Economic Integration and Labor Organization in Roman Mining: The Question of Capitalism

***

LINDA R. GOSNER
TEXAS TECH UNIVERSITY

ABSTRACT

This essay, via a case study of the early imperial mines of the Iberian Pyrite Belt (southern Lusitania and western Baetica), incorporates the study of Roman mining into wider discussions on the structure of the Roman economy and later capitalist mining enterprises by examining two aspects of Roman mining economies. First, it addresses the integration of imperial mining with private industries, arguing that the imperial economy both stimulated and depended upon local and, typically, privately organized economic activity for the supply of equipment, provision of food, and other services. Second, it explores the extent to which mining depended upon free labor and the ways in which free and slave labor were assimilated into the mining industry.

ESSAY

Mining, Capitalism, and Roman Economies[1]

Many discussions about the possibility of capitalism in the Roman world revolve around evidence from one of two contexts: first, trade and markets in urban places, and second, the accumulation of wealth through agriculture in suburban and rural environments. While Roman

[1] Thank you to Michael J. Kelly and Paulo Pachá for the invitation to participate in this symposium and the opportunity to engage in a number of new scholarly conversations. This paper has benefitted from discussions with students in my Archaeology of the Roman Economy course taught at the University of Michigan in Fall 2019 as well as feedback from colleagues in the Michigan Society of Fellows and in my writing group: Müge Durusu-Tanriover, Willis Monroe, Catherine Steidl, Brendan McMahon, Ben Mangrum, and Cynthia Gerlein-Safdi.

ISSN 2576-0483

mining and quarrying have long been studied in their own right from varied disciplinary perspectives, analyses of such extractive industries and industrial landscapes are often omitted from discussions of the nature and organization of the Roman economy. This is because – as David Mattingly and John Salmon have put it – they are exceptional activities, "clearly better interpreted as administrative or imperial enterprises than as a rational economic phenomena: cost was no part of the calculation."[2] The awe-inspiring scale of famous Roman extraction sites such as the gold mines of las Médulas in Spain or the granite quarries at Mons Claudianus in Egypt only reinforce this narrative. However, the scholarly urge to "exceptionalize" extractive industries obscures questions of how they were integrated with other facets of the Roman economy and, especially important in the present context, the ways in which they exhibit tendencies that might be considered "capitalist."

Meanwhile, mining and other extractive industries have played a central role in discussions of later global economies. In his lengthy review of the *Cambridge Economic History of the Greco-Roman World*, Peter Bang reminds us that "the terms of economic history have been dominated by capitalism and the industrial revolution."[3] This is especially true for the archaeology of mining – a discipline that has been split squarely down the middle, with pre-industrial, pre-capitalist societies falling on one side of analysis and post-industrial, capitalist societies on the other.[4] Indeed, during the 1800s the technological developments of the Industrial Revolution

[2] David J. Mattingly and John Salmon, "The Productive Past: Economies Beyond Agriculture," in *Economies Beyond Agriculture in the Classical World*, ed. David J. Mattingly and John Salmon (London and New York: Routledge, 2001), 1–13, at 3–4.
[3] Peter Fibiger Bang, "The Ancient Economy and New Institutional Economics," *Journal of Roman Studies* 99 (2009): 194–206, at 198; Willem M. Jongman, "Re-Constructing the Roman Economy," in *The Cambridge History of Capitalism Volume I: The Rise of Capitalism: From Ancient Origins to 1848*, ed. Larry Neal and Jeffrey G. Williamson (Cambridge: Cambridge University Press, 2014), 75–100.
[4] Linda R. Gosner, "Archaeology of Mining," in *Encyclopedia of Global Archaeology*, ed. Claire Smith, 2nd edn. (Berlin: Springer, 2019), 1–19. For recent work that pushes this boundary, see especially Jeannette Graulau, "Capitalist Miners in Feudal Europe: A Commentary on Marxist Agrarian History," *Journal of Agrarian Change* (2019): 1–18.; Jeannette Graulau, *The Underground Wealth of Nations: On the Capitalist Origins of Silver Mining, A.D. 1150-1450* (New Haven: Yale University Press, 2019).

ISSN 2576-0483

allowed the scale and organization of mining to be transformed radically from its origins in the pre-industrial past.[5] There are obvious changes in economic organization that came with these advances in technology, the demands of global trade networks, and historically contingent political events that cannot be ignored. Nevertheless, this stark division of pre- and post-industrial revolution chronologies in economic history has hindered the integration of Roman mining into long-term global economic history. The language of capitalism, borrowed from our post-industrial colleagues, provides one remedy.

In an effort to integrate the study of Roman mining into larger debates about the nature of the Roman economy *and* the relationship between mining and capitalist economies in the *longue durée*, this paper explores two aspects of Roman mining. First, I examine the extent to which mining depended upon a labor market and the ways in which free and slave labor were integrated in the mining industry. Second, but relatedly, I discuss the integration of Roman imperial mining with private industries. I show that the imperial economy both relied upon and itself stimulated local and often privately organized economic activity for the supply of equipment, the provision of food, and other services. In short, these are two areas where the trope of Roman mining as an irrational, exclusively state-controlled economic enterprise begins to break down. Instead, elements of economic organization that resemble later capitalist mining emerge, including the rise of specialized labor markets and privately organized profit-driven industries.

This paper takes as a primary case study the Roman mines of the early imperial period located in the Iberian Pyrite Belt, which extended across parts of two Roman provinces in Iberia: southern Lusitania and western Baetica. There, copper, silver, and other metals were extracted

[5] Joan Day and Ronald F. Tylecote, eds., *The Industrial Revolution in Metals* (London: The Institute of Metals, 1991).

ISSN 2576-0483

at unprecedented scales to supply the Roman Empire with coveted ores. The mines of Riotinto (Huelva, Spain) and Vipasca (Aljustrel, Portugal) provide a wealth of archaeological and epigraphic evidence that sheds light on the organization of mining economies in this corner of the Roman Empire. As James Fulcher has emphasized, "Capitalists existed before capitalism proper."[6] I do not argue that Roman mining in southwest Iberia or elsewhere should be used as evidence for capitalism in the Roman world. Nevertheless, examining these specific aspects of mining – labor organization and economic integration – through the lens of capitalism serves a valuable heuristic purpose. Not only does it allow mining economies to be integrated into larger theoretical debates about the nature of the Roman economy, but it also enables Roman mining to be brought into conversations about extractive industries and global economies from a long-term perspective.

Economic Growth and Roman Imperial Mines in Southwest Iberia

Central to discussions of the Roman economy in recent decades has been the topic of economic growth: what material proxies can be used to understand economic performance? How does economic growth track with wider political and social developments in the Roman Empire? And how does economic growth relate to the strategies for the organization of production that were employed?[7] It is now commonplace among economic historians to argue that the Roman Mediterranean saw steady economic growth from the late Republic through the early empire. Though opinions vary, many argue that a decline in economic growth beginning from the late

[6] James Fulcher, *Capitalism: A Very Short Introduction*, 2nd edn. (Oxford: Oxford University Press, 2015), 13.
[7] For a critical historiographical review of scholarship on economic growth, see Matthew S. Hobson, "A Historiography of the Study of the Roman Economy: Economic Growth, Development, and Neoliberalism," in *Theoretical Roman Archaeology Conference 2013: Proceedings of the Twenty-Third Theoretical Roman Archaeology Conference, King's College, London*, ed. Hannah Platts et al. (Oxford: Oxbow Books, 2014), 11–26.

