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Capitalism and Global Mining: Latin American Perspectives 1500-1914²

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Abstract. Objective/Context: The paper provides a comprehensive overview of Latin American mining history, exploring cross-pollination opportunities between mining historians and scholars of the emerging field of the new history of capitalism. The analysis spans from the region's integration into global markets during the 1500s to the twilight of export-led growth in the early twentieth century. **Methodology:** The study builds on an overview of both classic and contemporary literature, offering new insights into understanding existing data on mining history within a global context. By incorporating perspectives from geology, ecology, and economics, the article investigates the connections between specific mineral deposits and different paths of capitalistic development across Latin America. **Originality:** The paper sketches some of the gaps in the analysis of global and local flows of minerals and comments on notable contributions to the broader field of Latin American history. It introduces innovative approaches for the study of output cycles, geological and ecological endowments, technological spillovers, and mining economics. **Conclusions:** First, the existing literature has predominantly focused on precious metals, with few scholars studying non-precious metals and non-metallic minerals. Second, the narratives surrounding mining history have been primarily centered on silver, overshadowing the significance of bimetallism in understanding the emergence of global capitalism. Thirdly, examining the microeconomic dynamics of mining in the region may present fresh opportunities to explore the impact of mining on sectoral and managerial transformations. Finally, studies of the two-way interaction of capitalism and mining need to include research on the energy and environmental systems that underpinned mineral extraction and production.

Keywords: bullion flows, capitalism, economic growth, global history, Latin America, mining.

Capitalismo y minería global: perspectivas latinoamericanas, 1500-1914

Resumen. Objetivo/Contexto: El objetivo de este trabajo es ofrecer una visión global de la historia de la minería latinoamericana, explorando las oportunidades de diálogo entre historiadores de la minería y especialistas del campo emergente de la nueva historia del capitalismo. El análisis abarca la integración de la región en los mercados mundiales durante el siglo XVI hasta el declive del crecimiento impulsado por las exportaciones a principios del siglo XX. **Metodología:** El estudio se basa en una panorámica de la literatura clásica

² This research was financially and academically supported by the Universidad de los Andes (Bogotá, Colombia). I would like to thank the two anonymous referees and the guest editors, Constanza Castro and Kaveh Yazdani, for their constructive comments and suggestions. John Tutino, John McNeill, and Erick Langer at Georgetown University made suggestions and comments on earlier drafts and got me thinking across big scales. I am responsible for all remaining errors.

y contemporánea, que ofrece nuevas perspectivas para entender los datos existentes sobre la historia de la minería dentro de un contexto global. Al incorporar perspectivas de la geología, la ecología y la economía, se investigan las conexiones entre yacimientos minerales específicos y las diversas trayectorias del desarrollo capitalista a través de América Latina. **Originalidad:** Se abordan algunos de los vacíos existentes en el análisis de los flujos globales y locales de minerales y se destacan notables contribuciones al campo más amplio de la historia latinoamericana. Se presentan enfoques innovadores para el estudio de los ciclos de producción, los recursos geológicos y ecológicos, los desbordamientos tecnológicos y la economía minera. **Conclusiones:** En primer lugar, la bibliografía existente se ha centrado predominantemente en los metales preciosos, y son pocos los especialistas que estudian metales no preciosos y minerales no metálicos. En segundo lugar, la narrativa en torno a la historia de la minería se ha centrado en gran medida en la plata, eclipsando la importancia del bimetalismo para comprender el surgimiento del capitalismo global. En tercer lugar, el examen de la dinámica microeconómica de la minería en la región puede ofrecer nuevas oportunidades para explorar el impacto de la minería en las transformaciones sectoriales y empresariales. Por último, la investigación sobre la relación recíproca entre capitalismo y minería debería incorporar investigaciones sobre los sistemas energéticos y medioambientales que sustentaron la extracción y producción de minerales.

Palabras clave: América Latina, capitalismo, crecimiento económico, flujos de materiales, historia global, minería.

Capitalismo e mineração global: perspectivas latino-americanas, 1500-1914

Resumo. Objetivo/contexto: o objetivo deste artigo é fornecer uma visão global da história da mineração na América Latina, explorando oportunidades de diálogo entre historiadores da mineração e especialistas no campo emergente da nova história do capitalismo. A análise abrange a integração da região aos mercados mundiais durante o século 16 até o declínio do crescimento liderado pelas exportações no início do século 20. **Metodologia:** o estudo baseia-se em uma visão geral da literatura clássica e contemporânea, que oferece novas perspectivas para a compreensão dos dados existentes sobre a história da mineração em um contexto global. Ao incorporar perspectivas da geologia, ecologia e economia, são investigadas as conexões entre depósitos minerais específicos e as diversas trajetórias de desenvolvimento capitalista na América Latina. **Originalidade:** são abordadas algumas das lacunas existentes na análise dos fluxos minerais globais e locais e destaca contribuições notáveis para o campo mais amplo da história da América Latina. São apresentadas abordagens inovadoras para o estudo dos ciclos de produção, dos recursos geológicos e ecológicos, das repercussões tecnológicas e da economia da mineração. **Conclusões:** em primeiro lugar, a literatura existente tem se concentrado predominantemente em metais preciosos, com poucos acadêmicos estudando metais não preciosos e minerais não metálicos. Em segundo lugar, a narrativa sobre a história da mineração tem se concentrado em grande parte na prata, ofuscando a importância do bimetalismo na compreensão do surgimento do capitalismo global. Terceiro, o exame da dinâmica microeconômica da mineração na região pode oferecer novas oportunidades para explorar o impacto da mineração nas transformações setoriais e corporativas. Por fim, a pesquisa sobre a relação recíproca entre capitalismo e mineração deve incorporar investigações sobre os sistemas energéticos e ambientais que sustentaram a extração e a produção mineral.

Palavras-chave: América Latina, capitalismo, crescimento econômico, fluxos de metais, história global, mineração.

Introduction

From 1450 to 1914 bullion and monetary flows oiled the integration of world trade. Even before the dramatic decline in transportation costs in the second half of the nineteenth century, the market of several nonferrous metals had been globally integrated for centuries.¹ Extensive, dynamic networks of merchants and intermediaries connected producers in Andean highlands, Mexican arid plains, and Colombian tropical forests with coin and manufacturing users in Ottoman, Indian, and Chinese markets. Generations of scholars have discussed the imprints of such connections on the emergence of capitalism, the timing and location of the industrial revolution, and the mechanisms of commodity-money systems.² Paradoxically, the role of mining in these issues has not attracted enough attention in the literature, with demand-side studies of metallic connections overshadowing the imprints of ore extraction and processing. True, the share of nonferrous and fuel metals production in terms of aggregate economic activity has been modest in many regions worldwide. However, the mining industry's backward and forward linkages have transformed humans and nature dramatically.³

The reverberations of mining in Latin American history have been particularly significant. Since roughly 1500, most of the region's economies have experienced mining cycles, with the exploitation of large and diverse mineral deposits exerting profound changes on local societies. Debates have ensued on the positive/negative imprints of such changes. Classic studies have highlighted a negative relationship between economic growth and mineral endowments, suggesting that mining-dependent economies have struggled to achieve capitalistic development despite the historical importance of the sector in shaping labor markets and its technological spillovers. Mining, in this vein, promoted rent-seeking behaviors, sectoral crowding out, and distortions in capital markets, that led some countries to experience what is commonly referred to as the "natural resource curse."⁴

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- 1 For two diverging interpretations of this metallic-led integration, see Dennis Flynn and Arturo Giráldez, "Cycles of Silver: Global Economic Unity through the Mid-Eighteenth Century," *Journal of World History*, 13, n.º2 (2002): 391-427, <https://doi.org/10.0.5.73/jwh.2002.0035> and Rui Esteves and Pilar Nogues-Marco, "Monetary Systems and the Global Balance of Payments Adjustment in the Pre-Gold Standard Period, 1700–1870," in *The Cambridge Economic History of the Modern World*, edited by Stephen Broadberry and Kyoji Fukao (Cambridge: Cambridge University Press, 2021), 438-467.
 - 2 Two classic analyses in Fernand Braudel, *Civilization and Capitalism: 15Th-18th Century. The Wheels of Commerce* (Berkeley: University of California Press, 1992), 48-59 and Pierre Vilar, *A History of Gold and Money: 1450-1920* (London: Verso, 1984), 59-98. For a comprehensive review of the global effects of metal flows, see Ronald Findlay and Kevin O'Rourke, *Power and Plenty. Trade, War and the World Economy in the Second Millennium* (Princeton: Princeton University Press, 2007), 351-369 and Pim de Zwart and Jan Luiten van Zanden, *The Origins of Globalization: World Trade in the Making of the Global Economy, 1500–1800* (Cambridge: Cambridge University Press, 2018), 49-58.
 - 3 Roger Burt, "The Transformation of the Non-Ferrous Metals Industries in the Seventeenth and Eighteenth Centuries," *Economic History Review* 68, n.º 1 (1995): 23-44, <https://doi.org/10.1111/j.1468-0289.1995.tb01407.x> and Roger Burt, "Proto-industrialisation and 'Stages of Growth' in the Metal Mining Industries," *Journal of European Economic History* 27, n.º 1 (1998): 85-104.
 - 4 For a comprehensive introduction to the literature on Latin American mining and the natural resource curse, see Marc Badia-Miró, Vicente Pinilla, and Henry Willebald, "Natural Resources and Economic Development. What Can We Learn from History?," in *Natural Resources and Economic Growth: Learning from History*, edited by Marc Badia-Miró, Vicente Pinilla, and Henry Willebald (New York: Routledge, 2015), 2-25.

In the 2000s, however, scholars began to question the notion that mining necessarily led to economic backwardness. They pointed out notable exceptions such as the United States and Australia, which were able to achieve growth and structural change thanks to their mineral endowments.⁵ The debate has evolved toward an acknowledgment that the geological and ecological endowments alone do not, per se, determine economic performance. Instead, attention shifted toward the significance of political institutions that coordinate the allocation of revenues generated from the export of natural resources. It became evident that effective management and governance of these revenues play a crucial role in determining growth rates. Variables such as the size of other tradable and non-tradable activities and the opportunities for technological spillovers also matter in generating economic expansion.⁶

This new focus on the study of mining and development has not interacted with broader issues about the role of mineral extraction in the emergence of capitalism in Latin America. Historians of global economic history have long recognized the centrality of the new world's mineral output in the development of capitalist societies via expanding trade, technological innovations, and changes in labor and capital allocations.⁷ Latin American mining historians have debunked traditional views such as the enclave nature of preindustrial mineral extraction and processing while more analytically calibrating its effects on labor and capital markets.⁸ The emerging field of the new history of capitalism has made important contributions, showing how mining production sustained commercial-oriented, capitalistic societies in the Bajío and in regions traditionally linked with coerced labor and non-commercial forms of resource allocation such as Potosí.⁹ These studies have helped to decenter the study of capitalism from the traditional cores in the northwestern Atlantic. However, the connections between mineral wealth and the emergence of different types of capitalist societies have remained unexplored.¹⁰

This paper seeks to engage with existing literature by providing an analytical synthesis and distilling some opportunities for cross-pollination between historians of capitalism and mining

5 Ian McLean, "Why was Australia so Rich?," *Explorations in Economic History* 44, n.º 4 (2007): 635-656, <https://doi.org/10.1016/j.eeh.2006.11.003>; Gavin Wright, "The USA as a Case Study in Resource-based Development," in *Natural Resources and Economic Growth*, 119-139.

