Olivia Butler

Professor Hanson

INTD 262

09 December 2024

Silver Mining in Cerro Rico

Introduction

In 1545, Diego Huallpa discovered the famous silver deposit – Cerro Rico de Potosí – in the southern Bolivia mountains (Lane, 2015). Although Peruvian, Huallpa worked for a European overseer at the mines in Porco. Porco was the Incan Empire's main silver source from 1538 to 1539 (Lane, 2015). While traveling between Porco and their self-established capital, La Plata, Huallpa climbed a nearby mountain to look for an Inca shrine. On the side of this mountain, he uncovered a section of silver similar to that in the mines of Porco. Huallpa then collected some of this material to bring to Porco for further analysis. One year later, that mountain became known as the Cerro Rico – or "Rich Hill – of Potosí (Lane, 2015). Thousands of Spaniards, indigenous, and enslaved Africans swarmed to stake claim in the mountain. As a result, the city of Potosí emerged and Carlos I – the king of Spain – exploited its community members through silver taxation to fund his war efforts.

From the sixteenth to twentieth century, scientific advancements and attitudes saw significant shifts that shaped the practices and socio-economic landscape of silver mining in Cerro Rico. Silver mining in Cerro Rico, Potosí, exemplifies the intersection of economic ambition and the early scientific attitude, where meticulous documentation, innovative mining techniques, and empirical observations fueled the Spanish colonial economy. However, the

relentless pursuit of wealth also highlighted the environmental and social costs, shedding light on the necessity for scientific integrity and sustainable practices in exploiting natural resources.

Historical Context

Potosí's first mines looked like shallow pits (Lane, 2015). Its workers then dug out the ore with iron bars. Many of these workers had stories similar to those of Huallpa – indigenous people who depended on foreign overlords. After the ore was dug out, the "indios varas" – or "Indians by the yard" – sorted it by grade and transported it down the mountain to nearby refineries (Lane, 2015). They used as many as eight thousand llamas to carry the ore (Moore, 2010). The Andeans designed a furnace called a "huayrachina" or "huayra" – the Quechua word for "wind" or "ventilate" – at these refineries (Lane, 2015). It was made from stone and clay and more than six thousand populated the hillside of Potosí. It had a conical shape with a fire at its base and openings around its sides to guide airflow (Bigelow, 2016). As air tunneled through its openings, it simulated the effects of a bellow. Although they produced high-grade silver ore at impressive rates, these huayras required fuel – a scarcity (Lane, 2015). To combat this, they burned llama droppings and yareta moss.

The Andean Cordillera – where Hullapa was from – was the most developed mining region in the sixteenth century (Lane, 2015). Before the Spanish arrived, Cerro Rico was inhabited by indigenous people like the Quechua who established settlements in the Andean region. They lived off agriculture and trade until 1532 when Spain assumed all of their technology and knowledge after it conquered the Incan empire (Lane, 2015). With this information, they innovated the Andean mining system by implementing iron and steel tools and mercury amalgamation. This improved efficiency in the mines by quickening the extraction, crushing, and refining processes. It is important to note that although these new tools were

implemented in Potosí during the Incan conquest, mercury amalgamation was not until 1572 – forty years later (Lane, 2015).

Although the first decades of extraction had copious amounts of pure silver, by 1565 Cerro Rico ran out of high-grade silver ore ("Cerro Rico", 2023). In 1572, Potosí adopted a mercury-based refining process from a Seville merchant, Bartolomé de Medina (Lane, 2015). This method was called the "patio process" – an open-air system that mixed ground-up silver ore with mercury that was then stirred periodically throughout its weeks of amalgamation (Lane, 2015). It uses this mercury to form silver amalgams to extract solver from lower-grade ores ("Cerro Rico", 2023). The patio process was a ten-step method as follows:

