, 'La moneda y la economía de cambio en la península ibérica desde el siglo VI hasta mediados del siglo XI', *Sett. de Stud. del Centro Ital. di Studi sull'Alto Med.* 8 (1961), 203–30.

¹³⁰ *Étym.* 14. 4. 28; 13. 21. 33; 16. 22. 1; 5. 27. 31.

¹³¹ M. C. Díaz y Díaz, 'Metales y minería en la época visigótica a través de Isidoro de Sevilla' in *La Minería hispana e iberoamericana* (1970), 261–74.

¹³² Davies, op. cit. (n. 18), 76.

¹³³ Galliou, art. cit. (n. 24), 21–32, esp. 23; Sotiel Coronada: Díaz y Díaz, art. cit. (n. 131), 272, n. 35, referring to 'frequent discovery of Visigothic coins' and

a Visigothic necropolis near the mines at Carlos Cerdan.

¹³⁴ Barral i Altet, op. cit. (n. 129), 24–5, 53.

¹³⁵ On Sueves in general, E. A. Thompson, 'The end of Roman Spain. I', *Nottingham Medieval Studies* 20 (1976), 3–28, esp. 18 ff. and 'The end of Roman Spain. II', *ibid.*, 21 (1977), 3–31, esp. 3–15.

¹³⁶ So Grierson and Blackburn, op. cit. (n. 125), 78.

¹³⁷ G. C. Miles, *The Coinage of the Visigoths in Spain: Leovigild to Achila II* (1952), 69. The most productive mint was that of Emerita, situated not in an area of gold mines, it is true, but on a major road (later called the 'Via de la Plata') that led from the gold mining zone of Asturias via Salamanca to Emerita and thence Seville: Barral i Altet, op. cit. (n. 129), 146.

Limousin, another region of Roman gold mining; twenty-two can be located in close proximity to known Roman gold mines.¹³⁸ Thus the evidence from the Limousin provides some substantiation for the jibe that Frankish kings spent their time watching horse races at Arles and minting coins of Gallic gold.¹³⁹

Security was a necessary precondition for mining in the Roman period, as we have seen. Thus, if the Germanic invasions caused widespread security problems, this will have meant disruption to local economic life in general and will have threatened mining in particular. Early Christian writers paint a generally bleak picture of life under the Goths. For north-west Spain the account of Hydatius, bishop of Chaves, covering the period from 407 to 459, suggests that the area was persistently affected by plundering and pillage, hardly the ideal atmosphere for the continuation of mining.¹⁴⁰ However, a more critical reading of Hydatius, placed alongside what little archaeological material there is, shows that in contrast to Britain where the Saxons did cause a complete break with the Roman past, in Iberia dislocation occurred only in very restricted areas. After an initial period of uncertainty, Spain seems to have returned to life much as it had been under the Romans. Roman place-names, language, city life, provincial boundaries (for the most part) and bishoprics all survived the 'barbarian' invasions.¹⁴¹ In such an environment mining would at least have been possible.

The Germanic kings had taken over control of the Roman imperial estates, which included most of the gold and silver resources of the peninsula. Just as the Roman Emperors in the later fourth century tried to encourage individual landowners to exploit these gold resources, as we have seen, so possibly did the Germanic kings. A stimulus for continued mining may have been provided by the continued demands of taxation. The Visigothic kings seem to have maintained the basic structures of Roman taxation and customs dues; in addition, they continued to impose on the local aristocracy similar obligations to those current under the Romans (for example, providing horses for the public post or keeping roads and bridges in good repair).¹⁴² If it is correct that the demands of taxation in the later Roman Empire encouraged landowners to become involved in mining, then the continued burden of taxation under the Germanic kings would have acted as a similar stimulus to mining.

Any conclusions on the continuity of mining in Iberia and Gaul must be tentative. But I would suggest that some mining did take place in the post-Roman period, especially in those areas that had seen substantial Roman mining; it seems extremely unlikely, on the other hand, that many new mining areas were opened up. Individually the arguments may seem a little thin, but placed together, they are mutually supportive. What is needed is more widespread archaeological field surveys in known mining zones, especially those near the Germanic mints, to establish more firmly the history and pattern of mining from the pre-Roman to the post-Roman periods. Recent prospecting in Turkey have revealed startling evidence for the continuity of mining in the Bolkardağ district in the Taurus mountains: some 850 silver, tin, gold and antimony mines, mostly small-scale, were still operating in the eighth century, presumably to supply Byzantium with bullion for its precious metal.¹⁴³

As for the organization of production, the lack of a centralized administration under the Gothic kings militated against the operation of large-scale mining districts. Mining was, therefore, probably only practised on a small scale. But the presence of only small units of mining cannot be attributed to any economic decline brought on

¹³⁸ G. Tamain and D. Ratz, 'Les aurières de l'ouest du Massif central (France) dans leur contexte géologique et archéologique' in *Mines et fonderies antiques de la Gaule* (1982), 33-78, esp. 71-2.

¹³⁹ Reported by Procopius, *Bell. Goth.* 3. 33. 5.

¹⁴⁰ The Tharsis mines seem to have gone out of operation as a result of insecurity caused by the Visigothic invasions: see above p. 90 and n. 51.

¹⁴¹ E. A. Thompson, 'The end of Roman Spain. iv', *Nottingham Med. Stud.* 23 (1979), 1-21, esp. 5-8.

¹⁴² King, *op. cit.* (n. 20), 64-70 (tax), 71 (custom dues and obligations).

¹⁴³ Kind information of Dr Marlia Mango; for mining here in first millennium B.C. see K. Aslihan Yener and H. Ozbal, 'The archaeometry of silver and gold in ancient Anatolia: the Bolkardağ mining district survey', *AYA* 90 (1986), 469-72; and 'Tin in the Turkish Taurus mountains: the Bolkardağ mining district', *Antiquity* 61 (1987), 220-6. For Byzantine mines see A. A. M. Bryer, 'The question of Byzantine mines in the Pontos', *Anat. St.* 32 (1982), 133-50.

by the departure of the Romans; it was already a familiar feature in the later Roman Empire. Visigothic control of Spain ended in 711 with the Arab invasions. The dislocation and changes in the local society and economy brought about by this event were much more far-reaching than those caused by the earlier Germanic invasions.¹⁴⁴ However, Arab geographers provide a wealth of detail about the economic life of Moslem Spain, and refer in their (sometimes hyperbolic) accounts to the exploitation of metals: for example, of gold near Lisbon, or of tin at Faro in the Algarve.¹⁴⁵ Whether such sources of metal were exploited throughout the Visigothic period is uncertain; but the references do serve as a check on those who are too willing to see the complete disruption of local economic life as the natural corollary of the end of Roman rule in the West.

York University, Toronto

¹⁴⁴ See in general R. Collins, *Early Medieval Spain: Unity in Diversity, 400–1000* (1983).

¹⁴⁵ Lisbon: Edrisi, *Description de l'Afrique et de l'Es-*

pagne (ed. R. Dozy and M. J. de Gueje) (1968), 223; Faro: A. Tovar, *Iberische Landeskunde*. II. 2. *Lusitanien* (1976), 207.