ISSN 2576-0483

2nd and early 3rd c. CE can be attributed to phenomena such as the Antonine Plague and political upheaval in the provinces.[8]

Aside from the obvious role that mining played in the minting of coinage, Roman mining has often played a constant but tangential role in these arguments that chart the trajectories of Roman economic growth. The intense scale of mining across the Roman Empire has long been supported by studies of atmospheric pollution in the Greenland ice caps and European peat bogs.[9] This increase in the scale of metal extraction is viewed as one indicator of economic growth in the early empire, alongside many other proxies such as evidence for meat consumption, the proliferation of public building and other aspects of urbanization, and the increase in long-distance maritime trade of products such as wine and olive oil.[10]

For studies which position mining pollution as a proxy for economic growth, mining in southwest Iberia has played an important role, thus underscoring its value as a case study with which to explore the structure of the Roman economy. The original isotopic studies of the Greenland ice caps by Sungmin Hong and colleagues from the 1990s identified southwest Spain, and especially Riotinto, as a major contributor to atmospheric pollution in the 1st and 2nd c. CE.[11] More recently, a new study by Joseph McConnell and colleagues has pinpointed with

[8] For a summary of these arguments, see Paul Erdkamp, "Economic Growth in the Roman Mediterranean World: An Early Good-Bye to Malthus?," *Explorations in Economic History* 60 (2016): 1–20.
[9] E.g., Walter Scheidel, "In Search of Roman Economic Growth," *Journal of Roman Archaeology* 22 (2009): 46–70, at 49; Jongman, "Re-Constructing the Roman Economy," 83; Andrew Wilson, "Machines, Power and the Ancient Economy," *Journal of Roman Studies* 92 (2002): 1–32. For a more critical analysis, see Andrew Wilson, "Indicators for Roman Economic Growth: A Response to Walter Scheidel," *Journal of Roman Archaeology* 22 (2009): 72–82, at 78–79.
[10] For discussion on proxies for economic growth, see: Jongman, "Re-Constructing the Roman Economy"; Scheidel, "In Search of Roman Economic Growth"; Wilson, "Indicators for Roman Economic Growth: A Response to Walter Scheidel."
[11] Sungmin Hong et al., "Greenland Ice Evidence of Hemispheric Lead Pollution Two Millennia Ago by Greek and Roman Civilizations," *Science, New Series* 265, no. 5180 (1994): 1841–43; Sungmin Hong et al., "History of Ancient Copper Smelting Pollution During Roman and Medieval Times Recorded in Greenland Ice," *Science, New Series* 272, no. 5259 (1996): 246–49; Kevin J. R. Rosman et al., "Lead from Carthaginian and Roman Spanish Mines Isotopically Identified in Greenland Ice Dated from 600 BC to 300 AD," *Environmental Science and Technology* 31, no. 12 (1997): 3413–16.

ISSN 2576-0483

even more temporal precision the ebbs and flows of mining pollution in long-term history.[12] As with the earlier study, Spain emerges again as a major contributor to this pollution: "sustained high emission levels in the mid-fourth to second centuries BCE corresponded to intensive mining in Carthaginian and Republican Roman Spain, and in the first and second centuries CE to mining under the Roman Empire."[13]

The massive scale of extractive mining, which such studies demonstrate, fueled the increasingly monetized Roman economy by providing the ores used for minting.[14] Silver, gold, and especially copper from Iberia – where it is possible to confirm place of origin from archaeometric studies – made up proportionally high percentages of Roman coinage.[15] Gold for the minting of Augustan and other early imperial *aurei* derived from the imperial mines in northwest Iberia such as the monumental hydraulic opencast mines of Las Médulas and other less widely known alluvial and hard-rock gold sources across the region.[16] Southwest Iberia was an especially important source of copper that was used in coins of smaller denominations that would have been more frequently used in daily transactions than more valuable *aurei* or

[12] Joseph R. McConnell et al., "Lead Pollution Recorded in Greenland Ice Indicates European Emissions Tracked Plagues, Wars, and Imperial Expansion during Antiquity," *Proceedings of the National Academy of Sciences* 115, no. 22 (2018): 5726–31.
[13] Ibid., 5727.
[14] Christopher Howgego, "The Supply and Use of Money in the Roman World 200 BC to AD 300," *Journal of Roman Studies* 82 (1992): 1–31, at 4–8; Pere P. Ripollès, "The Ancient Coinages of the Iberian Peninsula," in *The Oxford Handbook of Greek and Roman Coinage*, ed. William E. Metcalf (Oxford: Oxford University Press, 2012), 356–74.
[15] For a summary on archaeometry, provenience, and coinage, see Matthew J. Ponting, "The Substance of Coinage: The Role of Scientific Analysis in Ancient Numismatics," in *The Oxford Handbook of Greek and Roman Coinage*, ed. William E. Metcalf (Oxford: Oxford University Press, 2012), 12–32; Matthew J. Ponting, Jane A. Evans, and Vanessa Pashley, "Fingerprinting of Roman Mints Using Laser-Ablation MC-ICP-MS Lead Isotope Analysis," *Archaeometry* 4 (2003): 591–97.
[16] Fernando López Sánchez, "The Mining, Minting, and the Acquisition of Gold in the Roman and Post-Roman World," in *Ownership and Exploitation of Land and Natural Resources in the Roman World*, ed. Paul Erdkamp, Koenraad Verboven, and Arjan Zuiderhoek (Oxford: Oxford University Press, 2015), 315–36.

ISSN 2576-0483

silver *denarii*. Riotinto ores from this area, for instance, are common in coins of the 1st c. CE and were used exclusively from 34 to 37 CE to make Roman *asses*.[17]

The rationale for my selection of southwest Iberia as a case study, then, is threefold. First, if evidence for elevated Roman mining in southwest Iberia is used in the big-picture narrative of economic growth, then it is all the more essential to examine the economic organization of the mining industry in this region on (and below) the ground. What ecological and human factors enabled the industry to grow to this elevated level? What kinds of economic decision making contributed to the success – and can any of these be attributed to rational, capitalist, economic thinking? Second, the archaeological and epigraphic record for mining in this region across southwest Iberia tracks readily with wider narratives about Roman economic growth in other industries, with the industry reaching a height in the early empire, and then declining from the late 2nd and early 3rd centuries onward. The material and textual records for understanding mining labor and the organization of the industry for this region are stronger than those available for many other locales. In southwest Iberia, we can rely on the published epitaphs that have been linked to mining as well as the unique and detailed Roman mining laws recorded in the Vipasca tablets. Archaeologically, underground and opencast mines and related settlements have been recorded – often by engineers during later epochs of mining activity – and artifacts, including tools, equipment, and domestic materials, saved. And finally, southwest Iberia has an unusually long history of mining with multiple, successive episodes of imperial, colonial, and modern capitalist intervention in its mining landscapes. It is therefore a place where the language of capitalism may indeed serve as a heuristic tool for understanding long-term human intervention in the landscape before and after the Industrial Revolution.

[17] Sabine Klein, Yann Lahaye, Gerhard P. Brey, and Hans-Markus von Kaenel, "The Early Roman Imperial AES Coinage II: Tracing the Copper Sources by Analysis of Lead and Copper Isotopes—Copper Coins of Augustus and Tiberius," *Archaeometry* 46, no. 3 (2004): 469–80, at 478.

ISSN 2576-0483

Explorations of Mining Economies in the Iberian Pyrite Belt

The Roman mines of southwest Iberia dotted the landscape across a vast territory extending from Portugal's Alentejo region in the west to Seville in Andalucía, Spain in the east. A geological formation known as the Iberian Pyrite Belt extends some 250 km across this region running east to west and about 40 km wide.[18] There, indigenous populations mined from at least 4000 BCE.[19] Later, the mines in southwest Iberia became drivers for long-distance trade and colonization by the Phoenicians in the early Iron Age along the coast of southern Spain. Subsequently, the Carthaginians built on this previous colonization, expanding some cities and using metals from Iberian mines in southern Iberia, though more so in the southeast around Cartagena, for coins to pay their troops in the Punic Wars.[20]

While mining in the Iberian Pyrite Belt continued during the Roman Republic after the annexation of Iberian territories beginning in the late 3rd century BCE, the height of exploitation was in the 1st and 2nd centuries CE. By this time, Hispania had been reorganized into three provinces: Tarraconensis, Baetica, and Lusitania, with the Pyrite Belt spanning the western and southern portions of the latter two regions, respectively.[21] Typically, mining districts called *metalla* were overseen by procurators and belonged to the Roman state in this period. Although some mines were overseen directly, often mining rights were leased out to *conductores* or

[18] Juan Aurelio Pérez Macías, "Patrimonio Arqueológico de la Faja Pirítica Ibérica," in *Arqueología y Patrimonio en la Faja Pirítica Ibérica: Actas de la I Jornada de Arqueología, Historia y Minerá de la Faja Pirítica Ibérica*, ed. José Suárez Suárez and Noemí Raposo Gutiérrez (Huelva: Asociación Herrerías, 2018), 23–54; Felix García Palomero, "Yacimientos de la Faja Pirita Iberica (F.P.I)," in *Metallum. La Minería Suribérica*, ed. Emilio Romero Macías and Juan Aurelio Pérez Macías (Huelva: Universidade de Huelva Publicaciones, 2004), 13–29; Wes Gibbons and Teresa Morena, eds., *The Geology of Spain* (London: The Geological Society, 2002), 478–80.