6 The articles compiled in the following two volumes have revolutionized the field: Badia-Miró, Pinilla, and Willebald, eds., *Natural Resources and Economic Growth* and Cristián Ducoing and José Peres-Cajías, eds., *Natural Resources and Divergence. A Comparison of Andean and Nordic Trajectories*, (London: Palgrave, 2021).

7 For two studies that, although not dealing with mining history, show the importance of integrating ore production into the study of broader issues, see Robert Allen, *The British Industrial Revolution in Global Perspective* (Cambridge: Cambridge University Press, 2009), 89-95 and Kenneth Pomeranz, *The Great Divergence. China, Europe, and the Making of the Modern World Economy* (Princeton: Princeton University Press, 2000), 59-69.

8 A pioneering research in this regard is the one by Carlos Assadourian, *El sistema de la economía colonial. El mercado interior, regiones y espacio económico* (Lima: Instituto de Estudios Peruanos, 1982). For a recent synthesis of Latin American mining history with a focus on silver, see Kendall Brown, *A History of Mining in Latin America: From the Colonial Era to the Present* (Albuquerque: University of New Mexico Press, 2012).

9 John Tutino, *Making a New World. Founding Capitalism in the Bajío and Spanish North America* (Durham: Duke University Press, 2011); Rossana Barragán, "Working Silver for the World: Mining Labor and Popular Economy in Colonial Potosí," *Hispanic American Historical Review* 97, n.º 2 (2017): 193-222, <https://doi.org/10.1215/00182168-3824041>

10 A solid introduction to these connections, albeit focusing on silver, has been crafted by Dennis Flynn. See "Silver, Globalization, and Capitalism," in *Capitalisms: Towards a Global History*, edited by Kaveh Yazdani and Dilip Menon (Oxford: Oxford University Press, 2020), 35-70.

in Latin America. The analysis expands from the integration of the region into the currents of global markets in the 1500s to the twilight of export-led growth and the expansion of industrial and non-selective mining across the region in the early twentieth century. The paper pursues an ample geographic scope, putting Latin American mineral output within the context of global mining history, with comparisons and encompassing approaches shaping the analysis.

A two-way interaction between the practitioners of the new history of capitalism and those who study the history of mining may benefit the two fields in several ways. The former has enriched the understanding of global economic history by emphasizing the worldwide scope of connections before industrialization, the importance of coerced labor, power, and violence in shaping economic exchanges, and the multicentered nature of capitalism's emergence.¹¹ Yet, as Eric Hilt and other scholars have pointed out, the field has encountered several problems regarding methodologies employed and its growing isolation vis-à-vis classic studies in economic history.¹² As a result, historians of capitalism have sometimes encountered challenges in accurately calculating key macroeconomic indicators. This has led to underestimating the significance of incentives and resource allocation at the firm-level analysis.

The very concept of capitalism—or capitalisms—has brought difficulties in defining the basic parameters of the field. While some scholars insist on the Marxian framework privileging wage labor and uncoerced social relations as the yardstick of the system, others have instead emphasized commercialization, sustained economic growth, competitive markets, and institutions as benchmarks.¹³ Mining historians have been more judicious in integrating economic history in their analysis, with growing multidisciplinary tools from geology, gender studies, and environmental sciences improving the understanding of mineral extraction across the region.¹⁴ Yet, the field still lacks the global focus favored by historians of capitalism, while systemic reverberations of mining in local economies have remained mostly unexplored. In short, by identifying key gaps in the analysis of Latin American mineral production and flows, this article seeks to distill hypotheses to study the synergy between the histories of capitalism and of mining.

The paper proceeds as follows. First, it describes the main cycles of Latin American mining and the changing role of the region's producers in global markets. Second, it examines the geological and ecological characteristics of the deposits in the region. Next, the paper provides a brief discussion of the technology and the economics of mining in Latin America. Finally, it ends with some closing remarks.

11 See, for example, the contributions edited by Yazdani and Menon, eds., *Capitalisms: Towards a Global History*, (Oxford: Oxford University Press, 2020).

12 Eric Hilt, "Economic History, Historical Analysis, and the New History of Capitalism," *The Journal of Economic History* 77, n.º 2 (2017): 511-536, <https://doi.org/10.1017/S002205071700016X>; Vicent Geloso, "The New History of Capitalism and the Methodologies of Economic History," *The Journal of the Economic and Business Historical Society* 39, n.º 1 (2021): 206-221.

13 See two diverging approaches to this matter in Yazdani and Menon, "Introduction," to *Capitalisms: Towards a Global History*, 1-27, and Larry Neal, "Introduction" to *The Cambridge History of Capitalism* (Cambridge: Cambridge University Press, 2014), 1-23.

14 For overviews of the recent literature, see Tatiana Seijas and Dana Velasco, "Introduction: A new Mining and Minting History for the Americas," *Colonial Latin American Review* 30, n.º 4 (2021): 485-497, <https://doi.org/10.1080/10609164.2021.1996977>; and James Torres, "Trade in a Changing World: Gold, Silver, and Commodity Flows in the Northern Andes 1780-1840" (PhD Thesis, Georgetown University, 2021), 15-29.

1. Global producers and Mining Cycles

Since antiquity, commodity money systems dominated the exchange landscapes of preindustrial economies, with gold, silver, and copper facilitating long-distance trade circuits. This money-driven demand reinforced the interconnectedness of global metalliferous flows, turning mining into a sector that was highly sensitive to international market conditions. Supply-side circumstances mattered as well. Mining has always been a capital-intensive activity, with sunk costs being particularly high.¹⁵ The sector, therefore, developed market-oriented forms of corporate investment that were harbingers of capitalistic development.¹⁶ It is not surprising, then, that global mining history experienced profound bust-and-bust cycles with frequent changes in the geographical location of leading suppliers and consumers.

The entrée of Latin American producers into the world economy in the 1500s transformed mining cycles in profound ways (See Map 1 for key locations). These transformations unfolded in distinctive ways within the markets of the three major monetary metals: gold, silver, and copper. The impact on silver flows was substantial, with each successive cycle releasing larger quantities into global markets. On the eve of Columbus' voyages, argentiferous production in the old world was bouncing back from a long downturn throughout the fifteenth century thanks in part to Chinese demand.¹⁷ Latin American producers played a pivotal role in not only strengthening the production of silver-bearing ores but also transforming the global mining industry in significant qualitative and quantitative ways. New technologies and new deposits transformed the cost structure of silver output while reducing its price worldwide, driving some mines in the old world out of business.¹⁸ From 1550 to 1650, silver surges were led by Upper Peruvian deposits in Potosí and Oruro, followed by suppliers in the Trans Mexican Volcanic Belt (Pachuca-Real del Monte, Taxco, hereafter TMVB), and the outflows from the mines of Western Japan particularly those located in the Iwami region.¹⁹ Estimates on the distribution of world output during these years vary, but there is growing consensus indicating that American silver accounted for around 65% of world production followed by Japanese supplies (30%), and other producers (5%).²⁰ On the demand side, this cycle reinforced the centrality of Asian economies as "silver sinks," with China and India

15 Ian Runge, *Mining Economics and Strategy* (Littleton: Society for Mining, Metallurgy, and Exploration, 1998), 25-29.

16 Jeannette Graulau, *The Underground Wealth of Nations. On the Capitalist Origins of Silver Mining, A.D. 1150-1450* (New Haven: Yale University Press, 2019), 35-45.

17 John Munro, "The Monetary Origins of the 'Price Revolution': South German Silver Mining, Merchant Banking and Venetian Commerce, 1470-1540," in *Global Connections and Monetary History, 1470-1800*, edited by Dennis Flynn, Arturo Giráldez and Richard von Glahn (Aldershot: Ashgate, 2003), 1-34; Flynn, "Silver, Globalization," 35-36.

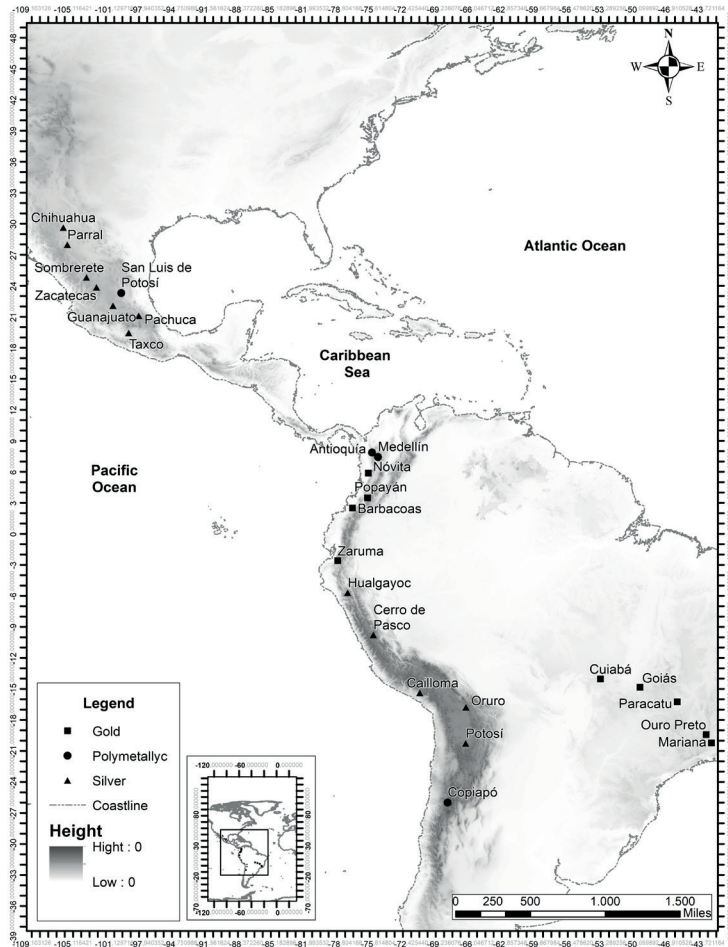
18 Munro, "The Monetary Origins," 10-20.

19 On Latin American changing production see John TePaske, *A New World of Gold and Silver* (Leiden: Brill, 2010), 35-46; On Japan, Robert Innes, "The Door Ajar: Japan's Foreign Trade in the Seventeenth Century" (PhD Thesis, University of Michigan, 1989), 78-86.

20 Unless otherwise stated, throughout this paper, estimates of the Latin American share of mining global output are drawn from the following sources: TePaske, *A New World* and Christopher Schmitz, *World Non-ferrous Metal Production and Prices, 1700-1976* (London: Routledge, 1979). For adjustments, particularly of gold output: Torres, "Trade in a Changing World," 39-48.

absorbing growing quantities of Latin American and Japanese silver.²¹ European, Ottoman, and Safavid merchants became key middlemen in these flows, while the expansion of domestic markets in Latin America led to a growing retention of silver coins for domestic transactions.²²

Map 1. Latin America's Main Mining Deposits before 1914



Source: Own elaboration following sources and information in the text.

