

THE TIN CENTURIES

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Technology and Statecraft in Qing China

YIJUN WANG

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To my parents and teachers

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CONVENTIONS

ROMANIZATION: Chinese terms are romanized with pinyin spelling unless the original book titles and quotations used other systems. Where the text compares Mandarin with nineteenth-century European transcriptions of Chaozhounese, pinyin is marked *PY* for clarity. When available, Manchu names and terms are romanized using the Möllendorff system.

NAMES: Following Chinese convention, historical Chinese figures in this book are presented with surname first, given name second. In the bibliography, Chinese-language publications maintain the Chinese convention (surname first). For English-language publications by Chinese authors, names are presented as they appear in the original publication.

DATES: Dates based on the Chinese lunar calendar are given in ordinal numbers. For example, the sixth day of the seventh lunar month of the third year of the Qianlong reign is shortened in the notes to QL 3/7/6, where *QL* indicates the Qianlong reign.

TITLES: In the interest of standardization, the translation of official titles follows that of Hucker, *A Dictionary of Official Titles in Imperial China*.

MEASUREMENTS: The weights and measures of the Qing dynasty varied by region, time period, and usage context. This chart shows the state-standardized measurements commonly used in the eighteenth and nineteenth centuries. For length, I use the *yingzao chi*, and for weight, I use the *kuping liang*.

1 <i>dan</i> (picul) 擔/石	= 100 <i>jin</i> (catty) 斤	≈ 59.7 kg
1 <i>jin</i> (catty) 斤	= 16 <i>liang</i> (tael) 兩	≈ 597 g
1 <i>liang</i> (tael) 兩	= 10 <i>qian</i> 錢	≈ 37.3 g
1 <i>qian</i> 錢	= 10 <i>fen</i> 分	≈ 3.73 g
1 <i>fen</i> 分	= 10 <i>li</i> 釐	≈ 0.37 g
1 <i>li</i> 里	= 180 <i>zhang</i> 丈	≈ 576 m

1 <i>zhang</i> 丈	= 10 <i>chi</i> 尺	≈ 3.2 m
1 <i>chi</i> 尺	= 10 <i>cun</i> 寸	≈ 32 cm

Data: Qiu Guangming, *Zhongguo lidai duliangheng kao*, 106–19, 494–513.

CHRONOLOGY OF CHINESE DYNASTIES

Shang, 1600–ca. 1045 BCE
Zhou, ca. 1045–256 BCE
 Spring and Autumn period, 770–476 BCE
 Warring States period, 476–221 BCE
Qin, 221–206 BCE
Han, 206 BCE–220 CE
Three Kingdoms, 220–280
Six Dynasties
 Western Jin, 265–317
 Eastern Jin, 317–420
 Southern and Northern dynasties, 420–589
Sui, 581–618
Tang, 618–907
Five Dynasties and Ten Kingdoms, 907–979
Song, 960–1279
 Northern Song, 960–1127
 Southern Song, 1127–1279
Jin, 1115–1234
Yuan, 1271–1368
Ming, 1368–1644
Qing, 1644–1912
 Shunzhi reign (sz), 1644–1661
 Kangxi reign (kx), 1662–1722
 Yongzheng reign (yz), 1723–1735
 Qianlong reign (ql), 1736–1795
 Jiaqing reign (jq), 1796–1820
 Daoguang reign (dg), 1821–1850
 Xianfeng reign (xf), 1851–1861
 Tongzhi reign (tz), 1862–1874

Qing, 1644–1912 (*continued*)

Guangxu reign (GX), 1875–1908

Xuantong reign (XT), 1909–1911

THE TIN CENTURIES

Introduction

Tin, a mundane metal that looks like silver, was as crucial to the lives of ordinary people as to the imperial state of China. In early modern China, tin was widely used to make everyday items, from dining utensils to religious objects. In addition, it was used to mint currency for the state. During the Qing dynasty (1644–1912), the intensification of global trade, combined with the changing mining policies of the Qing court, altered the ways this metal was excavated, traded, and managed. Hugh Gillan (?–1798), a Scottish doctor who joined the first British diplomatic mission to China in 1793, recorded a glimpse of changes since the late seventeenth century:

Tin is in great use. Large quantities of it are consumed daily and it is an article of great request through the whole of the provinces of the Empire. At Canton they employ a mixture of it in a small proportion with lead for forming the very thin plates which the tea packing cases are lined with, and everywhere kitchen stoves lined with clay, and ornaments for sedan chairs and their poles are made of it. . . . The greatest part of their imported tin comes from England, but it is not equal to the Malacca and Banca tin imported to them by the Dutch, and the Chinese accordingly give them the preference. The Banca and Malacca tin is quite pure, and on this account more easily rolled into thinner foil, and of a brighter lustre.¹

Hugh Gillan accurately noticed that tin had become a global commodity by the end of the eighteenth century. Despite China's long history of tin mining and substantial domestic reserves, the country became increasingly dependent on the global market for its tin supply. By the late eighteenth century, China was importing tin from diverse regions, including Bangka, an island in today's Indonesia, and Cornwall in England. Bangka tin even entered the mint in Beijing as the currency for the empire.²

The transformation of tin from a mundane metal to a global commodity must be understood in the larger context of global trade. From the second half of the sixteenth century, China began to engage in extensive trade relations with Europeans, first the Portuguese and the Spanish, then the Dutch and the British. These European traders tapped into and transformed pre-existing intra-Asian trading networks, becoming new maritime forces that connected expansive networks across the Indian and the Pacific Oceans. Chinese junk traders participated actively in these networks, serving as crucial connections between regional markets.

In the eighteenth century, with the establishment of the Canton System (1757–1842), Sino-European trading relations became increasingly integrated. The Sino-European trade created unprecedented global demand for Chinese tea and other manufactured luxuries, while simultaneously channeling massive inflows of American silver into China. Within this trade system, the most significant commodities by volume and value were not luxuries but bulk commodities—tea and silver. To trade for Chinese commodities, Europeans needed massive amounts of American silver. This situation only began to change when the British started to produce opium in India for export to China in the second half of the eighteenth century. As historian Andrew Liu demonstrates, the tea trade affected material and economic flows across the globe, connecting silver mines in Potosí, tea plantations in China, and poppy fields in India.³

The success of Sino-European trade changed the demand for and supply of tin. First, the increasing tea trade required vast quantities of tin for tea packaging. Second, massive silver inflows created difficulties for the Qing government's monetary system. Qing China operated under a dual currency system, using both copper coins and silver. The silver inflow required the government to mint more copper coins to maintain the exchange rate, which increased the demand for copper, tin, and zinc—the essential monetary metals. Moreover, population growth and economic development in the Qing empire further increased the domestic demand for tin to produce pewter vessels and religious objects for ordinary consumers. These changes, fueled by maritime trade combined with increasing domestic demand, made China the largest tin importer in Asia in the eighteenth century. When the Dutch East India Company (VOC) discovered that Southeast Asian tin could serve as an effective substitute for their dwindling silver supplies, they began to monopolize the tin trade and encouraged tin mining in Bangka.

These converging demands put tin under supply pressure, creating the context for the social, economic, and political transformations this book examines. Different actors reacted to these challenges in various ways, with each group exercising agency within its particular constraints and opportunities. The Qing state and its bureaucrats pursued a dual approach: promoting mining in Yunnan, the newly conquered southwest borderland of the empire, while sourcing tin through global and domestic trade networks. Gejiu, a small village in Yunnan, became the largest tin production center in China, while Bangka became the major supplier of tin to China from Southeast Asia. For nonstate actors—merchants and miners—the demand for tin and mining restrictions in China proper encouraged migration. They either joined the imperial expansion to Yunnan or emigrated to Southeast Asia, establishing mining communities that reshaped local socioeconomic landscapes and contributed to the global expansion of capitalism.

The Tin Centuries explores two interconnected themes. First, it examines the mining communities and technology transfer, discussing how Chinese miners established large-scale mining operations in Gejiu and Bangka. Central to this analysis is what I term the social technology of mining: the organizational structures, shareholding systems, and fraternal culture that enabled cross-border mobility and provided a competitive advantage in unfamiliar environments. The movement of technology and migration subsequently led to far-reaching socioeconomic changes in mining regions. Chinese mining enterprises inadvertently contributed to European colonial expansion and global capitalism by providing the labor force for resource extraction in Southeast Asia, thereby facilitating European capital accumulation.

Second, this book investigates how Qing bureaucrats developed a technocratic approach to statecraft through their daily involvement in mining management and metal procurement. Early Qing bannermen officials established the prototype of a technocratic way of thinking, writing, and governance. This culture was then adopted by civilian officials who had gained access to the bureaucracy through their mastery of Confucian classics. Mining administration and mineral sourcing provided a particular arena for these scholar-officials to master technocratic practice. Since these officials increasingly relied on technological knowledge to handle administrative tasks, they adopted a technocratic approach to statecraft that valued technological expertise alongside Confucian learning. Through systematic collection, codification, and publication of mining knowledge, these bureaucrats engaged

in knowledge production and developed a new political culture. This culture prefigured China's path to modernity and industrialization, suggesting an indigenous trajectory toward technocratic governance that preceded Western influence.

Tin as a Lens and a Framework

This book uses tin as a lens and a thread to examine technology transmission and the Qing bureaucracy's changing approach to statecraft. Tin's distinctive characteristics provide us with a special analytical perspective compared to other metals. Silver, for instance, entered China primarily as a currency and a precious metal, with scholarly discussions focusing either on economic history or luxury production.⁴ Tin, by contrast, allows us to concentrate more on its materiality, focusing on mining and alloying technologies. More importantly, tin provides a more symmetrical view of Chinese participation in the formation of the global capitalist economy. Most scholarship on silver focuses on Spanish silver mined by workers in the Americas, with China appearing simply as the recipient of silver flows. Bangka tin, excavated by Chinese miners using Chinese mining technology, reveals China as not merely a passive recipient but an active participant in shaping global flows of labor, technology, and materials.

Tin also offers a different angle from copper and zinc. Copper mining was nominally under state monopoly; therefore, much research has focused on monetary policy and state control over mining and transportation.⁵ Tin largely remained in the private sphere. The Qing state's control over tin was limited to taxation. It relied on merchants to manage mining and depended on commercial networks to source tin. This allows us to move beyond court-centered regulations to examine how entrepreneurs conducted mining operations outside of state control and how metal markets actually functioned. In this way, tin shifts the focus from state-centered grand narratives to granular interactions among low-level officials, merchants, miners, and craftsmen, thereby restoring the agency of these often overlooked actors. And unlike zinc mining, which remained largely domestic, tin's global and transregional nature offers a comparative framework for analyzing Chinese mining practices both within the Qing empire and in Southeast Asia.⁶

Despite these distinctive characteristics, tin has received far less scholarly attention than other metals, particularly for the early modern period.