- **Step 1:** Crush minerals and arrange them into piles that hold two to four thousand pounds of material. The silver ore was ground into a fine powder to increase the surface area of the ore and allow for better contact with the chemicals used in the patio process.
- **Steps 2 - 4:** Treat piles in several stages of incorporation, mixing reagents like salt, iron sulfide, or copper sulfate into silver mounds and allowing the mixture to harden. The mixture is spread out in a large, flat area called a "patio".
- **Step 5:** Carefully add mercury. Mercury reacts with silver in the ore to form a silver-mercury amalgam. The copper sulfate acts as a catalyst that enhances the amalgamation process.
- **Step 6:** Have the refiners stomp the mixture with their feet to allow for greater incorporation.
- **Step 7:** Wash the solution to remove the excess chemicals and ore particles.
- **Step 8:** Remove the partially-formed amalgams of silver and mercury that were fired in forty-five-pound molds. The mercury vapor condenses and is collected for reuse.

- **Step 9:** Separate the incorporated metals.
- **Step 10:** Melt the metals into bars and send them to be minted and taxed (Bigelow, 2016).

They did not discriminate what types of silver this amalgamation process was tested on – they manipulated all types of ore including mixes of copper, iron, and sulfur (Bigelow, 2016). Potosí integrated the patio process with industrial-scale technology after the Peruvian viceroyalty – Francisco de Toledo – visited (Lane, 2015). He instructed thousands of workers to build dams in the Kari-Kari mountains to accomplish this. This would serve as the water supply for the countless new crushing mills required for the patio process. The success of this project proved to be a cornerstone for Potosí's wealth restoration. Toledo also organized a new labor system for the mines called the "mita" – from the Quechua word "mit'a" for "turn" (Lane, 2015). This forced labor and constant exposure to toxins soon collapsed the Andean domination of mining.

Economic Impact

A misconception has been established that Latin America is a peripheral country lacking independence and industrialization (Bigelow, 2016). On the other hand, its silver industry has historically impacted its macroeconomic expansion by increasing its GDP per capita, wages, and market integration (Bigelow, 2016). For instance, an estimated sixty percent of Potosí's miners and refiners were independent wage laborers (Bigelow, 2016). The influx of people and resources transformed Potosí into one of the largest and wealthiest cities in the world during the sixteenth and seventeenth centuries. The city's population grew to over two hundred thousand, making it one of the most populous urban centers of its time. The discovery of Cerro Rico led to an economic boom as it attracted thousands of miners, merchants, and traders. However, in the 1540s to 1560s, Potosí experienced its first boom-and-bust cycle (Lane, 2015). This provided the

“huayradores” – or indigenous miners and refiners – an opportunity to thrive. Huayradores were also referred to as “yanaconas” – it derives from the Quechua word “yana(yaku-)kuna” (Bigelow, 2016). It translates to: “yana” (person you serve) + “ya” (continually) + ”ku” (for me) (Bigelow, 2016). It was eventually shorted to yanacona and implied that the Spanish empire inherited the Incan empire’s labor and technology knowledge. The yanaconas’ labor system triggered an economic impact, which resulted in a new labor system (Bigelow, 2016). Individualized wages created a new kind of slavery for mid-sixteenth century Potosí through movement, migration, and coercion (Bigelow, 2016). Despite having to give a portion of their silver earnings to their Spanish overlords, the smelters used however much was left to begin accumulating wealth (Lane, 2015). The yanaconas did not like paying tribute because they were not treated like community members, but passersby instead (Bigelow, 2016). These mining operations heavily relied on indigenous labor through its mita system, which not only forced the community to give up a portion of their profits but also suffered from harsh working conditions and diseases. It is important to note that this behavior will only continue if Cerro Rico can supply the silver ore demand on time. After ten years, however, it seemed that Potosí would experience its first decline.