- 21 Flynn and Giráldez, "Cycles of Silver," 395-400; Findlay and O'Rourke, *Power and Plenty*, 289-269. Scholars have traditionally regarded China as a larger silver sink than India. Yet, recent studies have driven up estimates of argentiferous flows absorbed by the latter. See Jan Lucassen and Radhika Seshan, eds., *Wage Earners in India 1500–1900: Regional Approaches in an International Context* (New Delhi: Sage, 2022).
- 22 The literature on the role of silver middlemen is extensive. See the classic studies compiled by James Tracy in *The Rise of Merchant Empires: Long Distance Trade in the Early Modern World 1350–1750* (Cambridge: Cambridge University Press, 1991). Estimates on the quantities of silver coins retained in Latin America remain a matter of debate. A growing consensus, however, points to wider local monetization than previously expected. See Assadourian, *El sistema de la economía*, 72-85 and Antonio Ibarra, "Debate. mercado colonial, plata y moneda en el siglo XVIII novohispano," *Historia Mexicana* 57, n.º 2 (1999): 279-308.

The second cycle of worldwide argentiferous flows stretched roughly from 1650 to 1820. On the supply side, despite a contraction in Potosí and other central areas, production stabilized or soared on the aggregate during the seventeenth century, paving the way for the dramatic expansion of the 1700s.²³ The surge in supply was further bolstered by growing Chinese and Asian demand, leading to a substantial increase in relative silver prices until the 1750s.²⁴ The expansion phase of this cycle marked the global dominance of suppliers in Spanish America, accounting roughly for 80% of the world output. After 1700, Mexican mines from Taxco to Guanajuato and Zacatecas overshadowed the production of the Andean deposits, despite a brief revival of Potosí.²⁵ The main outflows from Andean mines shifted to Lower Peru, with mines in Cerro de Pasco, Hualgayoc, and Cailloma exceeding Potosí's production on the aggregate.²⁶ Also during this period Peruvian producers started to take advantage of copper and tin as by-products of silver production.²⁷

The final cycle, less studied among Latin Americanists, spanned approximately from 1820 to 1914. This period was marked by the decline of both Mexican and Peruvian silver production during the early republican period and China's transformation into a net exporter of silver.²⁸ However, recent studies have shown that recovery was relatively fast in several regions. Production in Zacatecas recovered throughout the 1830s and 1840s, while Guanajuato's performance bounced back in the 1840s.²⁹ Around 1870, changes in the demand and supply sides of world markets shifted the patterns hitherto drafted. First, the US deposits in Comstock, the Great Basin, Colorado, and Australia's Broken Hill deposits slowly flooded the market, reducing the

23 TePaske, *A New World*, xviii-xix; Michel Morineau, *Incroyables gazettes et fabuleux métaux: Les retours des trésors américains d'après les gazettes hollandaises (xvii-xviii siècles)* (Cambridge: Cambridge University Press-Maison des Sciences de L'Homme, 1985), 350-369. See also Herbert Klein and Sergio Serrano, "Was there a 17th Century Crisis in Spanish America?," *Revista De Historia Económica / Journal of Iberian and Latin American Economic History* 37, n.º 1 (2019): 43-80, <https://doi.org/10.1017/S0212610918000101>

24 Flynn and Giráldez, "Cycles of Silver," 402-403.

25 Richard Garner, "Long-Term Silver Mining Trends in Spanish America: A Comparative Analysis of Peru and Mexico," *The American Historical Review* 93, n.º 4 (1988): 898-935; David Brading and Harry Cross, "Colonial Silver Mining: Mexico and Peru," *The Hispanic American Historical Review* 52, n.º 4 (1972): 545-579.

26 TePaske, *A New World*, 141-156; On mining in lower Peru, see John Fisher, *Silver Mines and Silver Miners in Colonial Peru, 1776-1824* (Liverpool: University of Liverpool Press, 1977).

27 José Deustua, *The Bewitchment of Silver: The Social Economy of Mining in Nineteenth-Century Peru* (Athens: Ohio University Press, 2000), 41-59.

28 Alejandra Irigoin, "The End of the Silver Era: The Consequences of the Breakdown of the Spanish Peso Standard in China and the United States, 1780-1850," *Journal of World History* 20 n.º 2 (2009): 207-243, <https://doi.org/10.573/jwh.0.0053>; Carlos Contreras, "La minería hispanoamericana después de la independencia. Estudio comparativo de Bolivia, Chile, México y Perú," in *Dos décadas de investigación en historia económica comparada en América Latina*, edited by Margarita Menegus (México: El Colegio de México, 1999), 255-284.

29 Ernest Sánchez, "Economía y fiscalidad en la guerra de Independencia," in *Iberoamérica y España antes de las independencias, 1700-1820. Crecimiento, reformas y crisis*, edited by Jorge Gelman, Enrique Llopis and Carlos Marichal (México: Instituto Mora, 2014), 163-224; John Tutino, *The Bajío Revolution: Remaking Communities and Capitalism in México, North America, and the World, 1800-1860* (Duke: Duke University Press, forthcoming); Harry Cross, "The Mining Economy of Zacatecas, Mexico in the Nineteenth Century," (PhD Thesis, University of California, Berkeley, 1976), 96-105.

once-central role of Latin America in global silver flows.³⁰ Second, the ascendancy of the gold standard had both positive and negative implications for silver producers. On the one hand, it reduced the demand for the gray metal and consequently caused a significant decline in its price.³¹ However, on the other hand, it provided a competitive advantage to countries like Bolivia, Mexico, and Peru that maintained a domestic silver standard, as favorable exchange rates enhanced their export competitiveness. These changes in relative prices provided an additional incentive for big companies to produce base metals despite the high sunk and average costs that characterize their extraction.³²

The study of worldwide cycles of gold flows has attracted less attention in the literature. By highlighting the role of international bimetallism in oiling global exchanges and defining the contours of capitalistic development, new studies have shown the importance of tracing the magnitude, direction, and structure of auriferous streams.³³ During the four centuries that followed the integration of Latin American producers into international flows, approximately four cycles of gold production unfolded. The first reinforced an already expanding production from western and eastern African fields, the streams extracted as a by-product of silver mines in Hungary and the Balkans since the 1450s, and small gold-bearing areas in India, Vietnam, Sumatra, and Japan.³⁴ Debates have ensued on the real quantitative imprints of this cycle and the influence of New World flows on them. It is clear, however, that prior to 1550, gold was exported in solid quantities from the placer fields in the Caribbean and New Spain, gradually declining as silver production rose.³⁵

The opening of major placers in New Granada during the second half of the sixteenth century had a profound impact on world markets. Gold production experienced a significant increase, foreshadowing a lasting association between slavery and gold production, as will be explored in the subsequent sections.³⁶ This shift in auriferous production transformed the Americas into the leading global supplier, accounting for 45% of the total, followed by Africa with 35% and South

30 Paul Rodman, and Elliott West, *Mining Frontiers of the Far West, 1848-1880* (Albuquerque: University of New Mexico Press, 2001), 56-58; Geoffrey Blainey, *The Rise of Broken Hill* (Melbourne: Macmillan of Australia, 1986), 15-26.

31 Antonio Mitre, *Los patriarcas de la plata: estructura socioeconómica de la minería boliviana en el siglo XIX* (Lima: Instituto de Estudios Peruanos, 1981), 21-25.

32 Deustua, *The Bewitchment of Silver*, 72-78; Mitre, *Los Patriarcas*, 85-89; William Schell, "Money as Commodity: Mexico's Conversion to the Gold Standard, 1905," *Mexican Studies/Estudios Mexicanos* 12, n.º 1 (1996): 67-89.

33 Marc Flandreau, *The Glitter of Gold. France, Bimetallism, and the Emergence of the International Gold Standard* (Oxford: Oxford University Press, 2003); Pilar Nogues, "Competing Bimetallic Ratios: Amsterdam, London, and Bullion Arbitrage in Mid-Eighteenth Century," *The Journal of Economic History* 73, n.º 2 (2013): 445-476, <https://doi.org/10.1017/S0022050713000326>; Torres, "Trade in a Changing World," 48-69.

34 John Munro, "Bullion Flows and Monetary Contraction in Late-Medieval England and the Low Countries," in *Precious Metals in the Later Medieval and Early Modern Worlds* edited by John Richards (Durham: Carolina Academic Press, 1983), 97-158; Philip Curtin, "Africa and the Wider Monetary World. 1250-1850," in *Precious Metals in the Later Medieval*, 231-268.

35 Harry Cross, "South American Bullion Production and Export 1550-1750," in *Precious Metals in the Later Medieval*, 397-423.

36 Kris Lane, "Mining the Margins: Precious Metals Extraction and Forced Labor Regimes in the Audiencia of Quito. 1534-1821," (PhD dissertation, University of Minnesota, 1996); Germán Colmenares, *Historia Económica y Social de Colombia II* (Bogotá: TM/Minciencias, 1998).

and East Asia with 20%.³⁷ A third cycle unfolded from 1700 to 1850. The Brazilian mining surge (1700-1750) dominated global output until the advent of the second cycle of New Granadan production after the 1760s. During this period, the opening of the Russian auriferous flows in the Urals and the Altai Mountains further contributed to the changing dynamics of global gold production, while West African and Southern Asian production declined or stagnated.³⁸ Brazilian outflows helped to offset the decline in the relative price of silver in bimetallic terms at a moment in which Mexican silver mines were flooding international markets while shoring up Britain's de facto shift to a domestic gold standard.³⁹ During the second half of the century, North Andean producers benefited from the decline in Brazilian and African production, resulting in higher relative prices for their gold vis-à-vis silver in international markets. British bullion dealers quickly adapted to these new conditions, leading to a shift of the "gold marts" from Lisbon to Jamaica. By the 1800s, the latter had become the key broker between North Andean producers and the global economy.⁴⁰

The Independence Wars exerted a short-term negative impact on North Andean production, while Brazilian outflows continued their secular decline throughout the nineteenth century. Between 1810 and 1850, global output fluctuated within a range of 20-100 tons per year, with Russia, New Granada, and ancillary flows from other small producers contributing to the overall production.⁴¹ This landscape experienced two major transformations throughout the nineteenth century. In the 1850s, production jumped to 200 tons per year and then declined to 150 tons in the 1880s. A new surge unfolded in the 1890s, reaching flows of 450 tons annually in 1900 and almost 600 tons in 1914. Both the US and Australia peaked in the mid and late centuries.⁴² New Zealand rushed in the 1860s and Russia experienced a new rush in the 1870s. In the 1890s and 1900s, Mexico and South Africa joined the ranks of major gold producers.⁴³ There is a debate among scholars as to whether these rushes were driven by changes in relative prices or simply serendipitous discoveries. However, this cycle witnessed an expansion of gold-based international payments that were pivotal in oiling industrial trade in the context of a new surge of global commodity flows.⁴⁴

37 TePaske, *A New World*, xv-xvi.

38 On the Brazilian cycle, see Charles Boxer, *The Golden Age of Brazil, 1695-1750: Growing Pains of a Colonial Society* (Berkeley: University of California Press, 1962); Angelo Carrara, *Minas e Currals. Produção Rural e Mercado Interno de Minas Gerais* (Juiz de Fora: Editora da UFJF, 2007); Laird Bergad, *Slavery and the Demographic and Economic History of Minas Gerais, Brazil, 1720-1888* (Cambridge: Cambridge University, 1999).