Previous studies of mining and smelting technologies in China have focused predominantly on copper, iron, zinc, and silver, with tin often relegated to the broader contexts of bronze technology and monetary policy.⁷ Existing scholarship on tin mining and smelting technology focuses only on earlier periods, while the time span of this book remains largely understudied.⁸

Tin's unique characteristics and analytical potential determine the geographical framework and social parameters of this book. Geographically, tin production and circulation transcended national boundaries, connecting mining sites in Yunnan and Bangka, thus permitting a translocal study focused on multiple locations. In addition, tin's complex supply chain involved actors across multiple levels of society and governance. I use tin as a thread to analyze diverse players, including Qing officials at different levels (from county administrators to provincial governors), Dutch and British traders and colonial officials, as well as adventurous Chinese entrepreneurs and miners.

This book's time frame is also based on tin. The "tin centuries" began approximately in the eighteenth century. It was during this period that large-scale migration to Yunnan and Bangka occurred, while the Qing empire also began importing significant quantities of Bangka tin. To provide historical context, we begin in the sixteenth century with the troubled mining policies in the Ming dynasty. Examining Ming practices illuminates institutional developments in the Qing period. Unlike the Ming court, which relied on eunuchs for irregular taxation, the Qing regularized mining taxation and institutionalized mining administration. Drawing lessons from the Ming-era miner uprisings, the Qing also reconfigured the geography of mining, restricting operations in China proper to prevent social instability while encouraging mining in borderlands like Yunnan and Guizhou. These administrative responsibilities further motivated Qing officials to familiarize themselves with technological knowledge, cultivating a new approach to statecraft.

The book ends in the mid-nineteenth century, when environmental degradation and fiscal crisis forced Qing elites to abandon their previous noninterference approach to mining. High-profile officials began applying technological knowledge in the policy-making process, drawing on practical knowledge to actively boost mining. This transformation in statecraft resonated with changing views regarding natural resources. The perception of mineral resources shifted from heaven's benevolence in providing for people's livelihood (which the state should avoid interfering with) to critical

assets essential for state wealth and power. This technocratic turn was the last native attempt by Chinese scholar-officials to avert crisis before succumbing to Western imperialism and scientism. This previously little-known transformation prefigured the more familiar story of modernization and industrialization in the late Qing, hinting at the intriguing possibility of China finding an alternative path to modernity. Of course, the tin centuries did not end there. In the twentieth century, the demand for tin increased due to industrial production. China transformed from importer to exporter, and Chinese intellectuals increasingly tied mineral resources to state sovereignty and revival.

The Movement of Mining Technology via Migration

This book engages with the study of knowledge and technology transfer through some understudied actors: migrant workers. In recent decades, scholars have investigated knowledge transmission through the lens of translation, motion, and exchange.⁹ Historians have followed the itinerary of materials and knowledge to examine the entanglements, negotiations, and local adaptations that happened in cross-cultural and cross-regional knowledge transmission.¹⁰ They have shown how Chinese artisans and scholars creatively adapted European technologies such as clock making, cartography and cannon production through their contact with Western missionaries and commodities.¹¹ Recent scholarship has demonstrated that the Chinese state managed the movement of technology by moving skilled artisans and *yang*, prototypes that served to transmit designs, across the empire.¹²

This book examines the movement of mining technology through a less studied channel: migration. The Chinese have a long history of emigration to Southeast Asia. Starting in the mid-fifteenth century, Southeast Asia entered what historian Anthony Reid calls “the age of commerce.”¹³ Residents from Fujian and Guangdong began to follow maritime trade routes to settle in Southeast Asia. The scale of emigration increased significantly in the eighteenth century. Southeast Asia specialists such as Leonard Blussé, Carl Trocki, Ng Chin-Keong, and Jennifer Cushman have shown that large-scale emigration occurred after the Qing government lifted maritime prohibitions in 1683. These emigrants settled in the emerging urban centers, port cities, and lowland plains to engage in the intra-Asian junk trade and to work on plantations and in mining. Many established autonomous communities.¹⁴

Miners working in the tin mines of Bangka came from the mountainous interior region of Chaozhou, located in the northeast coastal area of Guangdong. This area was a traditional tin mining center also known for its pirate activity. In the 1700s, Chinese miners followed established trade routes to Bangka, bringing with them Chinese mining technology. As historian Mary Heidhues points out in her pioneering work, these miners introduced large-scale water drainage systems and more powerful smelting furnaces.¹⁵ This technology enabled them to excavate deeper and more efficiently than the Bangkanese miners. The Chinese miners also established *kongsi*, an economic and political institution that operates almost like a state.¹⁶ Dutch colonizers found Chinese mining technology more effective than local Bangkanese techniques, and thus encouraged labor recruitment from China. Consequently, Chinese mining enterprises quickly dominated the tin industry in Bangka.

The Tin Centuries deliberately bridges the distinction between transnational and domestic migration, recognizing that migration of miners also occurred in southwest China. While historians like Nanny Kim and Yang Yuda have examined mobile mining communities along China's southwest border, the movement of mining technology through domestic migration remains understudied.¹⁷ Domestic migrants working in Gejiu mainly came from Hunan, Hubei, and Jiangxi in China proper. These miners brought mining technologies from their home regions to Gejiu, demonstrating that technological transfer was not limited to international movement. Much like the Chinese *kongsi* in Bangka, domestic migrants in Yunnan formed a semiautonomous Seven Chiefs system. By the eighteenth century, migrants dominated tin mining in Gejiu and marginalized the local Yi people into less profitable activities in the mining industry.

The parallel changes in Gejiu and Bangka provide a comparative perspective to examine mobility and immobility in technology transmission. Mining technology was not easily transmitted through the movement of skilled bodies, equipment, or texts. It was an industry that demanded substantial investment, knowledgeable experts, and sophisticated labor management. The cases in Gejiu and Bangka show that it was the "social technology" that allowed Chinese migrants to establish large-scale mining enterprises. While social technology provided mobility, its deep social embeddedness also created barriers. Although Chinese mining equipment and methods were not difficult to replicate, the local residents of Bangka and Gejiu lacked the capital and labor resources to achieve large-scale production. As a result,

they were gradually marginalized in the competition with Chinese mining enterprises.

The Social Technology of Mining

I define the social organization of miners as a social technology of mining. The advantages of Chinese mining were not complicated tools or machines but rather a social technology of organizing labor and capital. My definition of social technology is different from that of historians Steven Shapin and Simon Schaffer, who employ this concept to analyze knowledge claims and the fact-making process in Robert Boyle's scientific work.¹⁸ Their focus is on knowledge production, while my analysis centers on the production of tangible material (tin) and social relations in mining communities.

My approach draws inspiration from the work of Francesca Bray and Jacob Eyferth. Francesca Bray, based on her study of agriculture technology in China, extends the meaning of technology to social-material networks, including techniques, equipment, trained personnel, and institutions that generate material goods as well as social relations.¹⁹ Similarly, Jacob Eyferth's research on paper makers in rural southwest China shows that the secret of papermaking was embedded in social networks rather than residing solely in the secret recipe of paper makers.²⁰ Building on their definitions, I argue that both the *kongsi* system in Southeast Asia and the Seven Chiefs system in Yunnan worked as social technology that provided financial tools to raise funds, build large-scale equipment, recruit personnel, and ensure local security. These institutions not only formed the production organization but also enabled the migrants to sustain and reproduce their mining community in a different cultural context. Therefore, social relations not only affect technological transmission; they form part of the technology.

The social technology of mining, as seen in Bangka and Yunnan, provides an angle to understand the Chinese enterprises and labor that flourished in European colonies in Southeast Asia. A similar *kongsi* system is found in other areas, such as gold mines in Borneo. This system was based on a partnership and shareholding model, in which investors and skilled miners shared profits and risks, with investors taking the largest share. Similar to the equity compensation system of today's tech giants, this social technology enticed miners to work harder and longer hours, often long term without payment. Seduced by the illusion of future profits, the miners turned them-

selves into a diligent and disciplined workforce that met the demands of capitalism and colonialism.

The Tin Centuries delves into the shadowy aspects of the success of Chinese business enterprises in Southeast Asia. Historian Melissa Macauley describes how Chaozhou merchants seized the opportunities presented by European colonial expansion to extend their influence and power across Southeast Asia.²¹ However, this success was built on the brutal exploitation of Chinese laborers. This seemingly democratic and fraternal system motivated Chinese miners to contribute their bodies and labor to the wealth accumulation of European colonial powers and a few elite Chinese merchants, turning themselves into the often-neglected labor force that sustained European economic expansion in their colonies. This dynamic echoes Kenneth Pomeranz's concept of "ghost acres," with Chinese labor functioning as another form of the colonial resources that sustained European industrialization.²²

A Technocratic Approach to Statecraft

In addition to miners and merchants, government officials were important actors in this story. This book investigates an emerging change in Qing statecraft: the rise of a technocratic approach to governance among Qing officials during the eighteenth and nineteenth centuries. This transformation, characterized by systematic application of practical and technological knowledge to administrative challenges, spread from bannermen experts to Han scholar-officials and ultimately inspired the reformist *jingshi* (statecraft) movement.

Technocracy is commonly understood as the rule of experts: governance through scientific or technological knowledge.²³ It is used to describe scientific tendencies in both factory management as well as state politics in the twentieth century.²⁴ Technocracy is not just a form of governance but also a system of beliefs. As historian Victor Seow insightfully points out, "Technocracy is first and foremost an ideology" that elevates science and technology to unprecedented status as the means to solve society's problems.²⁵ Technical experts who hold fast to this ideology are technocrats.