Cerro Rico supplied the world with a currency boost so much that Potosí was named the “treasury of the world” for some time (Lane, 2015). Silver became the key to globalization between the sixteenth and nineteenth centuries (Bigelow, 2016). Global trade used indigenous silver as their standard currency because Iberian merchants used the revenue they earned from the Asian Markets to purchase materials and labor from Africa and Europe. This was because silver and gold were the most universally traded forms of currency, and kingdoms all over yearned for a steady supply of these precious metals as they would establish dominance over

others through glamour and warfare (Lane, 2015). Merchants also needed silver to trade their goods and pay off the investors of their commercialized ventures from every other corner of the globe. Potosí was able to facilitate both global trade and monarch happiness simultaneously. Most of their silver bars and coins found a home in China, and some in India. These Asian countries manufactured some of the most demanded products in the world – products that could only be paid for with American silver and gold. The king of Spain envied this – he was desperate to possess such a distinguished silver mountain. However, the influx of silver from Potosí profoundly affected Spain. The wealth generated from the mines allowed Spain to finance its military campaigns and maintain its status as a dominant European power. It even allowed them to pay for silks, noble palaces, and loans borrowed from neighboring European countries (Zoellner, 2014).

The Imperial Villa of Potosí was also considered a hub for global trade. They imported huge quantities of Spanish iron and steel, and English, Chinese, and Indian textiles. The silver from Potosí had significant effects on the broader European economy. The silver trade facilitated the development of global trade networks, connecting Europe with Asia and the Americas. This period is often considered the beginning of globalization, as silver flowed from the Americas to Europe and Asia, particularly China, where it was in high demand. The silver from Potosí played a crucial role in the global economy at the time. It supported the Spanish Empire's dominance and contributed to the rise of worldwide trade networks.

Ultimately, China had almost all silver supply (Marks, 2015). This is because of the sixteenth-century development of the “First Globalization.” Two new links brought the globe together to exchange commodities, ideas, germs, foods, and people. First, was Christopher Columbus in 1492 who opened the New World to relationships with the Americas, Europe, and

Africa. Next, was the Pacific Route in 1571 formed the relationship between the New World and China after the Spanish established a Philippine colony (Marks, 2015). It is important to understand that empires were the most successful political form to bring control, increase numbers, and sustain land. The dynamics of an empire include mobilizing resources within its control, extending its dynasty to new areas, and ending nomadic threats by placing the remaining nomads under its control. The Aztecs and Inca had the highest political organization in the Americas in the biological regime. The Incas incorporated conquered people into their culture by forcing them to adopt a common language – Quechua – and governing them with professional administrators.

However, the Incas were conquered by Spanish conquistadors led by Francisco Pizarro (Marks, 2015). Once the smallpox epidemic hit, the Indian population declined. The Spaniards arrived and lured all of the survivors into a trap and killed them all. With the conquest of the Americas came a two-way exchange between the New World and the Old World. With the agricultural revolution of Eurasia, people and domesticated animals created smallpox, chicken pox, and influenza epidemics. The Eurasians were able to develop immunities, however, the New Worlders were not due to the Ice Age (Marks, 2015). As a result, the Great Dying occurred. The smallpox epidemics weakened the Incas and the Spanish were able to conquer them. The pre-conquest population of the Native Americans was estimated to be forty to one hundred million, but the post-conquest population was estimated to be nearly eight million. Other contributing factors to the Native American's depopulation were war, oppression, forced labor, lower fertility, and increased depression.

After the Great Dying, the Spaniards stumbled upon a mass amount of silver left by the Incas (Marks, 2015). With this newfound wealth, Spain attempted to dominate Europe, however,

it failed due to excessive warfare among countries that led to its bankruptcy. Because Spain was preoccupied with war, silver flowed out of its hands and to the Dutch, English, and Italians. They used silver to finance trade missions with China. It had a huge demand for silver as it funded its monetary system and facilitated economic growth. China was considered the largest and most productive economy – in fact, there would be no Potosí mines without them as there would be no Spanish attempt to conquer Europe (Marks, 2015). It had success in developing additional resources to sustain larger populations. Although two-thirds of the world population was Asian, they produced four-fifths of the world's goods. Europe was so poor relative to Asia that it competed amongst itself to deal with Asian markets. So, China decided to get the silver because of its growing population.