39 For bimetallic ratios, see Angela Redish, *Bimetallism. An Economic and Historical analysis* (Cambridge: Cambridge University Press, 2006). For Great Britain's money supply, see Nuno Palma, "Money and Modernization in Early Modern England," *Financial History Review* 25, n.º 3 (2018): 231-261, <https://doi.org/10.1017/S0968565018000185>

40 For an analysis of these shifts see Torres, "Trade in a Changing World," 89-120 and 211-250.

41 Torres, "Trade in a Changing World," 355-369; Barry Eichengreen, and Ian McLean, "The Supply of Gold under the pre-1914 Gold Standard," *Economic History Review* 47, n.º 2 (1994): 288-309.

42 Paul and West, *Mining Frontiers*, 92-105; Benjamin Mountford and Stephen Tuffnell, "Seeking a Global History of Gold," in *A Global History of Gold Rushes*, edited by Benjamin Mountford and Stephen Tuffnell (Berkeley: University of California Press, 2018), 3-4.

43 Eichengreen and McLean, "The Supply of Gold," 295-296.

44 Ian Phimister, "Frenzied Finance: Gold Mining in the Globalizing South, circa 1886-1896," in *A Global History of Gold Rushes*, edited by Benjamin Mountford and Stephen Tuffnell (Berkeley: University of California Press, 2018), 139-162.

The world economy was much slower in developing a global market for copper. Production was less regionally concentrated than it was for gold and silver. Due to inelasticity of both supply and demand, global copper output remained relatively flat until the 1870s when non-selective mining and the use of electricity changed cupriferous flows on the supply side. At the same time, expanding industrial production transformed the demand side.⁴⁵ That said, the regional distribution of copper production underwent important changes even before the dominance of mass production. Colonial markets provided an important outlet for expansion given the demand for copper in the supply chain of sugar, silver, and other commodities.⁴⁶ Besides this, in contrast to silver and gold, a geographic separation between the extraction, refining, and smelting stages of the copper supply chain was developed early on. As historians of capitalism have rightly pointed out, this created an impetus for capitalistic transformations in some areas.⁴⁷

Central European mines dominated European and West African copper markets until the flooding of American silver affected the cost function of producers given the polymetallic nature of the cupriferous deposits. The entry of Swedish and Japanese producers in the sixteenth and seventeenth centuries signaled a new age in which copper flowed on a global scale.⁴⁸ In the eighteenth century, the polymetallic deposits of Cornwall and the coal fields of Swansea, allowed Britain to slowly dominate the European market again. Meanwhile, in the Americas, the market had been served by scattering deposits across the Spanish Empire, including Michoacán in New Spain, Moniquirá in New Granada, and Coquimbo in Chile.⁴⁹ The latter was the first area that served long-distance markets, providing copper as an input for a wide array of activities in nodes along the Pacific and the Andean ranges. Chilean and Cuban mines experienced an enduring expansion in the nineteenth century while Peruvian producers started to benefit from copper as the byproduct of both silver and gold after the 1850s.⁵⁰

As the nineteenth century unfolded, the industry experienced a process of production concentration. British smelting dominated markets until roughly 1870, drawing ores from Chile, Cuba,

45 Christopher Schmitz, "The Rise of Big Business in the World Copper Industry 1870-1930," *The Economic History Review* 39, n.º 3 (1986): 392-410; Ekkehard Westermann, "Tendencies in the European Copper Market in the 15th and 16th Centuries," in *Precious Metals in the Age of Expansion*, edited by Herman Kellenbenz (Stuttgart: Klett-Cotta 1981), 71-77.

46 Nuala Zahedieh, "Eric Williams and William Forbes: Copper, Colonial Markets, and Commercial Capitalism," *The Economic History Review* 74, n.º 3 (2021): 784-808 and "A Copper Still and the Making of Rum in the Eighteenth-Century Atlantic World," *The Historical Journal* 65, n.º 1 (2022): 149-166, <https://doi.org/10.1017/S0018246X21000212>

47 Chris Evans, "Brazilian Gold, Cuban Copper and the Final Frontier of British Anti-Slavery," *Slavery and Abolition* 34 (2013): 118-134, <https://doi.org/10.1080/0144039X.2012.709039>

48 Graulau, *The Underground Wealth*, 59-62; Martin Lynch, *Mining in World History* (Chicago: Reaktion Books, 2004), 120-125.

49 Elinore Barrett, *The Mexican Colonial Copper Industry* (Albuquerque: University of New Mexico Press, 1987), 39-45; Julio Pinto, "Historia y minería en Chile: estudios y fuentes," *América Latina en la Historia Económica* 1, n.º 1 (1994): 65-88. There are no monographs on copper production in New Granada. See Torres, "Trade in a Changing World," 351-365.

50 Deustua, *The Bewitchment of Silver*, 125-139; Luis Valenzuela, "The Chilean Copper Smelting Industry in the Mid-Nineteenth Century," *Journal of Latin American Studies* 24, n.º 3 (1992): 507-550; William Culver and Comel Reinhart, "The Decline of a Mining Region and Mining Policy: Chilean Copper in the Nineteenth Century," in *Miners and Mining in the Americas*, edited by Thomas Greaves and William Culver (Manchester: University of Manchester Press, 1985), 68-81.

and Australia.⁵¹ In the 1870s, the United States became the leader in the industry, with production in Minnesota, Montana, and Arizona expanding rapidly.⁵² Towards 1900, the global copper market was dominated by a few powerful syndicates that soon extended their reach to Chile, Mexico, and the African Copper Belt.⁵³ The expansion of nonselective mining, the mechanization of the industry, and the application of new technologies encouraged the development of economies of scale that soon created opportunities for short-lived yet influential attempts at market cartelization never before witnessed in the history of global mining.⁵⁴

This bird's eye view of world production leads to four insights into Latin American mining. First, the region's mineral deposits were not solely centered on silver. True, the outflow of argentiferous ores exerted worldwide transformations while locally altering the core regions of the Spanish Empire, but gold cycles should be integrated into the metallic landscape since several circuits of global exchange operated on a bimetallic basis. This structure became even more pivotal following the emergence of international bimetallism in the eighteenth century.⁵⁵ Both historians of mining and capitalism may benefit from the joint study of the flows of the two precious metals, providing new insights into patterns of mining-based development and international trade cycles.

Secondly, the story of base-metals production in the region was characterized by a limited number of producers that only experienced a genuine take-off during the nineteenth century when industrial capitalism transformed global mining markets. Tin in Bolivia and copper in Chile and Mexico are good examples of this pattern. Yet, cupriferous flows that served the demand of sugar and silver producers before industrialization remained scarcely studied. The production of metallic and non-metallic inputs such as salt and lead that were pivotal in silver output, has not received sufficient attention from mining historians. A more comprehensive analysis of the silver and gold supply chain may provide new insights into how mining either encouraged or delayed the development of capitalism in some regions and sectors.

Thirdly, coal mines in Latin America were marginal before 1914, explaining two main drivers in mining history: the precocious adoption of electricity across the region's mines and the late introduction of steam pumps to exploit ores below the water table.⁵⁶ The heyday of fuel mining had to wait until the twentieth century when the discovery and exploitation of natural gas in Bolivia, oil in Venezuela, and coal in Colombia had a significant impact on the global energy landscape. The extent to which this lack of coal reserves shaped industrialization in South America is still a matter of debate.

Finally, it appears that colonial policies that forced the colonies to purchase European ores hindered iron and steel production in Latin America. In the nineteenth century, the production of

51 Roger Burt, "The Extractive Industries," in *The Cambridge Economic History of Modern Britain Since 1700*, v.1, edited by Roderick Floud (Cambridge: Cambridge University Press, 2003), 417-450.

52 Kent Curtis, *Gambling on Ore: The Nature of Metal Mining in the US 1860-1910* (Boulder: University of Colorado Press, 2013), 105-116.

53 Schmitz, "The Rise of Big Business," 396-401.

54 Schmitz, "The Rise of Big Business," 406-408.

55 Torres, "Trade in a Changing World," 125-139.

56 Brown, *A History of Mining*, 169-178.

both metallic commodities was limited.⁵⁷ It wasn't until the following century that the production of iron and steel promoted large enterprises, such as Volta Redonda in Brazil.⁵⁸ Analyzing counterfactuals on the potential emergence of iron production in the absence of colonial restrictions can be a useful way to understand the impact of these restrictions on capitalist development in the region. Given the role that iron producers in the United States and some European regions fulfilled through linkages and technological spillovers since the eighteenth century, this is a topic that may be worth exploring further.⁵⁹

2. Geological Perspectives

In the diaries documenting his travels across the Spanish Empire, the Prussian polymath Alexander von Humboldt often speculated on the diverse nature of the mineral deposits he happened to visit. He yearned for a key to unlock the “arcane processes spanning perhaps thousands of years of mineral formation that make some ores suitable for specific methods of processing.”⁶⁰ Geology, indeed, is a key variable in understanding mining cycles in Latin America and the world. Metallogensis defines the nature of the metal compounds contained in each ore and of any collateral metallic species. As Humboldt surmised, the chemistry of the metal compounds and the other elements present in the ore determines the optimal refining process that can be applied to profitably extract its precious metal content, either smelting with lead, amalgamation with mercury, or cyanidation with cyanide.⁶¹ The characteristics of mineral deposits, in short, shaped some aspects of the technological and social organization of mining and its imprints on capitalist development.

As Saul Guerrero has convincingly pointed out, scholars have tended to focus on ore grades and the location of metals in the two enrichment zones below and above the water table.⁶² Nonetheless, mining history should combine the analysis of the chemical composition with the assessment of ore grades. The exploration of the geology of silver deposits provides good insights in this regard. Nine of the ten largest sources of primary silver ore known to humankind are located in the American Cordilleras.⁶³ There were important differences in the chemical composition of the ores across the Americas. Argentiferous deposits in the Upper Andes were basically tin-silver

57 Economic Commission for Latin America and the Caribbean, *A Study of the Iron and Steel Industry in Latin America* (New York: United Nations, 1955), 16-21

58 Oliver Dinius, *Brazil's Steel City: Developmentalism, Strategic Power, and Industrial Relations in Volta Redonda, 1941-1964* (Stanford: Stanford University Press, 2011).

59 On the technological spillovers of mining see Roger Burt, “The International Diffusion of Technology During the Early Modern Period: The Case of the British Non-ferrous Mining Industry,” *Economic History Review* 47, n.º 2 (1991): 249-271, and “Innovation or Imitation: Technological Dependency in the American Non-Ferrous Mining Industry,” *Technology and Culture* 41, n.º 2 (2000): 321-347, <https://10.0.5.73/tech.2000.0058>

60 Alexander Von Humboldt, *Alexander von Humboldt en Colombia; extractos de sus diarios, ca.1801-1802* (Bogotá: Flota Mercante Grancolombiana, 1982), 52-53.