Clearly, the twentieth-century definition cannot be fully applied to the Qing dynasty. Most Qing scholar-officials were not initially trained as technical experts, and the concept of scientism had not yet arrived in China. However, what occurred in China during the eighteenth and nineteenth centuries shared many cultural and ideological features with technocracy. Therefore,

in this book, I use “technocratic culture” and “technocratic approach” to describe the tendency to use practical and technological knowledge for governance. Here, I follow Dorothy Ko’s approach in interpreting *technocrat* in its Greek meaning: the power (*kratos*) of practical knowledge (*technē*).²⁶

The technocratic culture of the Qing bureaucracy elucidated in this book is twofold. First, it refers to the way Qing bureaucrats increasingly used technological knowledge to frame and solve governance problems. Second, it encompasses the increasingly close relationship between political power and technological knowledge. This technocratic approach has its roots in early Qing bannermen officials’ governance style, which emphasized technological expertise. Historians have shown that in order to rule a vast, multiethnic empire, the Manchu rulers used bannermen experts at the outset to supervise a wide array of activities, including the manufacture of silk and porcelain, the salt monopoly, the ginseng and fur trades, cartography, and even ethnographic surveys at the frontier.²⁷ As Dorothy Ko has pointed out, Manchu rulers developed a new knowledge culture. They recognized that technological power was integral to political power and put great effort into acquiring, transmitting, and systematizing artisanal knowledge.²⁸ Kai Jun Chen’s *Porcelain for the Emperor* investigates the training and career path of a bannerman, Tang Ying, to show that the Manchu bannerman experts shared a technocratic knowledge culture that was distinct from Han Chinese officials. Instead of passing the civil service exam, these bannermen were initially trained as financial and technological experts and acquired knowledge through hands-on experience in manufacturing management.²⁹

My study demonstrates that by the eighteenth and nineteenth centuries, the technocratic culture was no longer exclusive to bannermen experts at the central court, but had permeated all levels of state administration, from county magistrates to provincial governors. However, this technocratic shift did not occur uniformly across all areas of governance. The administration and sourcing of metals became a crucial site for the development of technocratic culture. In the context of the global expansion of capitalism, tin and other metals increasingly became in-demand resources. Therefore, officials were compelled to acquire detailed technological knowledge about mining operations, cost assessment, and supply networks. The shift of mining production to frontier regions also led to regional differences in technological expertise. Officials in mining frontiers like Yunnan had to master mining and smelting technology as well as shipping methods, while officials in other provinces had to navi-

gate trade networks, accounting methods, and shipping logistics. As a result, although most Han Chinese bureaucrats gained their positions through a mastery of Confucian classics, they eventually became expert in mining management, metal alloying, trade, and accounting. Such expertise helped them gain favor with the emperor and their superiors, and enabled them to garner promotions and power. While Confucianism remained the dominant ideology in political discourse, officials increasingly began to use empirical observation, experimentation, and technological expertise to solve problems and gain credibility in their memorials and official reports. In this way, Confucian officials and bannermen experts reached the same end by different means.

The involvement of Confucian scholars in technocracy during the Qing dynasty diverged from developments in the Song dynasty, when technocratic experts constituted a separate category from the institutionalized Confucian scholar-official system. Historian Charles Hartman has shown that Song technocrats—including military servitors, clerks, artisans, eunuchs, and female officials—formed a distinctive “imperial technocracy.” They created a separate structure of governance at the court and were thus despised by Confucian scholar-officials as “petty men.”³⁰ Unlike this Song dynasty pattern of polarization, the Qing period witnessed a convergence of Confucian scholarly training with practical expertise in the same individuals.

The development of technocratic culture in mining administration was unique in that, unlike established technocratic fields such as hydraulic engineering and salt administration, it lacked institutional precedents. Hydraulic management and salt administration had a long history in imperial China, with numerous experienced scholar-officials appointed to these positions. Salt had been under state monopoly since 119 BCE and reached its institutional maturity in late imperial China.³¹ Water management was regarded as a crucial indicator of dynastic legitimacy and had received significant attention since antiquity.³² Systematic administration and taxation of mining, however, was not part of any established statecraft tradition. The Ming dynasty only imposed irregular mining taxes collected by eunuchs. It was not until the Qing dynasty that mining administration became institutionalized and systematized. Consequently, it was only during the Qing dynasty that extensive production of mining treatises took place. This absence of precedent means that Qing officials had to develop new administrative methods and technological expertise from scratch, making mining administration a particularly fertile site for the development of technocratic governance.

While mining administration provides a particularly clear example of this technocratic turn, this study's findings illuminate broader transformations in Qing statecraft. As early as the eighteenth century, as historian William Rowe has pointed out, Confucian elites had developed expertise in diverse technical areas, including agronomy, fiscal administration, and military logistics.³³ At the turn of the nineteenth century, this trend became more pronounced. Social and environmental crises compelled officials to apply similar technocratic approaches to challenges such as famine relief, canal management, and anticorruption efforts.³⁴ The innovative methods Qing officials developed in mining—mobilizing the private sector and applying technological knowledge—became templates for addressing other governance challenges and ultimately paved the way for late Qing industrialization efforts.

Writing Knowledge About Mining

The technocratic turn in statecraft was both facilitated by and resulted in knowledge production. Qing officials actively collected, systematized, and published mining knowledge as part of their administrative duties. This was a long-term diachronic process, continuing from the eighteenth century to the middle of the nineteenth century. It involved multiple participants across various administration levels—county-level bureaucrats, administrative assistants, and ultimately, provincial governors. They produced a body of texts, including practical essays, administrative manuals, local gazetteers, and even comprehensive technological treatises. This body of texts represented a line of continuous knowledge accumulation that reflected and reinforced the technocratic turn in governance.

Technological writings produced by Qing officials, together with reports from European colonial officials, constitute an important part of my primary sources. In chapters 1–3, I use these records to reconstruct mining technologies and administrative practices. However, these sources require critical analysis due to their inherent biases. The mining treatises produced by Qing officials primarily served administrative purposes, emphasizing bureaucratic concerns while often overlooking miners' embodied knowledge. To address these gaps, I supplement official records with stele inscriptions and mining regulations produced by the mining communities themselves, as well as twentieth-century sociological surveys. European colonial records present different challenges: as profit-driven traders and colonizers, they

created highly judgmental descriptions of mining methods, often favoring the Chinese method, which aligned with their goal of intensive extraction. I critically analyze these biases throughout my study. Finally, in chapter 5, I conduct a more detailed analysis of mining texts to demonstrate how mining knowledge was gradually accumulated, reorganized, and systematized from the eighteenth to the nineteenth century, situating this process within the broader transformations of late imperial China.

This book engages with recent scholarship on knowledge production and knowledge culture in late imperial China. Scholars have demonstrated that Chinese intellectuals actively produced knowledge about nature through various modes of rationality. Dagmar Schäfer has shown how Song Yingxing's (1587–1666) search for cosmological order motivated his inquiry into craft knowledge.³⁵ Benjamin Elman reveals how Confucian scholars adapted Western science to their knowledge system to search for the principle of the world, leading them to approach modern science through evidential scholarship and philology.³⁶ Yulian Wu demonstrates how salt merchants expressed power through knowledge-collecting activities.³⁷ He Bian examines systematic knowledge reclassification and broader cultural transformations in pharmaceutical knowledge, accompanied by knowledge decentralization.³⁸ Mining knowledge shared these broader patterns but followed a different process.

In this book, I explore the rationales and motivations behind the compilation of mining treatises, as well as how this body of texts was created, cross-referenced, and reorganized across time. As mining centers moved from China proper to the southwestern frontier, county magistrates and their assistants in Yunnan became the principal collectors and producers of mining knowledge. To support their administrative duties, these local bureaucrats collected mining knowledge, transforming it into highly localized knowledge among Yunnan bureaucrats. The essays, reports, local gazetteers, and administrative manuals they produced became the source for provincial governors to compile mining treatises. In chapter 5, I analyze the authors and contents of these texts to reveal a genealogy of knowledge production, and to show that these mining texts aimed to provide the functional technological information essential for effective governance.

In the nineteenth century, the structure of this body of knowledge underwent gradual transformation. The priority shifted from monetary regulations to technological aspects of the production processes. The publication of *An*

Illustrated Strategy of Mines and Smelters in Yunnan (Diannan kuangchang tulüe; 1844) by Wu Qijun (1789–1847), the governor of Yunnan, represented the culmination of this long-term process, a moment I term the “Wu Qijun moment.” Its publication represented this Qing intellectual’s effort to centralize mining knowledge previously confined to local practitioners, complicating the stereotypical image of Confucian officials as purely classically minded rather than practically oriented administrators.

A Changing Approach to Natural Resources

One of the key findings of the book is that the technocratic turn in statecraft resonates with the Qing state’s changing approach to natural resources. Historians Shellen Wu and Victor Seow have demonstrated that in response to contact with European and Japanese imperial powers, Chinese statesmen adopted the idea that controlling and exploiting natural resources—coal, in their case—was key to the nation’s survival at the turn of the twentieth century.³⁹ Peter Lavelle’s *The Profits of Nature* explores the extraction of natural resources, particularly agricultural and sericultural resources, in Xinjiang in the late nineteenth century. Lavelle observes that the late Qing discourse about the extraction of agricultural resources stemmed from earlier discourses on mining, but he does not delve deeply into this origin.⁴⁰

This book bridges the gap between the much-studied high Qing (1683–1799) and the turbulent late Qing (1840–1912). Although Qing officials before the late nineteenth century did not conceptualize natural resources in modern terms, their management of mineral resources fell within what we would now recognize as natural resource management. In Qing documents, resources such as minerals were categorized under the rubric of “the beneficence of heaven, earth, and nature” (*tiandi ziran zhi li*). Before the middle of the nineteenth century, the Qing state saw itself as an agrarian state committed to the welfare of small family farms. Guided by Neo-Confucian ideology, it levied low land taxes, imposed minimal taxes on commerce and industry, and distanced itself from direct extraction of mineral resources. Tin, for instance, was excavated under the supervision of merchants rather than controlled by the state. But in the middle of the nineteenth century, faced with ecological pressure and fiscal crisis, the Qing state transformed its noninterference approach and began to actively

engage in mineral extraction. The emperor ordered his provincial governors to recruit more merchants to invest in new mining sites. Officials like Lin Zexu (1785–1850) institutionalized the model of merchant management under bureaucratic supervision, providing policy support and even state investment to the mining industry. The perception of mineral resources shifted from a Confucian view—as nature’s benevolence providing for the people’s livelihood—to a more modern understanding as critical assets for state wealth and power. This change was a precursor to modern natural resource extraction. While scholars like Shellen Wu and Victor Seow have studied later developments in this field, my analysis highlights the often-overlooked indigenous shifts that preceded them.