In sum, the influx of silver in Cerro Rico led to a substantial increase in silver entering the Spanish economy ("The Spanish Empire, Silver, & Runaway Inflation: Crash Course World History #25"). This led to a rise in the money supply, which contributed to a period known as the "Price Revolution" – characterized by widespread inflation ("The Spanish Empire, Silver, & Runaway Inflation: Crash Course World History #25"). The cost of goods and services rose rapidly as the value of silver decreased due to its abundance. This had mixed effects on the Spanish economy. It initially boosted its economic activity and allowed Spain to finance wars, however, it eventually led to monetary instability and a decline in the value of silver. It impacted global trade with China because the Spanish used silver to purchase goods from Asia, which further partnered with the global economy and increased inflationary pressures ("The Spanish Empire, Silver, & Runaway Inflation: Crash Course World History #25"). These economic changes resulted in social stratification and increased inequality because the benefits of silver mining were not evenly distributed.

Environmental Consequences

Mining inherently causes significant environmental disruption through deforestation, soil erosion, and water contamination (Lane, 2015). By 1603, Cerro Rico suffered from such high levels of soil erosion that the mountain was riddled with loose gravel and no fertile land (Moore, 2010). Even without mercury amalgamation, silver mining generated various toxic byproducts. These mines interfered with underground water flows, and the water exiting these mines typically pollutes streams and disrupts pH levels. The runoff from refineries is even more hazardous, as it often contains mercury, salt, and other solvents, which are seldom adequately filtered. The situation has seen little improvement since the colonial era. For instance, in 2014, burst sedimentation ponds around Potosí contaminated the Pilcomayo and other Bolivian rivers (Lane, 2015).

During colonial times, the vaporization of mercury after amalgamation was arguably the most insidious form of mining pollution (Lane, 2015). The wind could carry this invisible vapor and, for centuries, it settled over vast areas of Potosí and its surroundings. This contamination affected soils, food, clothing, cooking utensils, and almost everything else. Inhaling mercury vapor was known to be extremely dangerous, and the term “temblando como un azogado” – or “shaking like a victim of mercury poisoning” – was a common expression for being terrified (Lane, 2015). Additionally, significant hazards came from lead, which is used as a flux in silver smelting, and zinc, which often accompanies silver in sulfide ores.

Later, Cerro Rico’s silver extraction method was a drill, blast, shovel, and haul (Zoellner, 2014). In the 1670s, Potosí began blasting their mines with black powder. Blasting minimized the manual labor needed to chip the rock by hand (Lane, 2015). Black powder also heightened the dangers of rock fall and toxin inhalation – something that could make miners develop

life-threatening lung diseases. Despite these conditions, workers generally desired to develop their drilling and charge-placing skills to earn higher wages. Today, an estimated sixteen thousand miners actively work on the Cerro Rico mountain, with dozens of them dying and hundreds more of them diagnosed with severe cases of silicosis (Zoellner, 2014).

Socio-cultural Effects

The concentration of silver in Cerro Rico allowed its rulers to enforce a "radically interventionist imperial policy," (Moore, 2010). As a result, the mining industry in Potosí relied heavily on forced labor, particularly through the Mita system, which required indigenous communities to provide labor for the mines (Lane, 2015). This led to significant social and demographic changes, as indigenous populations were displaced and subjected to harsh working conditions. The labor-intensive nature of silver mining also contributed to the exploitation and suffering of enslaved Africans and indigenous workers. The local Quechua were forced into slavery – they had to dig for twelve hours each day and sleep in the underground tunnels for periods as long as four months (Zoellner, 2014). To make themselves feel better, they were told to pray to God, however, many of them saw this as an opportunity for traitors – they created the imaginary power "Tío," who served as the landlord and protector from the dangers of the mountain like cave-ins, silicosis, and a lack of silver (Zoellner, 2014).