61 The leading scholar on the connections between chemistry and mining is Saul Guerrero, *Silver by Fire, Silver by Mercury: A Chemical History of Silver Refining in New Spain and Mexico, 16th to 19th Centuries* (Leiden: Brill, 2017).

62 Guerrero, *Silver by Fire*, 26-40.

63 Richard Sillitoe, “Supergene Silver Enrichment Reassessed,” in *Supergene Environments, Processes and Products*, edited by Spencer R. Tittley (Littleton: Society of Economic Geologists, 2009), 15-32.

systems, while those of Lower Peru were heavily associated with copper and arsenic. In New Spain's main mines, silver was accompanied by lead, zinc, and subordinate gold.⁶⁴ According to Rodman Paul, the silver deposits of the Sierra Nevada were heavily associated with gold. In the Comstock Lode, for instance, silver ores contained almost 40% of auriferous particles.⁶⁵ This heterogeneity in the chemical composition of the ores forces historians to look beyond the metal content of the minerals (grades). And here again, Guerrero's remarks are revealing: "a silver ore containing 0.25% of silver in the presence of major amounts of lead or copper cannot be compared on the same basis as a silver ore containing 0.25% in the form of silver sulfide."⁶⁶

These geological variations had global implications. In Europe, for example, silver was often found as a secondary metal within galenas and copper compounds, making smelting the method of choice for processing. This technology was favored by the availability of ample biomass sources for fuel, as most European mines were situated below the expected tree line. In contrast, the lead-free ores in the Andes made the systematic use of amalgamation feasible. Amalgamation did not require large amounts of fuel, thus avoiding energy constraints that arose from the location of Andean deposits above the tree line. The procuring of mercury, however, was a complicated business since its production was concentrated in a few deposits located far away from the main argentiferous sources.⁶⁷ This led to supply-side attempts at monopolization, with the Spanish Crown controlling most of the deposits and subsidizing mercury prices for Mexican and Peruvian silver miners during the colonial era.⁶⁸ The Rothschilds replaced the Spanish government as the main suppliers after Independence, creating a cartel that led to soaring prices that affected the recovery of mining in several regions. Discoveries of mercury deposits in California during the 1850s lessened the cartel's market power, gearing up for an era of cheap mercury until the advent of cyanidation.⁶⁹

New Spain's ores diverged regionally. In central Mexico and other belts in the western Sierra Madre, amalgamation became the process of choice, while producers in San Luis Potosí and other eastern belts resorted to smelting.⁷⁰ In the latter, the polymetallic nature of the deposits allowed silver producers to get gold as a by-product while minimizing the consumption of lead and other inputs in the foundries. The simultaneous production of multiple metals enabled merchants in

64 Guerrero, *Silver by Fire*, 37-45.

65 Paul and West, *Western Mining Frontiers*, 65-66.

66 Guerrero, *Silver by Fire*, 36.

67 Huancavelica, Almadén, and Idrija were the three main global mercury deposits of the early modern world. They were in Peru, Spain, and present-day Slovenia respectively. For an introduction to global mercury flows, see Peter Bakewell, "Mining in Colonial Spanish America," in *The Cambridge History of Latin America. Volume 2: Colonial Latin America*, edited by Leslie Bethell (Cambridge: Cambridge University Press, 2008), 105-152.

68 Rafael Dobado and Gustavo Marrero, "El Mining-led Growth en el México Borbónico, el papel del estado y el coste económico de la Independencia," in *Oro y plata en la economía moderna. De las minas a la moneda*, edited by Bernd Hausberger and Antonio Ibarra (Mexico: El Colegio de México, 2014), 177-216; Adrian Pearce, "Huancavelica 1563-1824: History and Historiography," *Colonial Latin American Review* 22, n.º 3 (2013): 422-440, <https://doi.org/10.1080/10609164.2013.808467>

69 David St. Clair, "California Quicksilver in the Pacific Rim Economy 1850-90," in *Studies in the Economic History of the Pacific Rim*, edited by Sally Miller and Dennis O. Flynn (London: Routledge, 1998), 210-233.

70 José Avalos, "Formación de paisajes mineros en el Altiplano Potosino: siglos XVIII y XIX," (PhD Thesis, Universidad Autónoma San Luis Potosí, 2009), 59-68.

these regions to engage in extensive bimetallic networks, leading to significant technological advancements in extracting traces of subordinate metals.⁷¹ In the nineteenth century, as refining centers in Europe became more efficient at detecting small amounts of by-products, the income from these activities became central for bullion dealers and merchants in Latin America.⁷²

The geology of gold diverged significantly from that of silver. In South America, the auriferous deposits exploited before the twentieth century tended to be placer and epithermal deposits in shallow volcanic environments.⁷³ Placer gold is mostly derived from the erosion of orogenic deposits, with auriferous ores usually containing silver and small amounts of other metals such as copper. Gold being a noble metal, does not readily corrode. However, silver is susceptible to oxidation, and as water carries gold particles, some of the accompanying silver is washed away. This phenomenon contributes to the lower purity of gold nearer to the source compared to gold found closer to the end of its journey toward the sea.⁷⁴ The proximity to the source of ore also influenced the distinctive characteristics of various placer belts in South America.

New Granada's gold was accompanied by silver, copper, and, given the presence of recent epithermal activity, platinum. The presence of these metals varied according to the region's mining belts.⁷⁵ In Antioquia, by-product silver was used in Bogotá to mint small change. Later in the nineteenth century, the processing of subsidiary metals had important spillovers in the region's smelting activities. In Chocó, subsidiary platinum reigned but the crown's attempt at monopolizing its flow hampered the spillover effects on other sectors.⁷⁶ As industrial demand for platinum expanded during the nineteenth century, mechanized, foreign-owned firms exploited polymetallic placers, but its local linkages were few.⁷⁷ Brazilian orographic systems are much older than the Andean ones and, therefore, their placer deposits were purer, with few by-products exploitable through preindustrial methods.⁷⁸

The geology of copper belts encompassed three main types of ore bodies: massive sulfides, stratabound, and porphyry. The massive sulfides, found in locations such as Cornwall in England, Butte in Montana, and the Norte Chico in Chile, are rich in sulfur and arsenic, facilitating smelting

71 Sergio Serrano, "Mercado y red. La estructura del sistema de intercambio de oro y plata en San Luis Potosí a comienzos del siglo XVII," *Illes i imperis*, n.º 18 (2016): 18-43, <http://dx.doi.org/10.2436/20.8050.02.2>; Edward Beatty, *Technology and the Search for Progress in Modern Mexico* (Berkeley: University of California Press, 2015), 81-96.

72 Torres, "Trade in a Changing World," 411-425.

73 Richard Sillitoe, "Major Gold Deposits and Belts of the North and South American Cordillera: Distribution, Tectonomagmatic, Settings, and Metallogenic Considerations," *Economic Geology* 103, n.º 4 (2008): 663-687, <https://doi.org/10.2113/gsecongeo.103.4.663>

74 Mary Hill, *Gold. The California Story* (Berkeley: University of California Press, 1999), 93-96.

75 Robert West, *Colonial Placer Mining in Colombia* (Baton Rouge: Louisiana State University, 1952), 53-69 and 120-132.

76 For Antioquia's mining by-products, see James Torres, *Minería y moneda en el Nuevo Reino de Granada. El desempeño económico en la segunda mitad del siglo XVIII* (Bogotá: ICANH, 2013), 89-96; For Chocó's platinum see Kris Lane, "Gone Platinum: Contraband and Chemistry in Eighteenth-Century Colombia," *Colonial Latin American Review* 20, n.º 1 (2011): 61-79, <https://doi.org/10.1080/10609164.2011.552549>

77 Claudia Leal, *Landscapes of Freedom. Building a Postemancipation Society in the Rainforests of Western Colombia* (Tucson: University of Arizona Press, 2018), 135-142.

78 Anthony. Russell-Wood, "Technology and Society: The Impact of Gold Mining on the Institution of Slavery in Portuguese America," *The Journal of Economic History* 37, n.º 1 (1977): 59-83.

but also posing important environmental risks.⁷⁹ The less common stratabound deposits are exemplified by the African Copper Belt. Finally, porphyry deposits are characterized by their low grade and disseminated nature, lacking a sharp distinction between payable ore and barren rock. The two big members of this group are the Teniente and Chuquicamata fields in Chile, both of which were exploited systemically by the Guggenheims in the 1910s.⁸⁰ These deposits dominated twentieth-century copper production and given their geological structure, encouraged the transition from selective to non-selective mining.⁸¹

This brief discussion on the geological characteristics of mining belts in Latin America provides insights for future investigations into the relationship between mining and capitalism. Firstly, the chemical composition of the ores influenced the predominant extraction methods, with regions relying heavily on amalgamation due to the absence of forests and lead ores required for alternative processes. While this conferred certain advantages, these regions missed out on the positive externalities associated with smelting. According to the literature on mining in Australia and United States, smelting complexes fostered technical spillovers and significant downstream linkages in input production.⁸² Given the collapse of Huancavelica in the nineteenth century, the main input for amalgamation had to be imported, resulting in shortened mining linkages.⁸³ Regions in which galena compounds were pivotal witnessed the growth of smelting facilities, a topic that has received limited attention from historians. Towards the late nineteenth century, the utilization of US capital in foundry complexes and refineries gained new significance, leading to significant spillover effects and transformations in labor relations that shaped capitalistic development.⁸⁴

The geological structure of copper and tin deposits in Latin America played a role in promoting nonselective mining practices, yet the absence of coal deposits hindered the development of smelting mills for value addition. Consequently, certain base metal deposits became classic examples of enclaves that did not contribute to overall economic growth.⁸⁵ A regional focus, however, would enhance the existing framework, as areas like Chile and Antioquia benefited from the industrial mining linkages, leading to sectoral transformations.⁸⁶ Mining historians can gain valuable insights by conducting more in-depth analyses of the institutional context of mineral extraction.

Finally, the polymetallic nature of Latin American ores kept some mining regions in business for centuries. In Bolivia, Peru, and Mexico some producers quickly switched from silver to tin, copper, and gold respectively. Chile followed a similar path with its copper deposits, while

79 Schmitz, "The Rise of Big Business," 398.

80 Thomas O'Brien, "Rich beyond the Dreams of Avarice: The Guggenheims in Chile," *The Business History Review* 63, n.º 1 (1989): 122-159.

81 Broberg Rönnbäck, "The Gains of Going Global: The Return on Investments in International Copper-Mining during the Second Industrial Revolution," in *Born with a Copper Spoon: A Global History of Copper, 1830-1980*, edited by Robert Declercq and Duncan Money (Vancouver: The University of British Columbia Press, 2022), 29-48.