Organization of the Book

Two intertwined themes, technology and statecraft, shape this book. The first three chapters narrate the context of mining policy, the migration of miners, and mining technology in China and Southeast Asia. Chapter 1, “Migrating Miners and Shifting Centers,” establishes the context of mining in the Qing dynasty, charting policy changes, shifting locations of mining activities, and subsequent changes in knowledge production among bureaucrats from the Ming to the Qing dynasties. Chapter 2, “The Social Technology of Tin Mining,” reconstructs mining technologies and organizations in Gejiu, Yunnan. It defines the Seven Chiefs system as the social technology of mining and argues that the system’s organizational structure, shareholding arrangement, and brotherhood culture enabled the movement of mining communities and their success in Gejiu. Chapter 3, “Mining Organizations in the Formation of Global Capitalism,” follows the theme of social technology but shifts the focus to Southeast Asia. It situates Chinese miners’ migration and technology transfer within the context of global trade and provides a comparative analysis of mining technology in Bangka and Gejiu. It also shows that Qing bureaucrats and European colonial officials approached mining administration and technology in remarkably similar ways.

The last two chapters center on statecraft and discuss Qing bureaucrats’ technocratic culture, connecting the changing approach to statecraft to the broader reformist movement in the late nineteenth century. Chapter 4, “Thinking Like Artisans, Seeing Like Merchants,” examines monetary

reform in the 1740s, showing how Qing officials tackled China's monetary crisis through alloying experiments. The work of monetary reform and the procurement of monetary metals demonstrate how officials relied on empirical observation, experiments, commercial knowledge, and accounting skills to solve administrative problems, underscoring the emergence of a technocratic culture among these officials.

Chapter 5, "Transcribing Mining Technology for the Empire," examines provincial governor Wu Qijun as the representative of a broader transformation among mid-nineteenth-century officials like Lin Zexu and He Changling (1785–1848). To address the crisis in the empire, Wu compiled and published *An Illustrated Strategy of Mines and Smelters in Yunnan*, in which he reorganized, systematized, and centralized knowledge about mining. Wu exemplifies officials who, though trained in Confucian classics, became pragmatic technocrats to use technological knowledge to save the empire.

* * *

When we focus on tin, a global commodity and a natural resource, we can observe subtle but consistent changes since the eighteenth century. Miners and merchants, who were at the lower rungs of society, were particularly sensitive to the pressures of population growth and the opportunities brought by global trade. They were among the first to "vote with their feet." They migrated to mining frontiers and established capital- and labor-intensive mining enterprises. Their activities contributed to the European colonial project and became an integral part of the global economy. In this way, they became immersed in the global expansion of capitalism. Qing bureaucrats in Yunnan and Guangdong were also acutely aware of the changes brought about by global trade. They adeptly sourced tin through the global market, expanded their knowledge of mining technology, and managed mining operations through merchants. By the nineteenth century, as industrialization and a capitalist economy began to consume a broader range of natural resources, the fate of the state became increasingly tied to its ability to exploit nature. When the Qing government's silver reserves could no longer comfortably support its tin purchases, and Yunnan tin became a highly profitable commodity in the global market, Qing officials were compelled to abandon indirect management of tin and to actively invest in mining. The widespread

adoption of technocratic statecraft among Qing bureaucrats since the eighteenth century was driven fundamentally by the global expansion of capitalism and its unprecedented demand for resource extraction. While early Qing bannermen provided a foundation, it was capitalism's insatiable appetite for natural resources that became the primary force shaping administrative practices and the social fabric.

CHAPTER ONE

Migrating Miners and Shifting Centers

A Chinese export painting from the nineteenth century in the Peabody Essex Museum in Salem, Massachusetts, shows the interior of a pewter shop in the port city of Canton (fig. 1). The painting foregrounds the shop front. A customer in a blue robe sits at the counter, back to the viewer, gazing into the shop. The shopkeeper on the left presents a *gu*-shaped vase on the counter, probably promoting his wares. A pipe smoker sits to the right. The shop's shelves display sets of incense burners, candle stands, vases, and tea caddies. All the objects are heavily decorated—some candle stands are made in the shape of cranes, lion figures stand on the lids of censers, and vases are in the shape of a lady. In the background, a pewter artisan works at his station to produce more products. The signboard at the shop entrance reads, “Li He Hao produces various kinds of pewter dowry and altar pieces with excellent craftsmanship to ship to customers.”

In this painting, the commodities on display are made of pewter, an alloy of tin and lead. China has a long history of mining and using tin, with the earliest application being a combination with copper to produce bronze.¹ The use of tin in pewter alloys emerged during the Spring and Autumn period (771–476 BCE).² Starting in the twelfth century, people began to use pewter objects extensively. Specialized pewter shops appeared in Hangzhou, the capital of the Southern Song (1127–1279).³ Archeological evidence, such as the discovery of sixty-two pewter objects on a sunken ship in the South China Sea, suggests its widespread use in daily life and travel.⁴

The Chinese term for tin and pewter, *xi*, embodies multiple layers of ambiguity. First, the term could refer to both tin and pewter without distinction. Second, it carries connotations of gift giving, probably due to tin's



FIGURE 1. This export painting illustrates a pewter shop in nineteenth-century Canton, showing the characteristic front-shop, back-workshop structure common in Chinese craft production. The shop displays the diverse pewter objects used in everyday Chinese life. Although titled “Tutenage Metal Articles,” the shop sign-board indicates pewter production. Western consumers often conflated pewter with tutenage (a copper-nickel alloy known as *paktong*), a common misidentification in the China trade era. Artists in Guangzhou, *Tutenage Metal Articles*, from a series of forty paintings of Cantonese shops, ca. 1825. Opaque watercolor on paper, 27.94 × 36.83 cm. Gift of Mr. and Mrs. B. Rionda Braga, 1977, E80607.1. Courtesy of the Peabody Essex Museum, Salem, Massachusetts.

essential role in bronze production, since bronze was a preeminent medium for aristocratic rewards in Bronze Age China.⁵ Finally, *xi* occupied an intermediate position between lead and silver in metallurgical classification. According to *Shuowen jiezi*, a dictionary completed in the first century CE, *xi* refers to a metal between lead and silver.⁶ This definition shaped the subsequent perception of tin in scholarly discourse. The seventh-century material medical treatise *Xinxiu bencao* conflated tin with lead, while pre-fifteenth-century texts attributed tin’s softness and malleability to its yin energy and

claimed that tin could turn into silver when encountering yang energy over the course of two hundred years.⁷ These conceptual frameworks in scholarly writings created ambiguity among tin, lead, and pewter, while simultaneously establishing tin as a natural substitute for silver, as it possessed similar qualities at a fraction of the cost.

The medical properties of tin/pewter further affected its practical use. The twelfth-century scholar Hong Mai (1123–1202) claimed that tin/pewter possessed the ability to purify water, while sixteenth-century physician Li Shizhen (1518–93) believed tin/pewter powder to be a remedy capable of neutralizing arsenic poison.⁸ These metallurgical and medical understandings eventually translated into widespread adoption of pewter for everyday objects. In late imperial China, pewter was valued for two primary reasons: as an economical alternative to silver and as a material with purported detoxifying properties, which made it particularly suitable for food storage and beverage service. Consequently, people used pewter to manufacture a diverse array of household items, including drinking and dining vessels, candle stands, and ritual objects (see fig. 1). Additionally, pewter was used for the lining of ice chests, packaging for tea, and even architectural gutters. Tinfoil, representing silver ingots, was burned as joss paper in ancestral offerings.

In addition to its everyday use, tin was also an alloying metal used in mintage of the copper coins issued by the Qing. Although people habitually call Chinese money “copper coins,” they were in fact an alloy of copper, lead, zinc, and tin. The composition and the ratio of each metal were subject to change from time to time. The wide usage of tin brings our attention to the mundane metal that was crucial both to the Qing empire’s monetary system and people’s everyday life.

While tin had maintained its importance in Chinese society for centuries, established patterns of tin production and supply changed after the Ming-Qing transition. The Ming dynasty’s approach to mining was shaped by Confucian ideology and limited state capacity, resulting in irregular taxation through eunuchs and growing conflicts with local communities. The Qing court, learning from the Ming failure, developed a more systematic approach with significant regional variations. It restricted mining activities in China proper while actively encouraging extraction in frontier provinces like Yunnan and Guizhou.

These policy changes had far-reaching consequences. State restrictions pushed miners away from China proper, while the increasing global demand

for tin pulled them toward the southwest borderlands of the Qing empire and Southeast Asia. Migration of the mining population occurred both within the empire and across borders. This movement of people and technology in turn transformed the actors and locations of knowledge production. In the Ming dynasty, mining was managed by eunuchs from the central court, and knowledge about mining remained largely outside scholarly discourse. In contrast, Qing officials—particularly county magistrates in Yunnan—became active collectors and codifiers of mining knowledge. This chapter examines migration, technology transfer, and the transformations in knowledge production. To understand how these changes unfolded, we begin with the late Ming dynasty.

Tin Mining in the Ming: The Providential State and Its Limited Capacity

China has some of the largest tin deposits in the world.⁹ During the Ming dynasty, the most productive tin mines were located in Guangdong, Guangxi, and Hunan (map 1). Scholars in the Ming dynasty were aware of the existence of tin mines in Yunnan.¹⁰ However, these deposits were not fully exploited due to their remoteness. The mountainous landscape further increased the difficulty and cost of shipping. As a result, Yunnan did not become a major domestic producer of tin until the Qing dynasty.

Guangdong has a long history of tin mining, which can be traced back to the eleventh century. Starting in the late sixteenth century, Guangdong began to witness the development of large-scale tin mining sites and the arrival of tens of thousands of miners. According to Qu Dajun (1630–96), a Guangdong native and a Ming loyalist, “Changle, Xingning, Heyuan, Yong’an in Guangdong Province all yield tin. . . . The poor excavate it for a living. At the end of the Tianqi era [1621–27], [tin mining activities] were extremely prosperous.”¹¹

Guangxi was the biggest producer of tin during the Ming dynasty. In the sixteenth century, Nandan and Hechi in Guangxi were the major producers of tin, producing around 80 percent of the tin in the empire.¹² Tin and silver mines in Guangxi attracted miners and merchants from other provinces.¹³ In Hunan, Chenzhou and Hengzhou also had large-scale tin mining activities. In Hengzhou, there were over thirty mining sites and over ten thousand miners. Traders “gathered here to make huge profits by manipulating the market and exploiting the masses.”¹⁴



MAP 1. Major tin mines in the Ming and Qing dynasties. Based on the map in Wu Gongjian and Gao Rui, "Some Results and Prospects in the Application of Geo-physical and Geochemical Methods to the Search for Tin Deposits," 301; and Xia, Li, and Wang, *Zhongguo gudai kuangye kaifa shi*. Base map adapted from the Qing map of 1820, from Tan Qixiang, *Zhongguo lishi dituji*, vol. 8, *Qing shiqi*, 3–4. Map by Benjamin Pease.