In the early 1700s, the Spanish government became worried about the condition of Potosí (Lane, 2015). They believed Andean mine owners were not mentally fit enough to run such a city without supervision. The Bourbon kings decided to take action: all Potosí needed was the freshest tools, theories, and techniques, as well as a handful of tax incentives. The Spanish administration organized multiple technical missions with the first arriving in Potosí in 1789 (Lane, 2015). Polish Protestant Baron Thaddeus von Nordenflicht led the mission. With him, he

brought barrel-type amalgamation machines designed by Austrian engineer Ignaz von Born. Unfortunately, they soon realized that this new tool would be considered impossible to build in Potosí as they lacked the quality of craftsmanship, engineering, and steel. Although Borns' machines produced positive results, their expenses were not feasible to keep the operation running. Yet in the early 1820s, the British government visited Potosí and discovered that Bolivia's miners were still cutting and transporting ore with their bare hands and backs (Lane, 2015). They were also still using mercury amalgamation – a technique from the days of Toledo. Potosí's crushing mills were repaired on occasion but barely improved upon. Although the British urged the implementation of new technologies, the mine owners' primary concern was cheap materials and labor. From the late eighteenth century to the early nineteenth century, Potosí's silver production declined greatly as European supplies were cut off due to naval warfare and Potosí struggled to obtain mercury. In the 1900s, Potosí finally accepted that they were desperate for new technology (Lane, 2015). This was mainly achieved through rail line construction that connected mining towns along the Andean highlands. This meant that heavy machinery and equipment could be transported from countries like Europe or the United States, and therefore Potosí could begin to utilize local steel production.

The Scientific Attitude Towards Mining

Unfortunately, science in Latin America has been considered to be a secret throughout its entire history. To understand these underlying truths, scientists have banded together to investigate using archaeometallurgy, ethnohistory, and oral history (Bigelow, 2016). Renaissance science has had a profound impact on the mining practices in Cerro Rico. This is due to the significant advancements in developing metallurgical techniques, systemizing knowledge, and applying scientific principles. Renaissance scientists engineered new extraction and refining

methods to improve smelting, ore crushing, and furnaces (Sammuri and Macini, 2022). Renaissance scientists also applied principles of physics and chemistry to enhance their mining practices. This included the use of hydraulics for mine water management and mineral separation.

Mineralogy also played an important role in locating silver deposits in Cerro Rico. Scientists examined the minerals in rock formations to identify ore minerals like silver sulfide and chloride, indicating the presence of silver deposits. Mineralogy also provided detailed geological mapping to help pinpoint the distribution of rock types and mineral deposits in Cerro Rico. It used geochemical analysis to test rock samples and their chemical composition to identify the potential silver-rich zones. Understanding this geology means scientists can predict where silver can most likely be found. Mineralogy served as historical data and scientists used previous exploration data to guide their search for silver deposits.

They also utilized literary scientific tradition to define the language used by the indigenous miners. One example of this was 1600s priest Alvaro Alonso Barba who designed and wrote a series of novels about the theoretics and practical applications of linked European and indigenous understandings of how the world operates (Bigelow, 2015). He experimented and questioned authority frequently (Lane, 2015). He embodied the "New Science" movement during the seventeenth century. In 1640, his work *The Art of Metals* was published in Spanish and translated into English, German, and French until the end of the eighteenth century (Lane, 2015). This indicated the presence of "intellectual hybridity" – these somewhat mistranslated Hispanized forms of Quecha provide an understanding of how Andean miners founded a vocabulary for their knowledge and activity (Bigelow, 2016). This work provides a detailed description of mining techniques, equipment, and processes. It is important to note that the

miners were deeply opposed to the scientific advances in Cerro Rico (Scott, 2021). This is because they were concerned for their survival and earning a living under such harsh conditions (Zoellner, 2014). Their forced labor system often made it difficult for them to appreciate scientific progress. They also heavily relied on practical knowledge like traditional techniques, local expertise, and adaptation. Miners appreciated the indigenous workers' expertise in manual labor, simple tools, and ability to identify ore deposits and navigate tunnels. However, miners began to recognize the benefits of innovative techniques and technology like better ventilation and ore processing systems – this improved working conditions and productivity. This implementation of formal science with scientific methods like geological surveys and chemical analyses, technological innovations like the patio process, and engineering advances like improved water management techniques all contributed to the miners' shift in perspective. Both the scientists and miners began to adopt one another's approaches. Although this integration was challenging, this collaboration proved crucial for Cerro Rico's continuous development.