82 McLean, "Why was Australia so Rich?," 644-656 and Wright, "The USA as a Case Study," 125-130.

83 Deustua, *The Bewitchment of Silver*, 126-132.

84 Beatty, *Technology and the Search*, 69-78.

85 Brown, *A History of Mining*, 205-216.

86 María Botero, *La ruta del oro: una economía primaria exportadora, Antioquia 1850-1890* (Medellín: EAFIT, 2007), 61-73; Marc Badia-Miró and Cristian Ducoing, "Long-run Development in Chile and Natural Resource Curse Linkages, Policy, and Growth, 1850-1950," in *Natural Resources and Economic Growth*, 204-225.

Colombian gold miners also benefited from platinum and silver as by-products. A more comprehensive approach to mining, encompassing the study of mineral inputs and by-products will yield valuable insights into a wide range of topics in the history of capitalism, including corporate structure, production functions, labor relations, and technological spillovers.

3. Mining Ecologies

The study of the two-way interaction between ore extraction and ecological change has gained momentum among mining and environmental historians.⁸⁷ Scholars of capitalism may also benefit from such interaction. In Latin America, silver mining districts typically emerged in arid and semiarid ecosystems, while gold was predominantly concentrated in lowland tropical ecosystems. This distinction is key as it influenced the availability of energy across mining belts, thereby shaping social and economic structures. Andean miners, despite the scarcity of large biomass sources, extensively utilized water bodies as a renewable source of kinetic energy. For instance, in Potosí, a complex system of dams and channels transformed the city's stream into the main source of energy for the refining mills. Oruro, Pasco, and Hualgayoc also used watermills, but the literature has not explained the economic and technical processes behind them.⁸⁸ New Spain's mines were located below the expected tree line, but the availability of water bodies created diverse energy settings. In the belts that surrounded the central Mexican basin, refineries employed waterpower.⁸⁹ However, there is no evidence of the building of a system of dams and channels comparable to those of Potosí. Likely, the lack of agglomeration precluded the miners and the crown from investments in large dams. In northern New Spain, the use of waterpower was much more limited.⁹⁰ Yet, the soils there were especially appropriate for cattle ranching. This activity created a symbiotic relationship with several species of mesquite, a tree that was pivotal in the supply of fuelwood.⁹¹

The mining ecology of gold and copper was different from that of silver. The Northern Andes tended to be warmer and greener than the ranges in Bolivia and Peru while most of its placer fields were below the expected tree line and its surroundings had better agricultural conditions. Yet, mining ecologies in the north differed from region to region.⁹² Gold producers in Chocó, Raposo, and Barbacoas enjoyed elastic supplies of fuelwood for mining activities and shipbuilding but lacked local sources of agricultural staples since high precipitation levels (13.300 mm) affected soil fertility.⁹³ Mines located along the valleys and the highlands of the Andean cordilleras, such as those in Antioquia, had low rainfall levels and better soils. However, the scarcity of water turned mining into

87 See, for example, the studies compiled in John McNeill and George Vrtis, eds., *Mining North America. An Environmental since 1522* (Oakland: University of California Press, 2017).

88 Kris Lane, *Potosí. The silver city That Changed the World* (Oakland: University of California Press, 2019), 79-85; Ann Zulawski, *They Eat from Their Labor. Work and Social Change in Colonial Bolivia* (Pittsburgh: The University of Pittsburgh Press, 1994), 45-51.

89 Bakewell, "Mining in Colonial," 114-116.

90 Robert West, *The Mining Community in Northern New Spain: The Parral Mining District* (Los Angeles: University of California Press, 1951), 65-70.

91 Avalos, "Formación de paisajes mineros," 152-165.

92 West, *Colonial Placer*, 15-29.

93 Leal, *Landscapes of Freedom*, 26-39.

a seasonal activity, prompting the construction of small dams and canals to enhance productivity in certain regions. As the nineteenth century unfolded, the control of water supplies emerged as a crucial factor in the mechanization of mining in both Chocó and Antioquia.⁹⁴

Given the low elevation of the Serra Espinhaço (790 meters above sea level on average) in Minas Gerais, gold producers benefited from ample sources of agricultural supplies and fuelwood. Mining ecologies exhibited regional variations with certain fields located in upper and lower slopes relying on outside sources of biomass due to specific soil conditions in parts of the Mata Atlântica tropical forest.⁹⁵ In western regions such as Goiás and Matogrosso, mining often followed a seasonal pattern, closely intertwined with agricultural and cattle-raising activities.⁹⁶ However, despite this heterogeneity, most Brazilian mining belts were blessed with abundant water resources, serving as a valuable source of kinetic energy. Similar to the situation in New Granada, the availability of waterways allowed miners in both regions to employ specific techniques, which will be explored in the following section.

Local ecologies, in short, shaped the way in which mining operated throughout Latin American deposits. At least four points emerge from the former discussion. First, most mining regions tended to be net importers of biomass, creating opportunities for adjacent regions to serve the consumption linkages of ore production. Metallic flows not only oiled the wheels of international trade but also contributed to the multilateral exchange of goods and services in several parts of Spanish America.⁹⁷ While these connections have been extensively examined in the context of the colonial era, there is a scarcity of studies examining the industrial effects on mining linkages during the nineteenth century. The emerging field of industrial metabolism, which offers methodologies to measure the material and energy turnover of economic systems, holds promise in shedding light on the interplay between mining, ecology, and the unfolding of capitalism.⁹⁸

Recent studies have explored the transformative impacts of mining on local ecosystems, particularly in terms of deforestation and emissions.⁹⁹ However, as highlighted by Saul Guerrero, much of this literature falls short in terms of comprehensively understanding the chemical processes involved and identifying the specific ways in which mining activities generate negative externalities.¹⁰⁰ This is key for discerning the extent to which these externalities are associated with capitalistic development and what portion unfolds regardless of economic systems. Latin Americanists have much to offer in this regard. For instance, studies on the development of organometallic substances such as methylmercury that affect human and non-human organisms throughout the

94 The best analysis of mining ecologies in Colombia is the one by Leal, *Landscapes of Freedom*.

95 Dean Warren, *With Broadax and Firebrand. The Destruction of the Brazilian Atlantic Forest* (Berkeley: University of California Press, 1997), 59-68.

96 Maria Fernandes and Cassiano Rocha, "A fronteira da mineração em Goiás: história ambiental e os recursos naturais do Cerrado a partir da exploração do ouro em Pilar de Goiás," *Élisée* 9, n.º 2 (2019): 1-27.

97 For a review of this literature, see Torres, "Trade in a Changing World," 16-21.

98 Oscar Carpintero, *El Metabolismo de la economía española: Recursos naturales y huella ecológica (1955-2000)* (Madrid: Fund. Cesar Manrique, 2005).

99 Nicholas Robins, *Mercury, Mining, and Empire. The Human and Ecological Cost of Colonial Silver Mining in the Andes* (Bloomington: Indiana University Press, 2011); Daviken Studnicki and David Schecter, "The Environmental Dynamics of a Colonial Fuel-Rush: Silver Mining and Deforestation in New Spain, 1522 to 1810," *Environmental History* 15, n.º 1 (2010): 94-119, <https://doi.org/10.1093/envhis/emq007>

100 Guerrero, *Silver by Fire*, 131-133.

food chain are pivotal in providing insights into the historical trajectory of metal processing.¹⁰¹ In the same vein, the meaningful presence in some ore-bearing regions of dams, mills, canals, and other infrastructure raises questions about their impact on regional hydromorphology. Periodic flooding near mining centers has clearly been the result of pervasive sedimentation, and historical records are replete with complaints from agricultural producers about the consumption of polluted water downstream from mills and foundries. As in the American West, Latin American mining history has been shaped by little-studied “water wars.”¹⁰²

4. Mining Technology and Capitalism

Broadly conceived, mining encompasses the exploration, extraction, and processing of ores and mineral resources.¹⁰³ Each activity involves a diverse range of techniques and technologies that have evolved over centuries, leaving significant impacts on the trajectory of capitalist development. Exploration, despite its crucial role in labor allocation, has been relatively neglected in the literature. Indigenous peoples were the primary actors in prospecting and mine development before European entrepreneurs asserted control through coercion or negotiation.¹⁰⁴ Extraction methods in mining involved a dynamic interplay between placer and hard rock mining. Gold, given its geological characteristics, was typically extracted from placers and lodes while silver and copper extraction was the realm of underground mining. Open-pit mining emerged later, in the first half of the twentieth century, as non-selective mining techniques such as cyanidation and flotation gained popularity for extracting non-ferrous metals.¹⁰⁵ Refining methods, as mentioned earlier, predominantly involved smelting and amalgamation, but these techniques exhibited significant variations across time and space.¹⁰⁶

In hard-rock mining, extraction encompassed four main stages: 1. Access 2. Development and producing mining 3. Shoring-up, and 4. Ores and water removal. Before the nineteenth century, Latin American miners tended to excavate by following the structure of the vein, creating an erratic system of tunnels highly criticized by Humboldt.¹⁰⁷ Stages 1 and 2 were carried out by pickmen, whose numbers depended on factors such as the size of the tunnel and the availability of steel and iron tools provided by the mining entrepreneur.¹⁰⁸ The compactness of the mine played a significant role in determining the costs in stage 3, as some shafts did not require shoring, but ore-bearing structures had to be left as supports. In stage 4, workers (*apiris* in Potosí and *tenateros*

101 Jacqueline Gerson *et al.*, “Amazon Forests Capture High Levels of Atmospheric Mercury Pollution from Artisanal Gold Mining,” *Nature Communications* 13, n.º 559 (2022): 1-10, <https://doi.org/10.1038/s41467-022-27997-3>

102 Andrew Isenberg, *Mining California. An Ecological History* (New York: Hill and Wang, 2005), 43-56.

103 Runge, *Mining Economics*, 15-29.

104 Tutino, *Making a New World*, 35-65; Lane, *Potosí*, 25-29.

105 Brown, *A History of Mining*, 159-162.

106 On the global impact of these technologies, see Jeremy Mouat, “The Development of the Flotation Process: Technological Change and the Genesis of Modern Mining, 1898–1911,” *Australian Economic History Review* 36, n.º 1 (1996): 3-31.

107 Bakewell, “Mining in Colonial,” 115.

108 Sometimes workers provided their own tools. Bakewell, “Mining in Colonial,” 125-126; Brading and Cross, “Colonial Silver Mining,” 548-550.

in New Spain) manually carried ore to the surface in bags made of leather or vegetable fibers and wooden ladders.¹⁰⁹ Both pickmen and ore carriers used tallow candles for illumination in the underground works. Thus, the extraction process was labor-intensive and heavily reliant on biomass as an energy source.