To fully understand the policies and mining practices regarding tin during the Ming dynasty, we must contextualize them within the fiscal system of the Ming state through three key aspects: first, the Confucian ideology underlying the providential state; second, the Ming state's limited capacity for extracting mineral resources; and finally, the tension between local and central authorities, as well as security concerns. Richard von Glahn defines both the Ming and Qing states as providential states.¹⁵ This characteristic has been aptly described by R. Bin Wong as agrarian paternalism, which means the ruling elites adhered to a Neo-Confucian ideological commitment to the well-being of family farms.¹⁶ The state's fiscal policy was premised on low-level taxation levied on land, with minimal taxation on commerce, industry, and consumption (the salt monopoly being a notable exception). Many historians therefore describe this economic policy as *laissez-faire*, in which the state is reluctant to interfere with commerce and industry. Despite—or perhaps because of—this general principle of noninterference in market economies, the merchant class was even more removed from political power.

According to Confucian ideology, a state monopoly over mining was inherently unethical. Disdain toward state engagement in mining can be traced back to the first century BCE. In 81 BCE, a group of scholars gathered in the Western Han (206 BCE–8 CE) court to debate the economic policies of the preceding emperor, Emperor Wu (156–87 BCE), who created monopolies of salt and iron enterprises to fund wars against the Xiongnu. Confucian scholars in the Han dynasty opposed this policy, stating that such activities were not proper for the state, and the state “should not compete with people for profit.” Moreover, they argued that a state monopoly of mining would dispel “rustic generosity” and teach people to be greedy.¹⁷ Ming and Qing officials recapitulated this argument, which became the dominant political rhetoric used by officials to criticize state efforts to actively engage in mining and other profitable industrial activities.

Apart from ideological constraints, the Ming state also lacked effective means to extract mineral resources, as a result of its initial institutional design. The founder of the dynasty, Zhu Yuanzhang (1328–98), designed the Ming empire as an idealized agrarian state. The Ming state never established a systematized commercial tax or mining tax system. From the sixteenth century onward, the silver economy and the commercial revolution made this policy untenable. The influx of American silver and the booming market economy compelled the Ming court to issue more copper coins to

meet market demand. Wars against the Japanese and the Manchu also motivated the Ming court to boost mining activities to increase fiscal revenue. As a consequence, the Ming court resorted to irregular methods to augment fiscal income. The most notorious example was the mining tax during the Wanli period (1573–1620). From 1596 to 1620, the emperor dispatched over forty eunuchs as mining tax superintendents to collect taxes throughout the empire.¹⁸

The mining tax during the Wanli period extended far beyond revenue from mining itself, encompassing taxation from mining, commerce, and various miscellaneous levies. The portion directly related to mining revenue was mining tax silver (*kuangyin*), a tax on mining operations, assessed and payable in silver. Current historical sources provide no detailed information regarding the specific methods of collecting this silver tax. In fact, a substantial portion of the so-called mining tax during the Wanli period actually derived from commercial taxation. Therefore, historians view the mining tax as one of the Ming court's irregular methods of collecting commercial revenue. Moreover, this method was not institutionalized; it was performed through the emperor's direct deployment of eunuchs.¹⁹

The Ming government acquired mineral resources through quotas assigned to local governments. These metal revenues were deposited in the Dingziku Treasury, one of ten treasuries attached to the imperial household. According to the *Wanli kuaiji lu* (Wanli accounting records), the most comprehensive national account available for the Ming, the central government collected 19,503 *jin* of tin and 56,942.36 *jin* of various copper types in 1578.²⁰ While these metal revenues were collected in kind rather than converted to silver, they were not obtained directly through mining taxes. An examination of the sources of these metals reveals that much of the tin originated from quotas imposed on inland customs stations, including those in major urban centers, such as Suzhou, Songjiang, Yangzhou, and Zhenjiang, as well as from non-tin-producing regions in northern China, including Henan, Shandong, and Shanxi.²¹ It is likely that these local governments procured tin using commercial taxes and transported it to Beijing.

In sum, beyond Confucian ideological constraints, the Ming state lacked the capacity to systemically manage and extract mineral resources. The notorious Wanli mining tax served primarily as a mechanism for generating revenue beyond traditional land taxation, with the majority of income derived from commercial sources. Ming taxation of mines lacked institutional regu-

larity, relying instead on the irregular practice of imperial eunuchs. Most significantly, the Ming possessed no systematic framework for mineral resource management. The central government received tin through local government procurement using commercial and land taxes. Only during the Qing dynasty did the government develop a truly institutionalized system to manage mineral resources through a combination of taxation and procurement.

Revenue Conflicts and Social Upheaval in Mining Areas

In addition to ideological concerns and the limited capacity of the Ming state, practical considerations arising from local realities also heavily influenced mining policy and practice. The mining tax administered directly by eunuchs evolved into a competition between the central government and local society for profits and power. The central court imposed mining tax quotas on local governments, requiring each region with mineral deposits to pay specified amounts annually, and these amounts increased over time. The eunuchs encouraged, and sometimes forced, rich merchants to invest in mining and coerced the poor to work as miners.²² These extensive mining activities benefited the treasury of the central court and its eunuch supervisors while impoverishing local communities.²³

The conflict of interest can also be seen in the power struggles between eunuchs and scholar-officials. During the Ming dynasty, eunuchs were formidable competitors for power against Confucian scholars. They had direct access to the emperor and served as the monarch's trusted spies, secret police, and tax collectors.²⁴ Eunuch mining supervisors, representing imperial interests, had little sympathy for the concerns of local gentry and often superseded local administration. When they failed to meet prescribed quotas, local administrators had to compensate for shortfalls with funds from other sources, making mining a financial burden for local communities.²⁵ In other words, the power struggle between eunuchs and scholar-officials ran parallel to a broader tension between the monarch and local gentry elites.

Mining activities also imposed economic and ecological costs on local communities without corresponding benefits. As miners and traders were mostly migrants, their arrival sharply increased demand for food and everyday necessities. The famous traveler Xu Hongzu (1586–1641) noticed that in 1637, rice and meat prices in Guangxi tin mining areas were double those in neighboring regions.²⁶ In addition, mining damaged the local environment

and harmed agriculture. In Guangdong, polluted water from tin mines poisoned rice fields, starving the local peasants and causing endless disputes between local farmers and migrant miners.²⁷ Since taxes went directly to the central treasury, mining failed to benefit the community, leaving local officials with little incentive to bear the substantial economic and ecological costs associated with mining operations.

The most serious problem was the threat to local security. Miners were mostly migrant laborers or impoverished peasants from neighboring areas.²⁸ In Guangxi, many miners came from Hubei and Hunan.²⁹ In Guangdong, migrants from Fujian and impoverished locals gathered to engage in tin and silver mining.³⁰ It was difficult to control the miners through *baojia*, the group responsibility system that had been in place since the eleventh century, because the miners had no roots in the local society. The unpredictable economic risks in mining made these impoverished miners even more dangerous. The discovery of a deposit could attract tens of thousands of miners, but these miners were given no severance pay when the mine was exhausted. With no income, some skills in producing metal weapons, and the close-knit organization associated with mining production, miners could easily become organized bandits.³¹

Scholar-officials in the Ming dynasty frequently referred to miners as “mining bandits” (*kuangdao*). Since miners were engaged in organized labor, they tended to form secret societies, which could lead to large-scale rebellions. According to James Tong, a large percentage of collective rebellions in the late Ming were led by miners.³² Huizhou and Chaozhou in Guangdong suffered most from mining banditry. Local administrators claimed that migrants colluded with poor local peasants to gather at mining sites in the mountains. They engaged in mining when it was profitable and turned to banditry when the deposit was exhausted. These mining bandits formed highly militarized, autonomous societies with up to several thousand members. They entrenched themselves in mountain fortresses and raided local towns and villages.³³ Toward the end of the Ming dynasty, the government was busy chasing after mining bandits and suppressing local insurrections. Repeated internal uprisings and rebellions finally brought the troubled empire to an end.

Late Ming intellectuals and early Qing rulers interpreted the downfall of the Ming dynasty as a result of the crimes of greedy eunuchs and profit-seeking by the court. Confucian scholars in the early Qing further capital-

ized this narrative. Drawing on the long-standing “Debate on Salt and Iron,” Confucian officials argued that the state should refrain from profit-seeking economic activities or it would meet the fate of the Ming empire. The Ming experience and Confucian ideology worked together to affect mining policy in the Qing dynasty.

Mining Administration in the Qing Dynasty: Political Ideology and Practical Concerns

Learning from the collapse of the Ming empire, the Qing court implemented a mining policy with significant regional variation, which was a result of the interplay between political ideology and pragmatic concerns. This political ideology drew from both critical assessment of the Ming dynasty’s failure and Confucian political theories. After the fall of the Ming dynasty, Qing scholars viewed the mining campaign in the Wanli period as “the starting point of the collapse of the Ming dynasty.”³⁴ They blamed the emperor for pushing eunuchs to the point of depleting mineral resources, which ended up harming the people through heavy mining taxes and forced labor.³⁵ This lesson guided mining policy in the early Qing. As historians Wei Qingyuan and Lu Su point out in their thorough study of mining policy in the early Qing, the Qing court banned mining in most of China proper from 1683 to late 1730s.³⁶ Even when the court gradually lifted mining bans starting in the 1740s to address copper shortages, mining operations remained subject to strict restrictions. Direct state involvement in mining became a political third rail: whenever local officials in China proper sought to redevelop mining, they invariably faced accusations of competing with the people for profit.

The Yongzheng emperor’s 1724 edict exemplified this ideological stance. In the edict, the emperor claimed that “the right way to nurture the people is to promote agriculture.”³⁷ He further elaborated that agriculture was “the root” of society and the state, while the profit from mining was just “the branch.” Promoting mining was nothing but attending to trifles and neglecting the fundamental root. He reiterated the danger of mining banditry, stating that once mines were deserted, the miners would become a local threat. As for taxation, the emperor proudly stated that “I own the wealth of four seas, why would I rely on this [mining tax]?” At the end of the edict, the emperor concluded that it was “absolutely forbidden” to recruit merchants to develop large-scale mining sites in Guangdong.³⁸

This ideological constraint on mining mirrored broader patterns in Qing fiscal policy. Historian Taisu Zhang points out that the revisionist discourse against heavy land taxes in the Ming dynasty became the ideological basis for fiscal weakness in the Qing dynasty.³⁹ The Qing approach to mining reflected this same caution. Throughout the eighteenth century, whenever Qing officials wanted to promote mining in China proper, they underplayed the connection between mining and state revenue. Instead, they claimed that their promotion of mining was intended to provide a livelihood for landless peasants. Only in the nineteenth century, when the empire faced rebellions, environmental crises, and wars with Western powers, did scholars begin to directly discuss mining as a source of state revenue.