The discovery of Cerro Rico made it an "epicenter [for] commodity revolution" and transformed it into a capitalist empire – it was the frontier (Moore, 2010). Today, however, Potosí would be considered a classic example of Dark Ecotourism as they proudly publicized their systematic destruction of mountainsides and human beings (Zoellner, 2014). Its legacy as a major silver mining center continues to influence the region's cultural and economic landscape. Cerro Rico remains a symbol of the wealth and exploitation of colonial expansion. It exhibits "dark tourism" – a term created in 1996 by two British academics: Malcolm Foley and John Lennon (Zoellner, 2014). Dark ecotourism in Potosí is evident within the mountain itself. It was once rich with silver but now stands as a symbol of exploitation and danger. Tourists are paying to experience the harsh working conditions of the miners. Visitors are taken into the tunnels to

witness the laborious and hazardous environment firsthand. This form of tourism in Cerro Rico raises ethical questions about the commodification of suffering. Cerro Rico must implement sustainable mining practices and policies to mitigate environmental damage while considering its economic needs.

Conclusion

Throughout the sixteenth and seventeenth centuries, Cerro Rico was considered the world's largest source of silver. These mines funded the Spanish Empire's economy and imperial ambitions. Cerro Rico's mining operations heavily relied on forced labor through the mita system, which required indigenous people to work in the mines. After centuries of mining, Cerro Rico's local population faced detrimental social, economic, and ecological consequences. Today, Cerro Rico is a testament to the complex interworkings of wealth, exploitation, and cultural transformation. Potosí de Cerro Rico symbolizes the grand and dark aspects of colonial history.

References

Bigelow, Allison. “Incorporating Indigenous Knowledge into Extractive Economies: The Science of Colonial Silver.” *The Extractive Industries and Society*, vol. 3, no. 1, Jan. 2016, pp. 117–23, https://doi.org/10.1016/j.exis.2015.11.001. Accessed 09 Dec. 2024.

Lane, Kris. "Potosí Mines." Oxford Research Encyclopedia of Latin American History. May 04, 2015. Oxford University Press. <https://oxfordre.com/latinamericanhistory/view/10.1093/acrefore/9780199366439.001.001/acrefore-9780199366439-e-2>. Accessed 09 Dec. 2024.

Marks, Robert. *The Origins of the Modern World: A Global and Environmental Narrative from the Fifteenth to the Twenty-First Century*. 3rd ed., Lanham, Maryland, Rowman & Littlefield, 2015.

Moore, Jason. (2010). “This lofty mountain of silver could conquer the whole world”: Potosí and the political ecology of underdevelopment, 1545-1800. *Journal of Philosophical Economics*, *Volume IV Issue 1*(1), 58. https://doi.org/10.46298/jpe.10605. Accessed 09 Dec. 2024.

Paolo Sammuri, & Paolo Macini. (2022). The renaissance of minerals, mining and metallurgy in Tuscany: from Biringuccio’s Pirotechnia (1540) to Cosimo I de’ Medici. *Travaux Du Comité Français d’Histoire de La Géologie*, *3ème série*(tome 36 bis), 171–181. https://hal.science/hal-04424214. Accessed 09 Dec. 2024.

Scott, Heidi V. (2021). Mining, geological imaginations, and the politics of subterranean knowledge in the colonial Andes. *Geoforum*, *127*, 373–384. https://doi.org/10.1016/j.geoforum.2020.08.017. Accessed 09 Dec. 2024.

"The Spanish Empire, Silver, & Runaway Inflation: Crash Course World History #25." *Https://Www.oerproject.com/*, 2024, www.oerproject.com/OER-Materials/OER-Media/Videos/Origins/Unit6/The-panish-Empire-Silver-and-Runaway-Inflation-CCWH-25. Accessed 4 Dec. 2024.

Zoellner, Tom. "The Mountain That Eats Men: Dark Ecotourism in Potosí, Bolivia." *World Literature Today*, vol. 88, no. 3–4, 2014, pp. 83–87. *JSTOR*, https://doi.org/10.7588/worllitetoda.88.3-4.0083. Accessed 09 Dec. 2024.

"Cerro Rico." *Wikipedia*, 4 Oct. 2023, en.wikipedia.org/wiki/Cerro_Rico.