Three innovations transformed extraction from the seventeenth century onwards: blasting, animal-powered whims, and adits.¹¹⁰ The first saved energy and labor in stages 1 and 2. The second saved both in stage 4 while adits also saved energy in stage 4 while providing ventilation. These innovations, however, were not ubiquitously applied and their adoption was slow in some regions. By the eighteenth century, blasting was used widely in both New Spain and the Andes, but the use of animal-powered whims was a device only used in the former. According to Brading and Cross, the conical peak of Potosí's deposits made adits the most practical and feasible form of access and extraction.¹¹¹ Miners in Cerro Pasco and Hualgayoc followed the same pattern.¹¹² In New Spain, entrepreneurs in San Luis Potosí and other areas invested in adits but these never acquired the centrality they did in the Andes.¹¹³ During the nineteenth century, the mechanization and electrification of several processes including drilling, better blasting methods, electric pumping, and mine railways radically transformed the production function of mining and its social and environmental imprints.¹¹⁴

Placer mining was simpler. Speculators (*faiscadores* in Brazil and *mazamorreros* in New Granada) panned water courses using wooden or metal pans called *bateas* in Spanish or *bateias* in Portuguese.¹¹⁵ The oscillation of the pan caused gold particles to sink due to their higher density, while siliceous material was washed over the shallow sides. Using the same technique were the more elaborated *taboleiros* or *canalones*, which were sluices that diverted part of the river flow into a series of boxes that retained gold. If the sluices were built on a hillside they were called *grupairas* in Brazil or *canalete* in New Granada. Another similar technique was the so-called *catas* in Brazil or *congas* in New Granada. These were openings in the hillsides whose gravel was carried to the nearest water source for panning or water transported by wooden aqueducts to the *cata* where the gravel beds passed through a series of boxes that retained the gold. During the nineteenth century, the use of mechanical dredges was perhaps the main innovation

109 Enrique Tandeter, *Coercion and Market: Silver Mining in Colonial Potosí, 1692-1826* (Albuquerque: University of New Mexico Press, 1993), 49-55; David Brading, *Miners and Merchants in Bourbon Mexico 1763-1810* (Cambridge: Cambridge University Press, 1971), 102-119.

110 The following discussion builds on Bakewell, "Mining in Colonial," 130-135; Brading and Cross, "Colonial Silver Mining," 548-550, and Lane, *Potosí*, 29-39.

111 Brading and Cross, "Colonial Silver Mining," 552.

112 Fisher, *Silver mines*, 55-62; Carlos Contreras, *Los mineros y el rey: los Andes del norte, Hualgayoc, 1770-1825* (Lima: IEP, 1995), 71-74.

113 Avalos, "Formación de paisajes mineros," 225-229.

114 Marvin Bernstein, *The Mexican Mining Industry 1850-1950. A Study of the Interaction of Politics, Economics, and Technology* (Albany: State University of New York, 1964), 59-71; Mitre, *Los patriarcas de la plata*, 120-125.

115 The following discussion builds on, Boxer, *The Golden Age*, 30-45; Russell-Wood, "Technology and Society," 69-74; West, *Colonial Placer*, 26-32; Ann Twinam, *Miners, Merchants and Farmers in Colonial Colombia* (Austin: University of Texas Press, 1982), 25-39.

introduced in the sector, saving considerable amounts of labor but creating important changes in hydromorphology and water conditions.¹¹⁶

Refining was another matter. Once extracted, ores were sorted and then transported by mules or llamas to the refining complexes. Amalgamation involved several stages: 1. Milling the ore 2. Mixing the milled ore with salt, mercury, water, and copper compounds 3. Washing the mixture 4. Separation of mercury through volatilization.¹¹⁷ The specifics of stage 1 varied according to local conditions, with Potosí and other Andean miners utilizing kinetic energy effectively. Stage 3 was influenced by the availability of water and the design of the vat containers. Stage 4 depended on the type of ovens employed, with the recovery of mercury being a key endeavor in reducing variable costs. Over time, two main modifications emerged.¹¹⁸ First, in eighteenth-century New Spain, a stone-drag crushing device called *arrastre* was used to further pulverize the ore between stages 1 and 2. Second, to accelerate stage 2, heating was applied to the mixture in a process called *amalgamación en caliente* (hot amalgamation).¹¹⁹

As for smelting, it was usually carried out in three steps: 1. Crushing 2. Mixing the crushed ore with lead and iron compounds and 3. Roasting.¹²⁰ In stage 1, smelting did not require the flour-like consistency demanded by amalgamation, allowing the use of hammers and boulders. However, animal-powered milling stones were also widely used. Stage 2 depended on the lead content of the ore. In New Spain, the addition of *tequestite* (salt compound) improved the method during the eighteenth century.¹²¹ Stage 3 varied according to the furnace and the technique used to provide oxygen, with the use of bellows powered by animals or water improving the processing capacity over time. Variation in oven capacity and technology was important in the refining of copper-bearing ores but here the research has not been as active as in the case of silver or mercury mines.¹²² Gold refining was much simpler and usually required little mercury. In New Granada and New Spain, the extraction of gold by-products demanded elaborated processing with nitrates whose volumes elicited the development of little-studied, specialized establishments as the nineteenth century unfolded.¹²³

The end use of metals in domestic economies has not attracted enough attention. The study of workshops and independent artisans who produced copper and tin hardware may yield important insights into forgone opportunities for capitalistic development while the study of gold and silver jewelry, traditionally explored by art and social historians, may provide clues on little-explored topics. For instance, in Europe and Asia, gold and silver smiths became key financial

116 Leal, *Landscapes of Freedom*, 136-142.

117 For a recent analysis of refining, see Guerrero, *Silver by Fire*, 152-189.

118 See Bakewell, "Mining in Colonial," 135-138; Brading and Cross, "Colonial Silver Mining," 552-554, and Lane, *Potosí*, 83-89.

119 Brading, *Miners and Merchants*, 129-135; Tristan Platt, "The Alchemy of Modernity. Alonso Barba's Copper Cauldrons and the Independence of Bolivian Metallurgy (1790-1890)," *Journal of Latin American Studies* 32, n.º 1 (2000): 1-54, <https://doi.org/10.1017/S0022216X99005453>

120 Guerrero, *Silver by Fire*, 78-98.

121 Brading, *Miners and Merchants*, 129-135; Frédérique Langue, *Los señores de Zacatecas: una aristocracia minera del siglo XVIII novohispano* (México: Fondo de Cultura Económica, 1999), 59-68.

122 Barrett. *The Mexican Colonial*, 29-34.

123 Torres, "Trade in a Changing World," 169-172; Victor Soria, *La casa de moneda en México durante la administración borbónica 1733-1821* (México: Universidad Autónoma Metropolitana, 1994), 38-42.

intermediaries.¹²⁴ The field of minting history also lacks comprehensive studies on the technological and financial spillovers associated with minting activity. Although social and institutional histories of Latin American mints abound, further research is needed to explore the linkages of minting activity and its technological and financial spillovers.¹²⁵

Historians of capitalism may interact with the former discussion on mining technology on several fronts. For instance, research should be conducted to determine whether the late coal-based transformation of the region's mining stemmed from the location of fossil fuels, or the structure of relative input prices and social relations as studied in other regions. Intersectoral studies, in turn, may enrich the understanding of the incentives and restrictions of technological spillovers from mining to other economic activities. Exploring managerial patterns in mining, which have played a significant role in shaping the corporate organization of economic activity in Europe and Japan, could offer further insight into the distinctive insertion of Latin American societies into capitalism.

5. Some Economics of Mining

The economics of natural resources have tailored theoretical insights to analyze the distinctiveness of mining production functions and markets.¹²⁶ The prevalence of sunk costs, the joint production of minerals, and the specificity of each ore body turn mining into a special economic sector.¹²⁷ For generations, Latin American economic historians have studied economic conditions, with a focus on macroeconomic flows and cost structure. Microeconomic analysis has not received sufficient attention and may yield new venues for comprehending their importance in the region's capitalistic development. The study of ore markets is a case in point. In colonial Latin America, ore flows were regional in scope since transportation costs precluded the formation of large geographical networks.¹²⁸ This pattern changed when transportation costs declined during the nineteenth century, with ore prices converging internationally. Swansea smelters created a powerful complex capable of processing ores from distant regions such as Chile and Cuba.¹²⁹ In silver and gold, similar smelting centers drawing worldwide ore supplies were established in Europe and the United States, affecting local backward linkages during the nineteenth century.¹³⁰

The regional character of ore flows before industrialization led to diversity in ore market structures. According to Brading, in New Spain, most miners sold their output in weekly auctions, with refiners assembling at the pithead and whispering their bids.¹³¹ In some regions, refiners had a monopsonistic position (one big refinery possibly with economies of scale and many small

124 Kim Jongchul, "How Modern Banking Originated: The London Goldsmith-Banker' Institutionalization of Trust," *Business History* 53, n.º 6 (2011): 939-959, <https://doi.org/10.1080/00076791.2011.578132>

125 For an overview of the literature and estimates of mintage output, see Tespake, *A New World*, 202-230. See also Torres, "Trade in a Changing World," 202-211.

126 Harold Hotelling, "The Economics of Exhaustible Resources," *Journal of Political Economy* 39, n.º 2 (1931): 137-175.

127 Runge, *Mining Economics*, 26-38.

128 Brading, *Miners and Merchants*, 129-136.

129 Lynch, *Mining in World*, 89-95.

130 Beatty, *Technology and the Search*, 86-91.

131 Brading, *Miners and Merchants*, 130.

miners) while in other areas miners enjoyed a monopolistic position (big mine and many small refiners). Guadalajara mines belong to the first pattern while the Valenciana, in Guanajuato, certainly belonged to the latter.¹³² In Potosí, the state favored vertical integration that affected the market price of ores, but independent seekers established a parallel market of unrefined metals that competed heavily with big refiners.¹³³ The level of state intervention and the structure of ore markets may have explained productivity divergences in both areas.

Regarding other production factors, Latin American mines operated under distinctive conditions in both labor and capital markets. Labor systems ranged from slave to free, but these two “pure” forms had hybrid, overlapping characteristics. Free workers sometimes received payment through goods sold by the company’s store at prices above the market level, while in several placer fields, slaves were allowed to keep a portion of their output, alleviating the owners’ responsibility for providing rations.¹³⁴ This created a constellation of working arrangements that nonetheless exhibited broad patterns. The literature has traditionally distinguished between mining labor in New Spain and the Andes.¹³⁵ The former employed predominantly free workers and the latter a dual system of free and forced labor (*mita*). This image, if correct on the aggregate level, must be regionally contextualized. Free labor was the rule in Andean deposits such as Cerro de Pasco and Oruro.¹³⁶ In New Spain, the mines of the TMVB had a long tradition of forced labor and some scholars argue that the resurgence of coercive labor practices, such as the *cuatequil* system, contributed to the mining boom in the eighteenth century.¹³⁷

The very mechanics of free labor bring complications when it comes to analyzing mining production functions. Wages were paid in coins and goods, but also in shares of ores extracted per worker (*partido* in New Spain or *corpa* in the Andes).¹³⁸ As a result, part of the risk and variable costs of mine operation were absorbed by the workers themselves. In some regions, such as Oruro and Parral, labor was almost entirely paid in shares.¹³⁹ The extent to which these mechanisms encouraged labor productivity remains a matter of debate among specialists.¹⁴⁰ In the same vein, the notion of forced labor demands analytical nuances. Draft labor such as *mita* and *cuatequil* were subsidies given by the crown to the miners as incentives to increase output, with indigenous communities sending a share of their male labor force to work in the mines at wages below the

132 Antonio Ibarra, “Poca plata es buena plata. Producción y circulación de la plata-pasta en el mercado novohispano: Guadalajara, 1783-1810,” in *Oro y plata en la economía*, edited by Hausberger and Ibarra, 115-149; Brading, *Miners and Merchants*, 264-266.