Yet ideology alone does not fully explain Qing mining policy. While Confucian principles and lessons from the Ming collapse shaped official discourse, the Qing court also had to address practical security concerns, particularly the risk of mining-related social instability. The following section examines how the state regulated these security risks through regional differentiation.

Mining Bandits: Security Concerns in Guangdong

From a governance perspective, the most significant cost of mining was local security. In the Qing dynasty, mining bandits continued to be active in mountainous areas of South China. In the summer of 1712, a group of bandits looted towns in Chaozhou and Shaozhou in Guangdong. A general reported to the Kangxi emperor (1654–1722) that the bandits were in fact migrant miners who had worked in mines in the mountains of Chaozhou and Shaozhou, on the borders between four provinces, which had always been a site of illicit activities. Alarmed by the savage banditry, the governor and military commanders of Guangdong sent troops to round up the mining bandits.⁴⁰ It took more than two months for the Guangdong government to complete the mission. The provincial military commander explained to the emperor that it was difficult to arrest the miners because the mining bandits were mixed up with local idlers. Local informants showed the miners the locations of outposts and checkpoints. Once they caught wind of the government army approaching, the miners fled to other provinces, while the local idlers blended into the community. Therefore, it was extremely difficult for the Qing army to find them. This military campaign was by no means a

success; they caught only thirty mining bandits and failed to eliminate the group.⁴¹

A detailed mining banditry case that lasted from 1737 to 1738 offers an opportunity to understand why it was so costly for the government to prevent illicit mining.⁴² In the fall of 1737, Fan Yasi and his four friends schemed to excavate tin in Boluo County in Guangdong. The five initiators elected Fan to be the “big brother” (*dage*) and recruited some eight hundred to nine hundred people, who referred to Fan Yasi as “chairman of the board” (*dong laoda*). These miners were likely poor peasants looking to increase their meager income. The identity of Fan Yasi and his four fellows is no longer traceable, but their prosaic names, which probably reflect birth order, hint at humble origins. Fan recruited Huang Wenbing, a retired headman who had worked in mining decades ago, to manage his mining corporation.⁴³

Fan was skilled at weaving networks of power relationships and possessed some military talent. To secure his mining operation, he bribed some clerks in the county administration and low-level military commanders to provide advance warning of government suppression campaigns, so that the miners could flee before troops arrived. This arrangement was very successful. Although the local government routinely patrolled the mountains, they somehow turned a blind eye to the large group of miners and never reported it to the provincial administration. To prevent other miners from stealing his mining resources, Fan organized a security team of a hundred people to guard the sites and an elite squad of twelve, equipped with guns and cannons, to prepare for violent conflict. Many of them were family members of the local soldiers. A year later, the miners expanded their mining operation to over twenty sites.⁴⁴

The following fall, as the mining operation expanded, a member of the enterprise called Huang Zhao wanted to replace Fan and planned a mutiny. Huang assembled an armed force to raid Fan at night. Fan quickly organized a counterattack. The two forces, both equipped with guns and cannons, engaged in an intense conflict that claimed over twenty lives. Three days later, a team of Qing soldiers found the bodies and the weapons the miners left behind. At this point, the conflict was too serious to conceal. Governor-General Omida (1685–1761) was alerted and sent troops to search the mountain, but the miners quickly blended into the local community. It took the Qing army a month to arrest Fan Yasi, at which point most of the miners had already slipped away. Eventually, Omida had to give up. In a palace memorial, the governor-general

explained to the Qianlong emperor: “Most of the miners in the mountains were ignorant people. They were hoodwinked and enticed by Fan.”⁴⁵ Omida argued that it was too time consuming to arrest all the “ignorant” workers. Instead, he arrested the leaders, punished the corrupt officials, and burned the facilities to prevent further illicit mining. The Qianlong emperor approved his resolution but sternly reprimanded Omida, saying that it was ridiculous for him to take over half a year to notice such a big group of criminals.⁴⁶

The case of Fan Yasi provides an opportunity to explore how miners organized themselves. The enterprise started with a few adventurous, unruly, and entrepreneurial members: Fan Yasi and his four “brothers.” Fan was elected the head of the mining group and became the “big brother.” The major labor force consisted of the eight hundred to nine hundred people they recruited. These were mostly poor peasants who relocated from neighboring regions to earn extra income. These peasants-turned-miners formed a highly organized labor force with violent tendencies—they had around a hundred guards who patrolled the mining site. Neither Fan nor the newly recruited miners had any technical training in mining, so Fan recruited Huang Wenbing, a retired mine supervisor, to “join the partnership” (*ruhuo*).⁴⁷ Huang provided the mining technology and managerial knowledge for Fan’s organization, making it an excellent opportunity for poor miners in Guangdong.

Fan’s titles, both “big brother” and “chairman of the board,” reveal the dual nature of his organization. As a secret society, the miners were tied together by brotherhood, a fictive kinship that provided financial aid and physical protection. As a business corporation, members pooled resources to fund operations and shared profits. This dual structure was common among mining communities. Scholars use the term *secret society* to refer to unofficial associations formed through sworn brotherhood or religious bonds, though in practice these two forms often overlapped. Such organizations proliferated in late imperial China and among the Chinese diaspora, growing out of mutual aid societies in which members pooled resources to provide funds for various purposes.⁴⁸ Mary Heidhues points out that the secret societies and the Chinese *kongsi* in Southeast Asia were two sides of the same coin. Their dual character as both sociopolitical and economic production organizations provided Chinese migrants with financial support and physical security.⁴⁹

Fan Yasi’s organization exemplified this model. Connected by brotherhood and economic interest, people with little capital pooled resources to fund the operation. Skilled miners joined as partners to provide mining and

managerial technology. Poor peasants were recruited locally to provide the major labor force. This flexible structure enabled the miners to start with an extremely small investment and expand rapidly. Once a rich deposit was discovered, the operation could expand to encompass thousands of people.

Similar organizations were commonly found among Chinese mining enterprises in Yunnan and Southeast Asia. These organizational structures enabled Chinese migrant miners to establish large-scale mining corporations on the southwest frontier of the Qing empire and in Southeast Asia, where they had little financial support and few local connections. The collaboration between Fan Yasi and the family members of local soldiers also shows how these Chinese mining organizations managed to survive in a foreign or even hostile environment: leaders of the mining organization skillfully nurtured shared interests with local authorities, who might then provide support or at least turn a blind eye to illegal conduct. However, compared to the potential economic benefits, their function as secret societies made the mining organizations more of a headache than a blessing for Qing officials. Therefore, mining was initially banned in densely populated regions, and then strictly monitored in China proper.

Merchant Management under Bureaucratic Supervision in the Eighteenth Century

A few days after dealing with Fan Yasi's incident, Omidia, the governor-general of Guangdong and Guangxi, submitted a memorial to the Qianlong emperor to propose reviving mining in Guangdong. Before Omidia, a good number of officials had proposed lifting the mining ban, but their proposals had all been harshly rebuked by the previous emperor. Qianlong's ascension created a new opening. Omidia, together with other like-minded officials, seized this opportunity to promote mining in China proper.

The appeals of these officials coincided with Qianlong's intention. The primary reason for lifting the mining ban was the demand for mintage. The Qing empire used copper coins, which were made from an alloy of copper, tin, lead, and zinc. However, the copper supply in China proper was insufficient. In the early Qing, the mintage primarily relied on imported Japanese copper.⁵⁰ However, from 1698, the supply of Japanese copper dwindled, while the demand of the Chinese mints continued to rise. Therefore, while encouraging mining in the far west of the empire, some officials also advocated for a repeal of the

mining ban in China proper. To justify their actions, Qing officials tirelessly reiterated in their memorials that extraction of mineral resources was not for the benefit of the state but to support the people's livelihoods.

Unlike his father, the new emperor was open to lifting the mining ban. Seizing this opportunity, Omida used a politically correct argument in Confucian discourse—improving the people's livelihoods—to persuade the emperor. Omida argued, "In eastern Guangdong, where mountains are numerous and arable land is scarce, the livelihood of the common people is challenging. This work [mining] could provide a livelihood for countless people."⁵¹ Attached to this memorial was "Rules for Mining Operations," in which he proposed nine regulations to manage and regulate mining. His proposal was not immediately approved by the emperor, but it set up a protocol for the management of mines in China proper after 1740. Omida described his management policy: "Recruit local affluent merchants to provide their own capital for mining, and select capable bureaucrats to oversee the operations."⁵² This management model, repeated as "recruit merchants to operate mining" (*zhaoshang kaicai*) in eighteenth-century memorials, would become the precedent for "merchant operation under bureaucratic supervision" (*guandu shangban*) in the late nineteenth century.

Omida's proposal found support among many provincial officials. One year later, his successor, Martai, sent another memorial to the court, proposing to restart tin mining in Guangdong. In the memorial, Martai claimed he had a change of heart after reading the appeals of officials to restart mining, and he realized that lifting the mining ban "is of great benefit to the state's wealth [*guoji*]."⁵³ In the memorial, Martai clarified that he was motivated not merely by the prospect of profits for the government but by the health of the whole society. He argued, "I think pewter wares are everyday necessities for the people. Moreover, tin is cheaper than copper, so it can replace copper [to make everyday necessities]. Thus tin can complement the deficiency of copper. . . . In addition, Huizhou and its surrounding areas are densely populated, but there are few job opportunities. In the past, landless, poor peasants depended on tin mining for a living. After mining was banned, poor peasants suffered from the bitterness of being jobless, therefore the mining restriction is truly detrimental to people's livelihood."⁵⁴

In this neatly crafted memorial, Martai outlined the four foremost concerns of the Qing government: local security, income for the state, the shortage of metal for mintage, and local people's livelihoods. He first tackled the

biggest obstacle to mining policy—the threat to local security—by claiming that he had wiped out the mining bandits. He then claimed that tin mining was not only beneficial to the state economy but could also remedy the copper shortage. The most important argument hinged on people's livelihoods. Martai argued that tin mining would not only lower the price of everyday necessities but also provide job opportunities for landless peasants. In other words, Martai distinguished the Qing from the corrupt Ming court by arguing that tin mining was promoted to benefit poor peasants, not the state treasury. Any revenue the state gained was merely incidental. At the end of the memorial, Martai attached a detailed list of mining sites—a by-product of his diligent antibanditry campaign.⁵⁵

After several rounds of debate in the Qing court, the demand for fiscal income and monetary metals won out over the concern for local security. In the 1740s, the Qianlong emperor officially lifted mining restrictions in China proper. Mines in Guangdong, Guangxi, and Hunan were put back into operation. In this series of discussions, Qing officials had to justify their extraction of natural resources by emphasizing its benefits to the people's livelihoods. This discourse contrasts with changing attitudes in the nineteenth century, when mineral resources became “profits of nature” that contributed to the wealth and strength of the empire.