[19] Mark A. Hunt Ortiz, *Prehistoric Mining and Metallurgy in the South West Iberian Peninsula* (Oxford: BAR International Series (1188), 2003); Beno Rothenberg and Antonio Blanco-Freijeiro, *Studies in Ancient Mining and Metallurgy in South-West Spain: Explorations and Excavations in the Province of Huelva* (London: Institute for Archaeo-Metallurgical Studies, 1981).

[20] On monetization in 1st millennium BCE Iberia, see Ripollès, "The Ancient Coinages of the Iberian Peninsula." On the historical development of the region in general, see Maria Eugenia Aubet, *The Phoenicians and the West: Politics, Colonies, and Trade*, 2nd edn. (Cambridge: Cambridge University Press, 2001).

[21] On the political history of Hispania during this period, see Isabel Rodá, "Hispania: From the Roman Republic to the Reign of Augustus," in *A Companion to the Archaeology of the Roman Republic*, ed. Jane DeRose Evans (Malden: Blackwell Publishing, Ltd., 2013), 522–39.

ISSN 2576-0483

societates, private contractors and guild-like societies, who turned over a portion of their profits to the state.[22] The latter scenario was the case in early imperial southwest Iberia; this is especially important to note here given that capitalism relies on private property and the accumulation of private capital, and the central role that corporations or firms have come to have in modern capitalist mining.[23]

This period provides a range of data relevant to the present study, specifically epigraphic and archaeological evidence from the aforementioned mines of Riotinto just north of Huelva, Spain (Roman Onuba in Baetica) and those of Aljustrel, Portugal (Roman Vipasca in Lusitania). Following their extensive Roman exploitation in the early empire, both mines saw a decline in production, while evidence is scattered for exploitation in post-Roman times.[24] Each had a large role to play in mining economies after the Industrial Revolution, however. Their landscapes today are dominated by large opencast copper mines, first opened by British mining enterprises in the 18th century and later exploited by nationalist Spanish and Portuguese operations.[25] The Riotinto Mining Company – a giant among modern capitalist, corporate mining enterprises – traces its name and origins to the deeply layered history of exploitation of this landscape.

[22] For an expansive look at the organization of imperial mining, see Alfred Michael Hirt, *Imperial Mines and Quarries in the Roman World: Organizational Aspects 27 BC-AD 235* (Oxford: Oxford University Press, 2010).
[23] See especially Stuart Kirsch, *Mining Capitalism: The Relationship between Corporations and their Critics* (Oakland: University of California Press, 2014).
[24] On medieval mining in Andalucía, see Juan Aurelio Pérez Macías and Juan Luis Carriazo Rubio, eds., *Estudios de Minería Medieval en Andalucía* (Huelva: Universidad de Huelva, 2010). For more on the locations and chronologies of Roman era mines, see Claude Domergue, *Les Mines de la Péninsule Ibérique dans l'Antiquité Romaine* (Rome: École Française de Rome, 1990), 179–228; Claude Domergue, *Catalogue des Mines et des Fonderies Antiques de la Péninsule Iberique* (Madrid: Casa de Velázquez, 1987); Juan Aurelio Pérez Macías and Aquilino Delgado Domínguez, eds., *Las Minas de Riotinto en Época Julio-Claudia* (Huelva: Universidad de Huelva, 2007).
[25] For key works on these later histories, see Leonard Salkield, *A Technical History of the Rio Tinto Mines: Some Notes on Exploitation from Pre-Phoenician Times to the 1950s* (London: The Institution of Mining and Metallurgy, 1987); William Giles Nash, *The Rio Tinto Mine: Its History and Romance* (London: Simpkin Marshall Hamilton Kent and Co., Ltd., 1904); Manuel Flores Caballero, *La Nacionalización de las Minas de Río Tinto y la Formación de la Compañía Española* (Huelva: Universidad de Huelva, 2007); Artur Martins, Helena Alves, and Teresa Costa, *2000 Anos de Mineração em Aljustrel* (Aljustrel: Câmara Municipal de Aljustrel, 2003); S.G. Checkland, *The Mines of Tharsis: Roman, French and British Enterprise in Spain* (London: George Allen & Unwin Ltd., 1967).

ISSN 2576-0483

In the following sections of this paper, I explore two topics that provide a window into the organization of local economies at Roman Riotinto and Aljustrel: the organization of labor and the integration of state and private economic enterprises in the mining industry. These topics shed light on the ways in which our understanding of Roman economic growth intersects with local histories, and, ultimately, what these local histories can tell us about mining and capitalism.

Roman Mining and the Labor Market

Mining is the sector of the Roman economy that has perhaps been most associated with the widespread use of chattel slave labor and condemned prisoners. It is notoriously difficult, however, to identify forced or enslaved labor in the archaeological record given that being a slave or a condemned criminal was a juridical status and that there were no categories of labor in the Roman world that were exclusively restricted to slaves or free-born people.[26] This makes it nearly impossible to retroactively calculate, in any quantitative or even proportional sense, the number of unfree people working in mining in Roman Iberia, though it must have been sizeable. Although Moses Finley wrote little on mining in his work on the ancient economy, he declared that "throughout antiquity free miners were a negligible element,"[27] a view informed mainly by bleak descriptions of underground mining in Greek and Roman literary evidence.[28]

[26] For further discussion on identifying slaves in archaeology, see Ian Morris, "Archaeology and Greek Slavery," in *The Cambridge World History of Slavery*, ed. Keith Bradley and Paul Cartledge (Cambridge: Cambridge University Press, 2011), 176–93. On the restrictions on labor by status, see John Bodel, "Slave Labour and Roman Society," in *The Cambridge World History of Slavery*, ed. Keith Bradley and Paul Cartledge (Cambridge: Cambridge University Press, 2011), 311–36; Koenraad Verboven and Christian Laes, "Work, Labour and Professions. What's in a Name?," in *Work, Labour, and Professions in the Roman World*, ed. Koenraad Verboven and Christian Laes (Leiden and Boston: Brill, 2016), 1–20.

[27] Moses I. Finley, *The Ancient Economy*, 3rd edn. (Berkeley and Los Angeles: University of California Press, 1999), 72–73.

[28] Pliny, Strabo, and many ancient authors discussed Roman mines. The most topically relevant passages come from Diodorus Siculus's *History* and vividly describe the horrific work of slaves in Egyptian and Spanish mines (3.12-13.1, 5.36-38, respectively in: Charles H. Oldfather, trans., *Diodorus Siculus, "Library of History," Volume 2*, Loeb Classical Library 303 [Cambridge: Harvard University Press, 1935], 115–19; Charles H. Oldfather, trans., *Diodorus Siculus, "Library of History," Volume 3*, Loeb Classical Library 340 [Cambridge: Harvard University Press, 1939], 195–203). Evidence for condemned criminals (*damnatii ad metalla, damnatii in matalla*) comes mainly from later Christian law codes. See Fergus Millar, "Condemnation to Hard Labour in the Roman Empire,

ISSN 2576-0483

Yet this pervasive scholarly assumption that mining labor was dominated by unfree laborers overshadows other evidence that reveals the existence of a market for free-born or freed former slaves[29] who worked as entrepreneurs and wage laborers in Roman imperial mining. Recently, Miriam Groen-Vallinga and Laurens Tacoma have reminded us, "scholars have come up with more and more evidence that indicates that the labor force of the mines and quarries included not only convict and slave workers, but also freed and free, skilled and unskilled, as well as male and female laborers."[30] It is this evidence that I turn to now. An examination of mining labor in 1st and 2nd c. CE southwest Iberia suggests that, at least in this context, there was a well-functioning labor market that included free-born and freed workers laboring alongside slaves. This matters for our wider discussion because many of the arguments that identify the Roman economy as a capitalist system hinge on the contention that there were markets with capital, labor, and land.[31] Although these typically revolve around agricultural land and labor, a closer look at the organization of mining labor in southwest Iberia provides additional evidence of the heterogeneous workforce that comprised Roman labor markets.