133 Tandeter, *Coercion and Market*, 102-107.

134 Barragán, “Working Silver,” 196-200; Torres, *Minería y moneda*, 125-132; Carrara, *Minas e curráis*, 58-62.

135 Garner, “Long-Term Silver,” 902-905; Bakewell, “Mining in Colonial,” 125-129.

136 Zulawski, *They Eat*, 55-62; Fisher, *Silver Mines*, 89-92.

137 Robert Haskett, “Our Suffering with the Taxco Tribute: Involuntary Mine Labor and Indigenous Society in Central New Spain,” *The Hispanic American Historical Review* 71, n.º 3 (1991): 447-475; Ernest Sánchez, “La Minería Novohispana a fines del periodo colonial. Una evaluación historiográfica,” *Estudios de Historia Novohispana*, n.º 27 (2002): 123-164.

138 Barragán, “Working Silver,” 202; Tutino, *Making a New World*, 305-309.

139 Zulawski, *They Eat*, 65-72; West, *Mining Community*, 39-45.

140 Garner, “Long-Term Silver,” 906.

common market price.¹⁴¹ This measure increased output given the marginal income imposed by the market, affecting the incentives to adopt labor-saving technologies.

In both New Spain and Potosí, mine owners and refiners imposed a system of daily quotas on their draft laborers.¹⁴² In other words, the wage fixed by the crown was paid not per day of labor but per ore mined. According to Eduardo Saguier the cost of forced labor in mining underwent a transformation into a fixed operational cost.¹⁴³ Miners used to rent out their draft workers to other producers while accepting payments in silver from the communities to compensate for absentee workers. This income was sometimes used to hire free laborers, or even to temporarily suspend mining operations. After independence, draft labor was abolished but the transition towards a fully oriented wage labor did not occur automatically. The recovery of silver output during part of the nineteenth century was driven by a myriad of small-scale miners and independent prospectors who mined ores paying fees to former mine owners.¹⁴⁴ It was only after 1870, when large-scale firms in both regions started to expand their production towards economies of scale and mechanization, that the transition towards full-time, wage-based labor became more prevalent and consistent.¹⁴⁵

Labor dynamics in Brazilian and New Granadan gold mining differed from those in copper and silver production. In the gold fields, slave labor was the dominant type of labor, but as the distribution of mining surpluses expanded among former slaves, new mechanisms of labor allocation began to emerge.¹⁴⁶ Slavery was profitable and flexible, allowing miners to adjust the size of the slave gangs based on the deposits and fluctuations in both the gold and slave markets. Some miners rented out their slaves to perceive wages during seasonal periods while the structure of rations differed widely from mine to mine. Some owners supplied their slaves with food and clothes, conceding just one free day during the week in which the chattel could pan gold to acquire supplies. Others released their slaves under the condition that they had to pay a weekly rent in gold. These arrangements allowed slaves to save money to buy freedom, participate in consumption markets, and even buy their own slaves. In regions in which slave labor was not dominant such as Antioquia, in New Granada, *mestizos* and poor whites worked independently in the alluvial fields backed up by credits granted by small-scale merchants.¹⁴⁷ During the nineteenth century, dredge mining and mechanized hard rock mining slowly expanded wage labor arrangements in the northern Andes.¹⁴⁸

The linkages between mining and the development of the capital markets in the region remains largely unexplored. Traditional studies argue that miners and refiners had little access to church

141 Tandeter, *Coercion and Market*, 51-53; Haskett, "Our Suffering," 447-449.

142 Garner, "Long-Term Silver," 905-908.

143 Eduardo Saguier, "La crisis minera en su fase extractiva. La producción de plata del Cerro del Potosí a la luz de ocho visitas de minas inéditas," *Colonial Latin American Historical Review* 1, n.º 1 (1992): 67-100.

144 Erick Langer, "Desarrollo económico y contrabando de plata en el siglo XIX, Andes Centromeridionales," *Diálogo Andino*, n.º 66 (2021): 313-324, <http://dx.doi.org/10.4067/S0719-26812021000300313>; Tutino, *The Bajío Revolution*, 233-265.

145 Brown, *A History of Mining*, 152-159.

146 The following discussion builds upon William Sharp, *Slavery on the Spanish Frontier. The Colombian Chocó, 1680-1810* (Norman: Oklahoma University Press, 1976), 172-179; Torres, *Minería y moneda*, 127-143; Kathleen Higgins, *Licentious Liberty in a Brazilian Gold-Mining Region: Slavery, Gender, and social control in Eighteenth-century Sabará, Minas Gerais* (University Park: Penn State University Press, 1999), 54-62.

147 Twinam, *Miners, Merchants*, 49-53.

148 Leal, *Freedom Landscapes*, 205-210.

lending, with traders extending loans at high-interest rates to compensate for the sector's high risk.¹⁴⁹ Other scholars have emphasized the market power of merchants, suggesting a negative impact of commercial capital on the development of mining.¹⁵⁰ However, this perspective often frames the credit problem as a zero-sum game between commercial and mining capital. Social network analysis and sectoral studies have shed light on the complexity of the ties between miners and merchants, with changes in relative prices driving merchants to reduce interest and discount rates while directly investing in mining throughout the eighteenth century.¹⁵¹ Given the role of mining in capital flows and financial innovation in rapidly developing capitalist economies, analyzing credit structures could provide important insights into the diverging performance of Latin American mining regions in the long run.

State intervention in mining needs further research. In Potosí, the Crown interfered in the credit supply by taking over control of the San Carlos Bank, an institution that bought bullion and provided operating capital and cheap inputs to miners.¹⁵² Though excise policies varied from region to region, colonial policies tended to reduce the mining tax burden over the long term, with the aggregate impact of mining taxes on the total income of royal treasuries not being as large as previously thought. Recent research has suggested, in contrast, that the sector was highly subsidized through institutional privileges and the provision of inputs below market prices.¹⁵³ During the nineteenth century, this approach changed with some governments eliminating export restrictions and tax patterns inherited from the colonial era but becoming highly dependent on mining revenues as large foreign corporations and capital injections shifted to non-selective mining and fuel extraction.¹⁵⁴ As is well known, this pattern deepened the volatility of business cycles as the twentieth century unfolded.

The economics of mining, finally, provide pivotal inputs for the study of the intricate social and political processes in Latin American history. And here, further conversations with historians of capitalism emerge. By examining mining factor markets and their institutional underpinnings, we can gain a better understanding of the emergence of rent-seeking groups, technical inefficiencies, and the allocation of fiscal linkages, which have often led to political and military conflicts in the context of capitalist expansion. In the same vein, mining in most Latin American countries failed to encourage an early formation of a large proletariat class, with peasant-miners, coerced laborers, and independent prospectors accounting for a large share of the working force. Therefore,

149 For a critical review of the works holding the traditional view, see Eduardo Flores, ed., *Crédito y financiamiento a la industria minera: siglos XVI-XX* (México: Plaza y Valdés, 2006).

150 Ruggiero Romano, *Mecanismo y elementos del sistema económico colonial americano siglos XVI-XVIII* (México: Fondo de Cultura Económica, 2004), 133-139.

151 See Antonio Ibarra and Guillermina del Valle, eds., *Redes sociales e instituciones comerciales en el Imperio Español, siglo XVII a XIX* (México: El Colegio de México, 2007).

152 Guillermo Mira and Alicia Gil, "Minería, comercio y moneda en un período de transición. Potosí, la crisis colonial y las bases del crecimiento económico del Río de La Plata después de la independencia," in *La desintegración de la economía colonial: comercio y moneda en el interior del espacio colonial 1800-1860*, edited by Alejandra Irigoin and Roberto Schmit (Buenos Aires: Biblos, 2003), 37-56.

153 John Coatsworth, "The Mexican Mining Industry in the Eighteenth Century," in *The Economies of Mexico and Peru during the Late Colonial Period, 1760-1810*, edited by Nils Jacobsen (Berlin: Colloquium-Verlag, 1986), 26-45; Dobado and Marrero, "El Mining-led Growth," 188-194.

154 Cuauhtémoc Velasco, *Estado y minería en México (1767-1910)* (México: Secretaría de Energía, 1988), 102-112.

the organization of labor unions was slower than in other mining regions while the limited scope of labor markets has consistently depressed real wages, likely reducing the incentive to adopt labor-saving technologies. As the twentieth century unfolded, skilled jobs in some deposits owned by international syndicates have been filled by foreign workers (in some cases with clear racial biases) who reinforced the enclave character of mining in several regions.¹⁵⁵

Conclusions

The entrée of Latin American mining producers into the global economy during the 1500s marked a new era in world history. The emergence of capitalism and globalization, the timing and location of the industrial revolution, and the development of international monetary systems are some of the processes connected to the expanding outflows of minerals from the New World. This paper provided an overview of Latin American mining history to explore opportunities for cross-pollination between mining historians and scholars in the emerging field of the new history of capitalism. Besides examining specific venues of research regarding output cycles, geological and ecological endowments, technological spillovers, and mining economics, the paper highlights four main gaps in the field whose analysis may guide future research.

First, the existing literature has primarily emphasized precious metals, neglecting the integration of non-precious metals and non-metallic minerals within the broader context of capitalistic development in Latin America. Opportunities abound for historians interested in analyzing the role of the technological and managerial spillovers of base metal production. Additionally, examining counterfactual scenarios related to colonial restrictions and incentives on mineral production would be a valuable addition to the field. Second, among precious metals, silver mining has been privileged. Despite the pivotal importance of international bimetallism in promoting and regulating international trade during the eighteenth and nineteenth centuries, there is a scarcity of narratives focused on gold before the dominance of the gold standard in the 1870s. A bias for bimetallism may enrich the understanding of webs and connections within a global perspective while providing empirical fuel to examine different patterns of mining-led growth in Latin America.

Thirdly, economic theory has been creatively used at the aggregate level, but the microeconomic dynamics of mining have not attracted enough attention. Since mining management and technology exerted pivotal transformations in other mining areas of the world, the microeconomic approach may elicit a new understanding of the links between mineral production and capitalistic development in the region. Finally, the environmental history of mining in Latin America is one of the great ecological transformations of modern times, yet it has not received comprehensive attention. In particular, the synergic relationship between environmental settings, energy systems, and mining has not been systematically integrated into the analysis of capitalism in the region. The interdisciplinary nature of the history of mining and that of capitalism provides a unique laboratory from which to expand the study of the region in creative, unexpected directions.

155 The literature is extensive. See Michael Gonzáles, "U.S. Copper Companies, the Mine Workers Movement, and the Mexican Revolution, 1910-1920," *The Hispanic American Historical Review* 76, n.º 3 (1996): 503-534; Omar Manky, "Part-Time Miners: Labor Segmentation and Collective Action in the Peruvian Mining Industry," *Latin American Perspectives* 45, n.º 5 (2018): 120-135, <https://doi.org/10.1177/0094582X17709541>

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