Although the mining ban was lifted, there were still many restrictions in China proper. Local officials had to carefully balance mining production, its impact on agriculture, and its threat to regional security. To begin with, provincial governors had to “go to the mining sites to inspect *in person*” (*qin-wang chayan*) to ensure that the mines would not pollute neighboring farmland.⁵⁶ This requirement alone eliminated many potential mining sites. After a mining site began operation, the biggest challenge was management. Local officials hoped to recruit as many miners as possible to boost productivity while preventing the miners from starting an uprising that might threaten the local government. To maintain the delicate balance between productivity and local security, the Qing government applied a new model to administer mining: merchant management under bureaucratic supervision. The mining regulations proposed by Omidā two years earlier became the model for mining management in all of China proper.

In Omidā's master plan, the provincial governor appointed capable bureaucrats at the prefecture or county level as “special commissioners” (*wei-yuan*) responsible for the taxation and security of mining sites. The provincial

government collected 20 percent of the mining output, while procuring the remaining 80 percent of copper at a fixed price. A few soldiers were hired to patrol the mining site to prevent smuggling and keep unregistered miners from entering mining sites.⁵⁷ Because the Qing government refrained from direct investment in and management of mining, the special commissioners relied on merchants for these crucial tasks. The selection criteria for merchants were that they be well funded and local. In this way, they were less likely to suddenly withdraw their money or abscond due to losses, which could turn miners into mining bandits. After merchants received a license from the government, they were allowed to recruit miners and hire smelters.

To prevent illicit mining, the Qing government used the *baojia* system to manage the mining population. Under Omidā's regulations, merchants were required to recruit local peasants with no criminal record. They had to register each miner and send their ledgers to the government. Each miner was assigned to a unit of ten for mutual responsibility and surveillance. A tablet called a "waist tag" (*yaopai*) was issued to each miner as a pass to enter the mining site. The tablet contained the miner's identification information, including age, appearance, and birthplace. Blacksmiths were closely monitored, and all mining tools they produced had to be registered, as such tools could be easily transformed into weapons.⁵⁸

Omidā's regulations were meticulously crafted to address the myriad administrative challenges associated with mining. Although his intention was to boost mining, ironically, the cumbersome restrictions significantly hindered its development. To begin with, the regulations only allowed rich merchants to become investors. In many cases, salt merchants became major investors in Guangdong.⁵⁹ These merchants had close ties with the imperial court, enabling them to obtain licenses for the salt monopoly and act as agents in sourcing material objects for the imperial household.⁶⁰ From the state's perspective, recruiting wealthy merchants was a rational choice: they could provide more capital than ordinary merchants and were more easily controlled, since their business heavily depended on the government. However, this requirement excluded adventurous miners with little capital, such as Fan Yasi. As a result, these miners and merchants moved to Yunnan or Southeast Asia to make a living.

Merchant management under bureaucratic supervision may have been a blessing at the beginning, but it often became a burden for both sides when costs began to rise. The primary cost involved drainage and ventilation. As the

mines went deeper, costs skyrocketed. By the middle of the eighteenth century, the cost of mining had surpassed the procurement price for tin. For example, in 1743 the market price for tin in Guangdong was already two times higher than the procurement price.⁶¹ As merchants began to lose money, they tended to close the mines, and some even went bankrupt. The labor force also left.

Throughout the eighteenth century, tin mining in China proper witnessed a steady decline. Local mining officials reported many tin mines to be exhausted and depleted, leading to requests for their closure. In Guangdong, tin output in the 1740s was not even sufficient to supply the annual procurement quota for the capital mints in Beijing.⁶² By the end of the eighteenth century, tin mines in northern Guangdong had been closed due to depletion.⁶³ The productivity of tin mines in Hunan reached its peak in 1774–95, with an annual output of approximately 164,000–165,000 *jin*, but quickly declined to less than 4,000 *jin* in the early nineteenth century.⁶⁴ To fulfill the demand for mintage, the Qing government had to rely on the global trade network to source tin from Southeast Asia.

It is difficult to determine to what extent the reported depletion was true. While it is undeniable that no tin deposits exist today in eastern Guangdong, substantial tin deposits still remained in Guangxi and Hunan. It is more likely that a combination of rising costs, strict mining policies, and the depletion of shallow deposits contributed to this outcome. As mining costs increased, merchants preferred to abandon the site rather than continue to excavate. It was also hard to recruit miners with little prospective income. For the local bureaucrats, managing mining operations, especially with a reduced output, entailed the risk of being reprimanded for failing to meet tax quotas. As this situation presented more disadvantages than benefits, they may have preferred to close the mines altogether, using depletion as an excuse. Therefore, after an initial burst with the lifting of the mining restriction, the tin mining industry in China proper continued to shrink. Most of the poor peasants who were supposed to make a living through mining chose to migrate to the frontier of the Qing empire in search of better opportunities: some moved to Yunnan, while others crossed the border to Southeast Asia.

Moving Toward the Frontier: Migration of Miners

Starting in the seventeenth century, poor peasants and merchants began to leave their hometowns to move to places with fewer restrictions. To understand

the movement of mining, it is essential to grasp the geographical constraints and opportunities provided by tin deposits (map 2). Asia has two of the world's most important tin belts: the South China tin belt and the Southeast Asia tin belt. The South China tin belt extends from southeastern Yunnan to the coastal areas of South China, encompassing the Nanling mountains. Intense Yenshanian tectono-magmatism and mineralization gave rise to a concentration of tin deposits. The middle and eastern sections of the South China tin belt contains the major tin mining areas in Guangdong, Guangxi, and Hunan.⁶⁵ The western edge of this tin belt ends at Gejiu, which became a major tin mining center after the eighteenth century. To the south lies the renowned Southeast Asian tin belt, which runs from Myanmar through Thailand and the Malay Peninsula, extending to the Bangka Belitung Islands in Indonesia.⁶⁶ This geological continuity provided the material foundation for the movement of mining activities.

Miners from China proper moved in two main directions based on this geological continuity. From Guangdong and Guangxi, miners chose to move to Southeast Asia, while from Hunan and Hubei, many moved to Yunnan, the new mining frontier of the Qing empire. Scholars often distinguish between the study of cross-border migration and domestic migration. Experts on Southeast Asia tend to examine cross-border emigration under the framework of overseas Chinese, while scholars studying mining technology in China often overlook the migrant character of miners.⁶⁷ In reality, the scale and distance of domestic migration to Yunnan were comparable to, if not greater than, those of transnational migration. Miners have always been a mobile group, and they followed mineral deposits rather than state borders. The challenges faced by these migrant miners were also similar: they had to establish a labor and capital-intensive industry in environments with significant cultural differences and without local or lineage support. Therefore, in this book, I treat cross-border and domestic migration as similar events.

The tin mines in Guangdong and Guangxi were connected to the Southeast Asian tin belt. The increasing global demand for tin and the mining restrictions together motivated miners to move to Vietnam, Malaysia, and even to Indonesia. In 1731, the regional commander of Guangxi, Zhang Yingzong (active 1728–34), discovered rampant border crossing between China and Vietnam. According to Zhang, those “unscrupulous miners” (*kuangtu*) were mostly from Hunan and Guangxi. When the harvesting season ended, these peasants turned into miners and crossed the mountain passes into Vietnam. The following spring, they returned to China for the farming season.⁶⁸ Official



MAP 2. The tin belt and geological structure in South China and Southeast Asia. Notice the geological similarity among eastern Guangdong, the Malay Peninsula, and the Bangka Islands. This map has been modified based on information from Hutchison, "The Tin Metallogenic Provinces of S. E. Asia and China," 231. Map by Benjamin Pease.

records in the later Lê dynasty (1533–1789) show that in the eighteenth century, there were tens of thousands of Chinese miners in north Vietnam, most of them from Guangdong.⁶⁹ Similar situations also occurred in silver mines along the border between the Qing empire and Burma.⁷⁰ The most significant cross-border migration of tin miners followed a long-established maritime route to Bangka and Belitung. From the first decade of the eighteenth century, Chinese miners dominated the tin mining industry in Bangka. Their products became one of the major commodities that the Dutch East India Company (VOC) traded with China.

While miners from Guangdong crossed the border into Southeast Asia, another group of miners, mostly from Hunan and Hubei, chose to follow the Qing army to Yunnan. There, they engaged in mining various metals, including copper, silver, lead, tin, and zinc. In 1682, one year after the Kangxi emperor (r. 1661–1722) suppressed the Revolt of the Three Feudatories and extended the territory of the Qing empire to Yunnan, Cai Yurong (?–1699), the governor-general of Yunnan and Guizhou, submitted a memorial, “Ten Solutions to Prepare for the Development of Yunnan” (Chou Dian shi shu), to the Kangxi emperor. In this memorial, Cai offered ten proposals for the central court to enhance its governance over the southwest frontier and restore the local population and economy after years of war. The proposals included relief from the land tax, the establishment of more military garrisons, the removal of previous feudal officials and indigenous chiefs, the promotion of mining, suppression of the remaining bandits, and the reestablishment of local administrative institutions. One of the recommendations the emperor accepted was to revive mining. In this proposal, Cai explicitly pointed out that the mountainous landscape of Yunnan failed to provide enough land tax to support the ever-growing military expenditure. Furthermore, more minerals were needed for the mints in Yunnan to issue copper coins to pay the soldiers and bureaucrats. Without mining revenues and copper supplies for coinage, the newly established Qing administration in Yunnan would have struggled to maintain its financial viability.⁷¹

Mining also helped the Qing state repopulate Yunnan and better control the land and its population. Years of warfare had reduced the local population, desolated farmland, and devastated the economy. Mining operations provided a profitable opportunity for the impoverished population, thereby reducing local instability. Moreover, Yunnan had been ruled by non-Han groups such as the Yi, Miao, and Tai, and governance was divided among

various local chieftains. Bringing in Han Chinese would not only increase government revenue but also enhance the Qing government's direct control over the frontier.⁷² Hence mining in Yunnan was not only crucial to the financial security of the provincial government but also central to the consolidation of the borderland areas.