The histories of free and freed people are typically easier to trace than those of their enslaved counterparts. In the case of early imperial Baetica and Lusitania, a robust tradition of funerary and legal epigraphy confirms the presence of a labor market for free and freed workers. Roman naming conventions and regional traditions of the epigraphic habit in Roman tombstones mean

from the Julio-Claudians to Constantine," *Papers of the British School at Rome* 52 (1984): 124–47; Mark Gustafson, "Condemnation to the Mines in the Later Roman Empire," *The Harvard Theological Review* 87, no. 4 (1994): 421–33; Pál Sáry, "The Rules of Condemnation to the Mines in Imperial Rome," *Journal on European History of Law* 2 (2015): 116–21.

[29] Here I use the term "free" to denote the juridical status of individuals who were not enslaved (either by the state or by private individuals) or imprisoned (by the state), and not, of course, individuals who were working for free.

[30] Miriam J. Groen-Vallinga and Laurens E. Tacoma, "Contextualising Condemnation to Hard Labour in the Roman Empire," in *Global Convict Labor*, ed. Christian Giuseppe De Vito and Alex Lichtenstein, Studies in Global Social History 19 (Boston and Leiden: Brill, 2015), 49–78, at 72.

[31] See the introduction to this volume; Fulcher, *Capitalism: A Very Short Introduction*, 17. The prevalence of slavery in a society is often viewed as an indication of a non-market economy, and, by extension as a possible indication of the absence of capitalism, see Peter Temin, "The Labor Market of the Early Roman Empire," *Journal of Interdisciplinary History* 34, no. 16 (2004): 513. This further underscores the importance of clarifying the labor system in Roman mining.

ISSN 2576-0483

that many epitaphs indicate a person's status as a free or freed person, their origin (*origo*), and their age, among other pieces of information. In his seminal work on mining in Roman Iberia, Claude Domergue compiled a list of stone funerary epitaphs found in close association with Roman mines across the peninsula, noting that many of these belonged to free immigrants.[32] Recently, Claire Holleran collected these and additional epitaphs found within 20 km of major Roman mines, mapping the *origo* of the deceased (when mentioned on the tombstone) or the origin implied by their name as well as and the place of burial for individuals in over 80 inscriptions.[33] Stated simply, her data suggest that free and freed people – including men, women, and children – who were buried near mines often came from long distances away: journeys ranged from 36 to 580 km with an average of 206 km.[34] All epigraphically attested migrants came from within the Iberian Peninsula, and movements from towns in the northern meseta and Lusitania to the mines in the southwest seem to have been particularly common. Of those epitaphs from Riotinto, two of the deceased came from Olisipo (Lisbon, Portugal), while others came from Augusta Emerita (Mérida, Spain) and Nova Augusta in the north.[35] In and around Aljustrel, immigrants are attested from Olisipo and Bracara Augusta (Braga, Portugal).[36]

It stands to reason that if people were voluntarily traveling such long distances from their homes to mining districts, they were doing so because of the demand for labor that arose in and around Roman mines. The opportunities that mining labor provided must have been a source of upward

[32] Claude Domergue, *Les Mines de la Péninsule Ibérique dans l'Antiquité Romaine*, 339–40.
[33] Claire Holleran, "Labour Mobility in the Roman World: A Case Study of Mines in Iberia," in *Migration and Mobility in the Early Roman Empire*, ed. Luuk de Ligt and Laurens E. Tacoma (Boston and Leiden: Brill, 2016), 95–136.
[34] Holleran, "Labour Mobility in the Roman World: A Case Study of Mines in Iberia," 114.
[35] Most of these come from the necropolis of La Dehesa, see Geraint Dyfed Barri Jones, "The Roman Mines at Riotinto," *Journal of Roman Studies* 70 (1980): 146–65; Linda Gosner, "Extraction and Empire: Multi-Scalar Approaches to Roman Mining Communities and Industrial Landscapes in Southwest Iberia," *Archaeological Review from Cambridge* 31, no. 2 (2016): 125–43.
[36] Holleran, "Labour Mobility in the Roman World: A Case Study of Mines in Iberia," 120–37.

ISSN 2576-0483

mobility, or at least economic gain, for those who were willing to engage in the dangerous menial labor of mining or who developed specialized skills in the industry (such as engineering, prospection, or equipment production). These patterns of migration also suggest that there were varied mechanisms for the recruitment of labor. Chain migration within families, communities, or towns might have developed organically. Enhanced communication between mining centers or between mining centers and urban places – a result of Roman imperial administrative and economic networks – might also have provided a means for direct recruitment of wage labor. This phenomenon was certainly not limited to southwest Iberia; labor contracts exist from the Roman imperial quarries at Mons Claudianus as well as the gold mines of Alburnus Maior in Dacia, imperial *metalla* which also attracted paid laborers from distant origins.[37] Forcible resettlement of labor also played a role in certain cases.[38]

If free laborers could profit from their participation in the labor market, what was the benefit to the Roman state of using this labor source? Another epigraphic source provides some insight, showing the way that the state handed over both general organizational responsibility and risk to free people who served as *occupatores* (occupants) or *coloni* (tenants) who held possession of mining concessions. A large copper alloy tablet (Vipasca II) – one of two from Aljustrel – records a letter to the *procurator metallorum* Ulpius Aelianus from the Emperor Hadrian that outlines mining laws for the *metalla* of Vipasca, laws which were likely applicable to other contemporary mining districts in southwest Iberia with similar geological requirements and administrative oversight.[39] Important here are two passages that detail the payments owed by

[37] Hélène Cuvigny, "The Amount of Wages Paid to the Quarry-Workers at Mons Claudianus," *Journal of Roman Studies* 86 (1996): 139–45; Holleran, "Labour Mobility in the Roman World: A Case Study of Mines in Iberia," 95; Dennis P. Kehoe, "Contract Labor," in *The Cambridge Companion to the Roman Economy*, ed. Walter Scheidel (Cambridge: Cambridge University Press, 2012), 114–30.
[38] For a summary of scholarship see Hirt, *Imperial Mines and Quarries in the Roman World.*
[39] Now stored in the Museu Nacional de Arqueologia, Lisbon (989.35.1); FIRA I, 204. For recent translations and historical background see Sergio Lazzarini, *Lex Metallis Dicta: Studi sulla Seconda Tavola di Vipasca* (Rome: L'Erma di Bretschneider, 2001); Claude Domergue, *La Mine Antique d'Aljustrel (Portugal) et les Tables de*

ISSN 2576-0483

the *colonus* to the Roman state. For the working of copper, half of the ore discovered in a shaft was property of the imperial *fiscus* and had to be paid before the ore was smelted. If the occupant did not pay his share, he forfeited his half as well as his claim to the mining shaft. Anyone who reported this transgression would receive a quarter of the sum owed to the *fiscus*.[40] The second passage details the procedure for silver mines at Vipasca: the *colonus* takes ownership of the shaft only after offering a price and paying 4000 *sesterces* to the *fiscus*. While the exact procedures for each of these transactions have been much debated,[41] what is key here is the way in which the state relied on the work of free *coloni* and *occupatori* to handle the logistics and assume the associated risks of underground copper and silver mining. These risks might range from personal injury, to loss of slaves and workers, to payment of their workforce even when shafts produced very little ore.

Several other passages from Vipasca II lay out punishments for transgressions such as stealing ore, endangering safety in underground workings, and damaging drainage ditches, among other offenses. They provide further evidence for a market in specialized mining labor by suggesting it would be a serious loss in livelihood for workers to be cut off from access to this market. Importantly, each describes different penalties for both enslaved and free workers. In general, slaves were whipped, sold, and forbidden from working at Vipasca or other mining districts. Free people, by contrast, forfeited their property to the procurator and were barred from work in the mining district. From these passages, we can infer that slaves were regularly used by the concession owners as labor in the mines alongside free, paid laborers for the same types of

Bronze de Vipasca (Paris: Publications du Centre Pierre Paris (E.R.A. 522), 1983); Jonathan C. Edmondson, *Two Industries in Roman Lusitania: Mining and Garum Production* (Oxford: BAR International Series (362), 1987).

[40] The document does not specify whether this is the *fiscus Caesaris,* the private funds of the emperor, or the *fiscus provinciae, part of the aerarium Saturni* containing public money of the provinces. See Hirt, *Imperial Mines and Quarries in the Roman World*, 172.

[41] For a recent summary of historical debates and current status, see: Hirt, *Imperial Mines and Quarries in the Roman World*, 262–69.

ISSN 2576-0483

work. The law incentivizes the owners of the slaves to keep their workers in line or risk loss of their financial investment in human capital. Further, because punishments regularly involved free workers being banned from mining, it is clear that miners relied on the possibility of remaining in the profession – using their learned expertise and social connections to sustain their livelihoods – enough to fear such a punishment.

In sum, the epigraphic evidence suggests that Roman imperial mining in southwest Iberia created a market for free labor that drew workers from near and far. The imperial administration benefited from this system because it was able to distribute the economic risks involved in exploitation of public mines to private actors while still receiving a large portion of the profit. The system was not limited to providing a market for mining work, however, but extended into other aspects of local and regional economies. It is to the integration of imperial mining with other industries and the reliance on provincial economies and local markets that I turn next.

Integrated Industries: Roman Imperial Mining and Local Production

Recent work on the Roman imperial economy has been criticized for its lack of attention to economic integration between state-driven and private economic activities and its primary focus on large-scale imperial trade. As Eli Weaverdyck reminded us in a recent review of Andrew Wilson's edited volume on trade, commerce and the Roman state, "real questions remain about the integration of areas off the main trade routes and the relative importance of macro-regional vs. empire-wide trade."[42] The significance of southwest Iberian mining to the imperial economy at a macro-scale cannot be brought into question given the ubiquity of metals from this region in coinage and other products that were used and distributed throughout the

[42] Eli J. S. Weaverdyck, review of *Trade, Commerce, and the State in the Roman World*, ed. Andrew Wilson, Oxford Studies on the Roman Economy (Oxford; New York: Oxford University Press, 2018), *Bryn Mawr Classical Review* (2018), np.

ISSN 2576-0483

Roman Mediterranean. Scholarly emphasis on the imperial economy and the state-oversight of mining, however, has eclipsed some of the ways that the imperial industry relied on local and regional industries (and, by extension, became integrated with and stimulated local and regional economies). In this section, I examine the integration of public and private enterprise in mining and subsidiary industries, including tools and equipment for mining as well as other services required for daily life in mining towns.

The requirements of mining in any period are shaped by the character of the landscape, most importantly its geology, its natural resources, and its connection to wider networks of trade and communication. The landscapes of Riotinto and Aljustrel today are dominated by enormous, barren opencast mines. While technologies developed after the Industrial Revolution for the processing of low-grade ores facilitated the profitability of open pit mining, the geological formation of the Iberian Pyrite Belt – with silver deposits close to the surface and rich copper deposits much deeper – meant that copper could only be accessed through complex underground networks of shafts and galleries.[43] These tunnels had to be excavated with picks, illuminated with oil lamps and torches, cleared with baskets and buckets, and then reinforced for safety with wooden scaffolding and ladders. Many of these passages extended below the water table, which created the need for constant drainage and additional logistical barriers to underground work. This was carried out by bailing water out by hand, as well as through the use of various water-lifting technologies such as mechanical bucket chains, Archimedean screws, and water wheels.[44]

[43] Leonard Salkield, *A Technical History of the Rio Tinto Mines: Some Notes on Exploitation from Pre-Phoenician Times to the 1950s* (London: The Institution of Mining and Metallurgy, 1987), 478.
[44] Domergue, *Les Mines de la Péninsule Ibérique dans l'Antiquité Romaine*, 401–62; Gosner, "Extraction and Empire: Multi-Scalar Approaches to Roman Mining Communities and Industrial Landscapes in Southwest Iberia," 130–34; R. E. Palmer, "Notes on Some Ancient Mine Equipments and Systems," *Transactions of the Institution of Mining and Metallurgy* 35 (1927): 299–336; Aquilino Delgado Domínguez and Maria de la Cinta Regalado Ortega, "*Rotae Urionensis*. Las Norias Romanas de Riotinto (Huelva, España)," in *Patrimonio Geológico y Minero: Una Apuesta por el Desarrollo Local Sostenible*, ed. Emilio M. Romero Macías (Huelva: Universidad de Huelva, 2010), 659–75; Antonio Blanco-Freijeiro, "Antigüedades de Riotinto," *Zephyrus* 13 (1962): 31–45; Pedro

ISSN 2576-0483

A great number of tools have been recovered from both Aljustrel and Riotinto – often discovered by later miners in the course of opencast mining in areas of former Roman workings[45] – and these help to shed light on the local and regional industries involved in imperial mining enterprises.

Many pieces of equipment were woven from esparto grass, a perennial plant that grows across southern Spain, which was used from early in prehistory for textiles and basketry.[46] In Roman mining districts, esparto producers crafted equipment for use in underground mines, including two-handled baskets, rope, caps for protecting miners' heads, and sandals.[47] Many of these survived in the anaerobic environments of underground mines. Their varied weaving styles and unstandardized sizes suggest that this was not an industry that was overseen directly or controlled by the Roman imperial administration as a part of mining operations, but rather one whose practitioners benefitted from their proximity to mines by altering their production strategies to serve the needs of the growing mining industry. That esparto harvesting, processing, and weaving is a complex, seasonal process that would have been much more familiar to local inhabitants of Iberia than newcomers from elsewhere also lends support to this

Manzano Beltrán, Reyes Ojeda Calvo, and Eduardo Rodríguez Trobajo, "Las Ruedas de Achique Romanas de Riotinto a La Luz de la Intervención en la 'Rota Aquaria' del Museo de Huelva," in *Las Técnicas y las Construcciones en la Ingeniería Romana*, ed. Isaac Moreno Gallo (Madrid: Congreso de las Obras Públicas Romanas, 2010), 347–80; Aquilino Delgado Domínguez and Juan Aurelio Pérez Macías, "Artífices e Industrias Auxiliares en las Minas Hispanas," in *Artifices Idoneos: Artesanos, Talleres y Manufacturas en Hispania*, ed. Macarena Bustamante Álvarez and Darío Bernal Casasola (Mérida: Anejos de la AEspA LXXI, 2014), 389–420.

[45] Juan Aurelio Pérez Macías and Aquilino Delgado Domínguez, "Obras de Romanos en Riotinto según las Noticias de los Ingenieros de Minas de los Siglos XVIII y XIX," *Italica* 1 (2011): 87–103.

[46] Joaquín Fernández Pérez, "Algunos Especies Vegetales de Uso Industrial en la Época Romana," in *Artifex: Ingenería Romana En España (Museo Arqueológico Nacional)*, ed. Igancio González Tascón (Madrid: Fundación Juanel Turriano, 2002), 315–30; José Fajardo et al., "Traditional Craft Techniques of Esparto Grass (*Stipa tenacissima L.*) in Spain," *Economic Botany* 20, no. 10 (2015): 1–7; Carmen Cacho Quesada et al., "La Cestería Decorada de la Cueva de Los Murciélagos (Albuñol, Granada)," *Complutum Extra* 6, no. 1 (1996): 105–22.

[47] Examples from Aljustrel are on display at the Geological Museum of Portugal (Lisbon) and from Riotinto at the Museum of Huelva and the Rio Tinto Mining Museum. Delgado Domínguez and Pérez Macías, "Artífices e Industrias Auxiliares en las Minas Hispanas," 407–10; Juan Aurelio Pérez Macías and Aquilinio Delgado Domínguez, "Materialies Precederos en las Minas Romanas de Hispania," in *Emphemeral Archaeology*, ed. Angel Morillo Cerdán, Marcus Heinrich Hermanns, and Javier Salido Domínguez (Mainz am Rhein: Nünnerich-Asmus Verlag & Media, 2019), 231–48, at 243–46.

ISSN 2576-0483

hypothesis. In effect, increased Roman mining stimulated local economies of esparto weaving by providing a new market for its products. Although this is one example, it is easy to reason that mining may have stimulated other less visible industries such as textile manufacture for specialized uniforms, to medicinal and first-aid products for mining-related ailments, to logging for fuel to smelt ore and equipment to build water wheels and scaffolding.

Outside of those industries directly related to mining, Roman mining communities in southwest Iberia also relied on local and regional networks for their supply of food and other services. Amphorae that were imported to mining districts can serve as a useful proxy for understanding economies surrounding food. Assemblages from mining settlements at Riotinto show increased access to goods from nearby production centers in Baetica and Lusitania as well as items imported from Italy and elsewhere. The settlement of Cerro del Moro (Nerva, Spain), one of a constellation of mining towns excavated near Riotinto, has produced a wealth of ceramic material from its short-lived occupation period from about 27 BCE to 14 CE.[48] The most common amphorae type was Haltern 70, a form associated with Baetican production centers of olive and wine products along the Guadalquivir River, including Hispalis, Orippo, and Puente Melchor. Other forms included Dressel 7-11 from production centers in the Bay of Cádiz and Dressel 20 amphorae, produced across Baetica for olive oil.[49] In general, amphorae indicate that the town relied on nearby production centers for the supply of most of their foodstuffs. Much of the other domestic pottery is also of local or regional origin, including cooking pots with ovoid bodies and Late Iberian ceramic forms common across southwest Iberia in the first half of the 1st

[48] Paul Craddock, Ian C. Freestone, and Mark Hunt, "Recovery of Silver from Speiss at Rio Tinto (SW Spain)," *Institute for Archaeo-Metallurgical Studies Newsletter* 10/11 (1987): 8; Oliver Davies, *Roman Mines in Europe* (Oxford: Clarendon Press, 1935), 128; Juan Aurelio Pérez Macías, *El Cerro del Moro: Campaña Arqueometalurgia de 1984 (Nerva, Huelva)* (Nerva: Ayuntamiento de la Villa de Nerva, 1984).
[49] Juan Aurelio Pérez Macías and Aquilino Delgado Domínguez, "Los Metalla de Riotinto en Época Julio-Claudia," in *Las Minas de Riotinto en Época Julio-Claudia*, ed. Juan Aurelio Pérez Macías and Aquilino Delgado Domínguez (Huelva: Universidad de Huelva, 2007), 37–184, at 63–72.

ISSN 2576-0483

century CE.[50] While Cerro del Moro did have some imported ware from Italy, namely Pompeiian red ware plates and *terra sigillata Italica*, it appears that most wares associated with the distribution and consumption of food products were of local or regional origin.[51] Agricultural production, therefore, was another industry whose practitioners stood to profit from the daily requirements of the increased population of specialized laborers in Roman mining districts.

To explore other industries that supported the mining community, we can return again to the mining laws from Vipasca. The *Lex Metallis Vipacensis* (Vipasca I) is another law tablet uncovered from slag heaps at Aljustrel.[52] While the tablet discussed above outlines laws related to mining, this one imposes rules for the governance of the mining district and puts limits on certain professions within the town of Vipasca. Shoemakers, barbers, fullers, auctioneers, and public bath operators were required to lease permission to carry out their work, and only those holding the official concession were allowed to operate within the *metallum*. For instance, the barber who had acquired the mining contract could hire additional workers, but itinerant barbers were not allowed to practice their trade within the *metallum*. Slaves were allowed to cut their master's hair at home, but could not do so for profit in the wider community (VIP I.5[53]).

While this system would have reduced competition within Vipasca in a decidedly uncapitalist way, it does give us more insight into the relationship between imperial oversight, labor markets, and regional economies. The concession system for leasing rights to these professions must have produced only a minor profit for the imperial administration, so one larger goal of

[50] Pérez Macías, *El Cerro Del Moro: Campaña Arqueometalurgia de 1984 (Nerva, Huelva)*, 6–32.
[51] Ibid., 30.
[52] *Corpus Inscriptionum Latinarum* II, 5181=FIRA I, 108. Now in the Geological Museum of Portugal (Lisbon). Domergue, *La Mine Antique d'Aljustrel (Portugal) et les Tables de Bronze de Vipasca*.
[53] Line divisions based on Jonathan Edmondson's translation: Edmondson, *Two Industries in Roman Lusitania: Mining and Garum Production*.

ISSN 2576-0483

codifying these laws must have been to ensure that the needs of the town were met, thereby promoting efficient production in mining and ultimately increased output. As mines in southwest Iberia grew rapidly, mining districts may not have had local labor available to supply basic services that were necessary for everyday life. The market for free labor in mining districts described above may not have been limited to those working directly in mining, but could include those who worked in these various service or subsidiary industries. This also helps to explain the gender and age diversity of those who came to southwest Iberia as immigrants. The demands of the imperial economy, therefore, stimulated regional markets for specialized labor where they did not previously exist.

Ultimately, the Roman imperial mining industry distorted economies and monumentally increased local demand for specific goods and services. What is key here is that these demands were not met simply by imperial mandates, but through gradual shifts in production and distribution of products (and labor) derived from local and regional industries. Here, the local esparto industry grew and transformed its output in accordance with the demands of underground mining; suppliers of wine and olive oil expanded their market to include regions that had been able to supply these needs locally prior to the rise in imperial mining; and the demands for services of growing communities were filled by skilled laborers who tapped into the shifting needs of the labor market in imperial mining districts.

Concluding Lessons: Mining and Capitalism in Long-Term Perspective

The conclusions and evidence I have presented here are not novel to the scholar familiar with Roman mining archaeology and epigraphy in Hispania; the Vipasca tablets, the epitaphs, as well as the archaeological remains of tools and equipment and of the mines themselves have long been discussed among scholars specializing in the archaeology and history of mining in

ISSN 2576-0483

Roman Iberia. Nevertheless, my discussion of labor and economic integration has provided a window into some of the ways that activities and behaviors typically associated with capitalist economic systems were already at play in the economies of Roman mining. There were labor markets, risk was allocated to private individuals, economic systems were integrated at various scales, and local industries were stimulated by global needs. I hope what is interesting is not the early appearance of these phenomena, but rather the productive possibilities this opens up for contextualization and comparison. Mining may offer more potential for diachronic comparison than other facets of the economy simply because the basic task of mining, to extract minerals, has always remained unchanged through time. As Bathseba Demuth has written, "The original state of these nonhuman elements mattered for how human muscle and ingenuity could operate."[54] Thus, comparing better-documented labor markets and economic integration in similar geological landscapes – such as in the copper-mining towns of the American West or in Spanish colonial silver mining in Mexico – can aid us in thinking through the possibilities for the organization of labor in Roman mining *and* to further contextualize Roman mining within our narrative of the imperial economy.

In sum, the attention I have given to local histories and small-scale evidence should encourage the economic historian to take a second look at the role of mining in the Roman economy and in global economic history. This was an industry very much dominated and distorted by the needs and desires of the Roman imperial government, and it is therefore a sector of the Roman economy that we might expect to exhibit the fewest capitalist tendencies. However, I have shown that using the language of capitalism as an exploratory tool opens up new possibilities for analysis of our existing evidence, for integrating Roman mining more thoroughly into other

[54] Bathsheba Demuth, "Grounding Capitalism: Geology, Labor, and the Nome Gold Rush," in *A Global History of Gold Rushes*, ed. Benjamin Mountford and Stephen Tuffnell (Oakland: University of California Press, 2018), 254.

ISSN 2576-0483

wide-ranging discussions of the Roman economy, and for bridging the pre- and post-Industrial Revolution chronological barrier that has constricted studies of mining landscapes. In short, the language of capitalism can be a tool to think with – here, to explore the possibilities and implications of labor markets in Roman mining as well as the integration of the Roman economy at multiple scales and across industries.

ISSN 2576-0483

Bibliography

Primary and Reference

Corpus Inscriptionum Latinarum. https://arachne.uni-koeln.de/drupal/?q=en/node/291

Diodorus Siculus. *Library of History.* Charles H. Oldfather, trans. *Diodorus Siculus, "Library of History," Volume 2*. Loeb Classical Library 303. Cambridge: Harvard University Press, 1935; Charles H. Oldfather, trans. *Diodorus Siculus, "Library of History," Volume 3*. Loeb Classical Library 340. Cambridge: Harvard University Press, 1939.

Secondary

Aubet, Maria Eugenia. *The Phoenicians and the West: Politics, Colonies, and Trade*. 2nd edition. Cambridge: Cambridge University Press, 2001.

Bang, Peter Fibiger. "The Ancient Economy and New Institutional Economics." *Journal of Roman Studies* 99 (2009): 194–206.

Blanco-Freijeiro, Antonio. "Antigüedades de Riotinto." *Zephyrus* 13 (1962): 31–45.

Bodel, John. "Slave Labour and Roman Society." In *The Cambridge World History of Slavery*, edited by Keith Bradley and Paul Cartledge, 311–36. Cambridge: Cambridge University Press, 2011.

Cacho Quesada, Carmen, Conceptión Papí Rodes, Sánchez-Barriga Fernandez, and Fernán Alonso Mathias. "La Cestería Decorada de La Cueva de Los Murciélagos (Albuñol, Granada)." *Complutum Extra* 6, no. 1 (1996): 105–22.

Checkland, S. G. *The Mines of Tharsis: Roman, French and British Enterprise in Spain*. London: George Allen & Unwin Ltd., 1967.

Craddock, Paul, Ian C. Freestone, and Mark Hunt Ortiz. "Recovery of Silver from Speiss at Rio Tinto (SW Spain)." *Institute for Archaeo-Metallurgical Studies Newsletter* 10/11 (1987): 8–11.

Cuvigny, Hélène. "The Amount of Wages Paid to the Quarry-Workers at Mons Claudianus." *Journal of Roman Studies* 86 (1996): 139–45.

Davies, Oliver. *Roman Mines in Europe*. Oxford: Clarendon Press, 1935.

Day, Joan, and Ronald F. Tylecote, eds. *The Industrial Revolution in Metals*. London: The Institute of Metals, 1991.

Delgado Domínguez, Aquilino, and Juan Aurelio Pérez Macías. "Artífices e Industrias Auxiliares en las Minas Hispanas." In *Artifices Idoneos: Artesanos, Talleres y Manufacturas en Hispania*, edited by Macarena Bustamante Álvarez and Darío Bernal Casasola, 389–420. Mérida: Anejos de la AEspA LXXI, 2014.

Delgado Domínguez, Aquilino, and Maria de la Cinta Regalado Ortega. "*Rotae Urionensis*. Las Norias Romanas de Riotinto (Huelva, España)." In *Patrimonio Geológico y Minero: Una*

ISSN 2576-0483

Apuesta por el Desarrollo Local Sostenible, edited by Emilio M. Romero Macías, 659–75. Huelva: Universidad de Huelva, 2010.

Demuth, Bathsheba. "Grounding Capitalism: Geology, Labor, and the Nome Gold Rush." In *A Global History of Gold Rushes*, edited by Benjamin Mountford and Stephen Tuffnell, 252–72. Oakland: University of California Press, 2018.

Domergue, Claude. *Catalogue des Mines et des Fonderies Antiques de la Péninsule Iberique*. Madrid: Casa de Velázquez, 1987.

———. *La Mine Antique d'Aljustrel (Portugal) et les Tables de Bronze de Vipasca*. Paris: Publications du Centre Pierre Paris (E.R.A. 522), 1983.

———. *Les Mines de La Péninsule Ibérique dans l'Antiquité Romaine*. Rome: École Française de Rome, 1990.

Edmondson, Jonathan C. *Two Industries in Roman Lusitania: Mining and Garum Production*. Oxford: BAR International Series (362), 1987.

Erdkamp, Paul. "Economic Growth in the Roman Mediterranean World: An Early Good-Bye to Malthus?" *Explorations in Economic History* 60 (2016): 1–20.

Fajardo, José, Alonso Verde, Diego Rivera, Concepción Obón, and Susan Leopold. "Traditional Craft Techniques of Esparto Grass (*Stipa tenacissima L.*) in Spain." *Economic Botany* 20, no. 10 (2015): 1–7.

Fernández Pérez, Joaquín. "Algunos Especies Vegetales de Uso Industrial en la Época Romana." In *Artifex: Ingeniería Romana en España (Museo Arqueológico Nacional)*, edited by Igancio González Tascón, 315–30. Madrid: Fundación Juanel Turriano, 2002.

Finley, Moses I. *The Ancient Economy*. 3rd edition. Berkeley and Los Angeles: University of California Press, 1999.

Flores Caballero, Manuel. *La Nacionalización de las Minas de Río Tinto y la Formación de la Compañía Española*. Huelva: Universidad de Huelva, 2007.

Fulcher, James. *Capitalism: A Very Short Introduction*. 2nd edition. Oxford: Oxford University Press, 2015.

García Palomero, Felix. "Yacimientos de la Faja Pirita Iberica (F.P.I)." In *Metallum. La Minería Suribérica*, edited by Emilio Romero Macías and Juan Aurelio Pérez Macías, 13–29. Huelva: Universidade de Huelva Publicaciones, 2004.

Gibbons, Wes, and Teresa Morena, eds. *The Geology of Spain*. London: The Geological Society, 2002.

Gosner, Linda. "Archaeology of Mining." In *Encyclopedia of Global Archaeology*, edited by Claire Smith, 1–19. 2nd edition. Berlin: Springer, 2019.

ISSN 2576-0483

———. “Extraction and Empire: Multi-Scalar Approaches to Roman Mining Communities and Industrial Landscapes in Southwest Iberia.” *Archaeological Review from Cambridge* 31, no. 2 (2016): 125–43.

Graulau, Jeannette. “Capitalist Miners in Feudal Europe: A Commentary on Marxist Agrarian History.” *Journal of Agrarian Change* (2019): 1–18.

———. *The Underground Wealth of Nations: On the Capitalist Origins of Silver Mining, A.D. 1150-1450*. New Haven: Yale University Press, 2019.

Groen-Vallinga, Miriam J., and Laurens E. Tacoma. “Contextualising Condemnation to Hard Labour in the Roman Empire.” In *Global Convict Labor*, edited by Christian Giuseppe De Vito and Alex Lichtenstein, 49–78. Studies in Global Social History 19. Boston and Leiden: Brill, 2015.

Gustafson, Mark. “Condemnation to the Mines in the Later Roman Empire.” *The Harvard Theological Review* 87, no. 4 (1994): 421–33.

Hirt, Alfred Michael. *Imperial Mines and Quarries in the Roman World: Organizational Aspects 27 BC-AD 235*. Oxford: Oxford University Press, 2010.

Hobson, Matthew S. “A Historiography of the Study of the Roman Economy: Economic Growth, Development, and Neoliberalism.” In *Theoretical Roman Archaeology Conference 2013: Proceedings of the Twenty-Third Theoretical Roman Archaeology Conference, King’s College, London*, edited by Hannah Platts, John Pearce, Caroline Barron, Jason Lundock, and Justin Yoo, 11–26. Oxford: Oxbow Books, 2014.

Holleran, Claire. “Labour Mobility in the Roman World: A Case Study of Mines in Iberia.” In *Migration and Mobility in the Early Roman Empire*, edited by Luuk de Ligt and Laurens E. Tacoma, 95–136. Boston and Leiden: Brill, 2016.

Hong, Sungmin, Jean-Pierre Candelone, Clair C. Patterson, and Claude F. Boutron. “Greenland Ice Evidence of Hemispheric Lead Pollution Two Millennia Ago by Greek and Roman Civilizations.” *Science, New Series* 265, no. 5180 (1994): 1841–43.

———. “History of Ancient Copper Smelting Pollution During Roman and Medieval Times Recorded in Greenland Ice.” *Science, New Series* 272, no. 5259 (1996): 246–49.

Howgego, Christopher. “The Supply and Use of Money in the Roman World 200 BC to AD 300.” *Journal of Roman Studies* 82 (1992): 1–31.

Hunt Ortiz, Mark A. *Prehistoric Mining and Metallurgy in the South West Iberian Peninsula*. Oxford: BAR International Series (1188), 2003.

Jones, Geraint Dyfed Barri. “The Roman Mines at Riotinto.” *Journal of Roman Studies* 70 (1980): 146–65.

Jongman, Willem M. “Re-Constructing the Roman Economy.” In *The Cambridge History of Capitalism Volume I: The Rise of Capitalism: From Ancient Origins to 1848*, edited by Larry Neal and Jeffrey G. Williamson, 75–100. Cambridge: Cambridge University Press, 2014.

ISSN 2576-0483

Kehoe, Dennis P. "Contract Labor." In *The Cambridge Companion to the Roman Economy*, edited by Walter Scheidel, 114–30. Cambridge: Cambridge University Press, 2012.

Kirsch, Stuart. *Mining Capitalism: The Relationship between Corporations and their Critics*. Oakland: University of California Press, 2014.

Klein, Sabine, Yann Lahaye, Gerhard P. Brey, and Hans-Markus von Kaenel. "The Early Roman Imperial AES Coinage II: Tracing the Copper Sources by Analysis of Lead and Copper Isotopes—Copper Coins of Augustus and Tiberius." *Archaeometry* 46, no. 3 (2004): 469–80.

Lazzarini, Sergio. *Lex Metallis Dicta: Studi sulla Seconda Tavola di Vipasca*. Rome: L'Erma di Bretschneider, 2001.

López Sánchez, Fernando. "The Mining, Minting, and the Acquisition of Gold in the Roman and Post-Roman World." In *Ownership and Exploitation of Land and Natural Resources in the Roman World*, edited by Paul Erdkamp, Koenraad Verboven, and Arjan Zuiderhoek, 315–36. Oxford: Oxford University Press, 2015.

Manzano Beltrán, Pedro, Reyes Ojeda Calvo, and Eduardo Rodríguez Trobajo. "Las Ruedas de Achique Romanas de Riotinto a la Luz de la Intervención en la 'Rota Aquaria' del Museo de Huelva." In *Las Técnicas y las Construcciones en la Ingeniería Romana*, edited by Isaac Moreno Gallo, 347–80. Madrid: Congreso de las Obras Públicas Romanas, 2010.

Martins, Artur, Helena Alves, and Teresa Costa. *2000 Anos de Mineração em Aljustrel*. Aljustrel: Câmara Municipal de Aljustrel, 2003.

Mattingly, David J., and John Salmon. "The Productive Past: Economies Beyond Agriculture." In *Economies Beyond Agriculture in the Classical World*, edited by David J. Mattingly and John Salmon, 1–13. London and New York: Routledge, 2001.

McConnell, Joseph R., Andrew I. Wilson, Andreas Stohl, Monica M. Arienzo, Nathan J. Chellman, Sabine Eckhardt, Elisabeth M. Thompson, A. Mark Pollard, and Jørgen Peder Steffensen. "Lead Pollution Recorded in Greenland Ice Indicates European Emissions Tracked Plagues, Wars, and Imperial Expansion during Antiquity." *Proceedings of the National Academy of Sciences* 115, no. 22 (2018): 5726–31.

Millar, Fergus. "Condemnation to Hard Labour in the Roman Empire, from the Julio-Claudians to Constantine." *Papers of the British School at Rome* 52 (1984): 124–47.

Morris, Ian. "Archaeology and Greek Slavery." In *The Cambridge World History of Slavery*, edited by Keith Bradley and Paul Cartledge, 176–93. Cambridge: Cambridge University Press, 2011.

Nash, William Giles. *The Rio Tinto Mine: Its History and Romance*. London: Simpkin Marshall Hamilton Kent and Co., Ltd., 1904.

Palmer, R. E. "Notes on Some Ancient Mine Equipments and Systems." *Transactions of the Institution of Mining and Metallurgy* 35 (1927): 299–336.

ISSN 2576-0483

Pérez Macías, Juan Aurelio. *El Cerro del Moro: Campaña Arqueometalurgia de 1984 (Nerva, Huelva)*. Nerva: Ayuntamiento de la Villa de Nerva, 1984.

———. "Patrimonio Arqueológico de la Faja Pirítica Ibérica." In *Arqueología y Patrimonio en La Faja Pirítica Ibérica: Actas de la I Jornada de Arqueología, Historia y Minerá de la Faja Pirítica Ibérica*, edited by José Suárez Suárez and Noemí Raposo Gutiérrez, 23–54. Huelva: Asociación Herrerías, 2018.

Pérez Macías, Juan Aurelio, and Aquilinio Delgado Domínguez, eds. *Las Minas de Riotinto En Época Julio-Claudia*. Huelva: Universidad de Huelva, 2007.

———. "Los Metalla de Riotinto en Época Julio-Claudia." In *Las Minas de Riotinto en Época Julio-Claudia*, edited by Juan A. Pérez Macías and Aquilino Delgado Domínguez, 37–184. Huelva: Universidad de Huelva, 2007.

———. "Materialies Precederos en las Minas Romanas de Hispania." In *Emphemeral Archaeology*, edited by Angel Morillo Cerdán, Marcus Heinrich Hermanns, and Javier Salido Domínguez, 231–48. Mainz am Rhein: Nünnerich-Asmus Verlag & Media, 2019.

———. "Obras de Romanos en Riotinto Según las Noticias de los Ingenieros de Minas de los Siglos XVIII y XIX." *Italica* 1 (2011): 87–103.

Pérez Macías, Juan Aurelio, and Juan Luis Carriazo Rubio, eds. *Estudios de Minería Medieval en Andalucía*. Huelva: Universidad de Huelva, 2010.

Ponting, Matthew J. "The Substance of Coinage: The Role of Scientific Analysis in Ancient Numismatics." In *The Oxford Handbook of Greek and Roman Coinage*, edited by William E. Metcalf, 1–20. Oxford: Oxford University Press, 2012.

Ponting, Matthew J., Jane A. Evans, and Vanessa Pashley. "Fingerprinting of Roman Mints Using Laser-Ablation MC-ICP-MS Lead Isotope Analysis." *Archaeometry* 4 (2003): 591–97.

Ripollès, Pere P. "The Ancient Coinages of the Iberian Peninsula." In *The Oxford Handbook of Greek and Roman Coinage*, edited by William E. Metcalf, 1–23. Oxford: Oxford University Press, 2012.

Rodá, Isabel. "Hispania: From the Roman Republic to the Reign of Augustus." In *A Companion to the Archaeology of the Roman Republic*, edited by Jane DeRose Evans, 522–39. Malden: Blackwell Publishing, Ltd., 2013.

Rosman, Kevin J. R., Warrick Chisholm, Sungmin Hong, Jean-Pierre Candelone, and Claude F. Boutron. "Lead from Carthaginian and Roman Spanish Mines Isotopically Identified in Greenland Ice Dated from 600 BC to 300 AD." *Environmental Science and Technology* 31, no. 12 (1997): 3413–16.

Rothenberg, Beno, and Antonio Blanco-Freijeiro. *Studies in Ancient Mining and Metallurgy in South-West Spain: Explorations and Excavations in the Province of Huelva*. London: Institute for Archaeo-Metallurgical Studies, 1981.

ISSN 2576-0483

Salkield, Leonard. *A Technical History of the Rio Tinto Mines: Some Notes on Exploitation from Pre-Phoenician Times to the 1950s*. London: The Institution of Mining and Metallurgy, 1987.

Sáry, Pál. "The Rules of Condemnation to the Mines in Imperial Rome." *Journal on European History of Law* 2 (2015): 116–21.

Scheidel, Walter. "In Search of Roman Economic Growth." *Journal of Roman Archaeology* 22 (2009): 46–70.

Temin, Peter. "The Labor Market of the Early Roman Empire." *Journal of Interdisciplinary History* 34, no. 16 (2004): 513–38.

Verboven, Koenraad, and Christian Laes. "Work, Labour and Professions. What's in a Name?" In *Work, Labour, and Professions in the Roman World*, edited by Koenraad Verboven and Christian Laes, 1–20. Boston and Leiden: Brill, 2016.

Weaverdyck, Eli J. S. Review of *Trade, Commerce, and the State in the Roman World*, edited by Andrew Wilson. Oxford Studies on the Roman Economy. Oxford; New York: Oxford University Press, 2018. *Bryn Mawr Classical Review* (2018), np.

Wilson, Andrew. "Indicators for Roman Economic Growth: A Response to Walter Scheidel." *Journal of Roman Archaeology* 22 (2009): 72–82.

———. "Machines, Power and the Ancient Economy." *Journal of Roman Studies* 92 (2002): 1–32.

ISSN 2576-0483