Initially, the government relied completely on the private sector to manage mining, while state bureaucrats were responsible only for taxation.⁷³ Later in the eighteenth century, the Qing government increased its involvement in copper mining, providing loans to merchants and procuring post-tax copper at a fixed price.⁷⁴ Other minerals, such as tin, remained completely under the management of merchants. The most significant difference between mining policy in Yunnan and that in China proper was that local bureaucrats in Yunnan did not have to worry much about local security, and there were no restrictions on the locations of mining sites or their scale. As a result, officials in Yunnan were motivated to promote mining, and some even invested in mining themselves.

The Qing government provided material support to stimulate mining in Yunnan—most significantly, infrastructure. Yunnan was cut off from China proper by steep mountains and rivers. The Qing state made an extensive effort to improve roads and waterways in Yunnan to facilitate transport of minerals.⁷⁵ Bridges and roads were built to shorten the distance and reduce transportation costs. For example, the road between Yunnan and Guizhou was leveled and straightened to make it more suitable for caravan cart transportation. In the 1740s, the Qing state spent over 200,000 taels of silver to dredge the Jinshajiang River to create a safer and cheaper shipping route to transport minerals from Yunnan to Sichuan.⁷⁶

Two major shipping routes were carefully maintained to connect the mining sites of Yunnan with China proper. In the first route, minerals were transported by caravan to northeast Yunnan, then loaded onto barges to sail down the Jinshajiang River to Luzhou. Then cargo boats sailed down the Yangzi River and the Grand Canal to Beijing.⁷⁷ In the other route, minerals were transported overland through southeast Yunnan to enter Guangxi via Bo'ai. Then they were carried north by boat to Lake Dongting and the Yangzi.⁷⁸ These two routes were not just used to ship mineral resources out of Yunnan; they were also used to ship miners, merchants, tools, and other consumer goods into Yunnan. It is very likely that miners from Hunan and Hubei traveled to Yunnan along these two shipping routes. The heavy traffic of people

and materials closely connected Yunnan to China proper, solidifying imperial rule over the southwestern frontier.

The supportive mining policies and infrastructure development attracted miners to the southwestern borderlands of the Qing empire to excavate copper, silver, lead, zinc, iron, tin, and other minerals. This migration fundamentally transformed the demographic, environmental, and cultural landscape of Yunnan, particularly in mining towns. As historian Fei Huang has demonstrated in her work on the changing landscape of Dongchuan, one of Yunnan's most important copper mining centers, Han migrants, local ethnic groups, imperial officials, and merchants all participated in the transformation of the local landscape. The negotiations and interactions among different groups created new commercial networks and multicultural settlement patterns.⁷⁹ Gejiu, a small mountain village, was transformed into an industrial town centered on tin and silver mining, and its population became mainly migrants from Hubei, Hunan, and Jiangxi.

In Yunnan, the migrant miners and mining sites became new administrative categories. The Qing state began to use *chang* as an administrative unit designating industrial complexes, typically referring to large areas that encompass mining sites, smelting centers, and mining-related supply businesses. In local gazetteers, these industrial complexes were commonly listed under distinct categories, such as *changwu* (mining affairs) or *kuangchang* (mining industry complexes), reflecting their recognition as separate administrative entities.⁸⁰ Correspondingly, Qing bureaucrats referred to people who engaged in the mining industry as “population involved in the mining industry” (*changmin*) or “itinerant workers in the mining industry” (*zouchang zhe*), distinguishing them from farmers and non-Han ethnic groups.⁸¹ In contrast to the negative portrayal of miners in China proper, by referring to the miners as the “mining population,” officials in Yunnan acknowledged their equal standing with farmers, recognizing both groups as civilians (*min*) who contributed to the state by paying taxes.

The shifting of mining centers from China proper to frontier regions and Southeast Asia necessitated development of new trade networks to connect producers, craftsmen, and consumers. Expanding trade networks led to the emergence of several key trading hubs. Hankou on the Yangzi became an important metal market where copper, lead, zinc, and tin from Yunnan and Guizhou were traded before being transported to eastern provinces such as Jiangsu and Shandong or continuing northward via the Grand Canal to reach

Beijing.⁸² Metals from international markets created another series of trading centers in the eastern part of China. The port city of Canton, the sole designated port for trade with European merchants, became a crucial trading center for American silver and Southeast Asian tin.⁸³ Chaozhou, the hub for the junk trade and Chinese emigration, also received Southeast Asian tin and became an important center for pewter manufacturing. Suzhou served as a vital city for Sino-Japanese trade. Copper from Japan and tin from Southeast Asia (transshipped through Japan) supported the development of metal shops in Suzhou.⁸⁴ These networks served as crucial infrastructure supporting both Qing mineral procurement and the commercial economy.

The geographic changes in the mining industry from restrictive China proper to the permissive frontier reshaped the Qing empire's political economy and the social fabric of mining areas. Long-distance trade networks now connected remote but bustling mining towns in Yunnan with metal markets in China proper, while cross-border migration linked Chinese miners to Southeast Asian tin deposits. These developments simultaneously altered the geographical distribution of mining knowledge among state bureaucrats.

The Formation of Mining Knowledge on the Southwest Frontier

During the Qing dynasty, low-level bureaucrats in Yunnan became major producers of mining knowledge. Without doubt, such expertise and skills were always in the hands of miners and merchants. However, this tacit knowledge remained embodied in miners' practices and merchants' commercial networks. Mining technology only became knowable and accessible to scholars through collection, codification, and systemization by lettered elites. European historians have acknowledged that scientific knowledge is a result of the systemization of vernacular knowledge through collaboration between artisans and natural philosophers.⁸⁵ Therefore, to fully understand tin mining technology, we must first understand the individuals who codified it. As mining administration shifted from Ming eunuchs to county bureaucrats in the Qing dynasty, the production of mining knowledge also changed. Low-level officials, especially county magistrates and their clerks, replaced eunuchs as administrators and thus became the primary codifiers of mining knowledge. Moreover, this process became increasingly decentralized and localized, with Yunnan emerging as the new center of knowledge production.

The Ming central court was deeply involved in craft manufacturing. In state-owned silk factories, porcelain kilns, and shipyards, the Ming court employed men of letters as administrators to manage hands-on tasks. These scholars collaborated with master craftsmen to produce detailed documents. These documents informed the managerial understanding of certain fields with technical explanations about raw materials, the labor force, and machinery.⁸⁶ For instance, the polymath Song Yingxing acquired craft knowledge through his involvement in these industries. However, this does not mean that Ming scholars were all interested in producing scientific and technological knowledge. Historian He Bian has pointed out that scholars experienced a decentralizing culture of pharmaceutical knowledge in the Ming dynasty.⁸⁷ The central government lost control of the production of pharmaceutical texts, and the gulf between civil officials and technical experts widened. A similar pattern could be found in mining. When mining was controlled by eunuchs, practical knowledge almost never entered the knowledge system of Ming scholars. Published works about mining all centered on military campaigns against miner uprisings.⁸⁸

There is no evidence of Ming eunuchs producing or collecting mining knowledge. Although they supervised the collection of mining taxes, the so-called mining taxes were in fact a complicated system comprising multiple sources, including levies on mining operations, commercial taxes, and various miscellaneous fees.⁸⁹ Commercial taxes, collected in silver, constituted a significant part of this revenue and bore no direct relation to actual mining output. Therefore, eunuchs presumably did not personally inspect mining sites or monitor production. Moreover, since eunuchs did not rotate between postings, as did Confucian scholar-officials, they had no incentive to record and disseminate mining knowledge.

According to existing records, efforts to acquire mining knowledge during the Ming dynasty occurred primarily at the central court. In the sixteenth century, Ming emperors began to show interest in promoting technological knowledge to raise funds to fight against the Manchus. The Ming court translated and published the European mining treatise *De Re Metallica*.⁹⁰ Unfortunately, this top-down approach proved a failure. The publication project received extensive criticism from scholar-officials, and circulation of the published work was so limited that the text was lost soon after the collapse of the Ming empire.⁹¹

This pattern changed after the Qing state replaced eunuchs with county magistrates. In China proper, due to cumbersome regulations, local magistrates' knowledge of mining was usually confined to financial and accounting aspects.⁹² Circumstances were different in Yunnan. Because Qing policy connected mining output with the career path of county magistrates, bureaucrats in Yunnan were motivated to master technological and managerial details. The governor-general, Cai Yurong, even proposed that "if the local bureaucrats could attract merchants to invest in mining, and if the mining tax reached over ten thousand taels of silver, the bureaucrats could get a promotion."⁹³ The close tie linking power, promotion, and technological knowledge nurtured a technocratic culture among bureaucrats in Yunnan. Since officials could not serve in their hometowns and thus lacked local mining experience, they actively collaborated with merchants and miners to acquire technological and managerial knowledge. Then they systematically documented such knowledge for their colleagues and successors.

The Making of Tech-Savvy Bureaucrats and Clerks

A transformation over four generations of the Ni family illustrates the sharp change from mining-despising Confucian scholars to tech-savvy bureaucrats. In 1715, Ni Tui (1668–1748), a native of Songjiang (today's Shanghai), moved to Yunnan as a personal assistant to Gan Guobi (1669–1747), the provincial governor of Yunnan.⁹⁴ Ni Tui was trained as a Confucian scholar but never passed the civil service exam. He chose a career path as the private adviser of Gan Guobi, providing policy advice, handling paperwork, and managing financial and legal documents. During Gan Guobi's appointment in Yunnan (1715–20), Ni wrote an essay responding to Gan's consultation on mining affairs.⁹⁵ In this article, Ni used silver mining as an example to discuss the conditions of mining sites, the distribution of profits among mine investors and laborers, and taxation. Ni explained that mining began with a shareholding system. The merchants who provided food and equipment shared 60 percent of the mining profit, while the tunnel constructors and mine managers shared 10 percent. The miners who provided their labor shared the remaining 30 percent.

Ni Tui had no mining experience before arriving in Yunnan. Although he did not mention where his knowledge came from, we may glimpse its possible

origin from his writing. He mentioned that officials at the provincial, prefecture, and county levels sent their assistants to the mines. If mineral resources were abundant, they would even send their assistants to invest on their behalf using the officials' private capital.⁹⁶ It is possible Ni Tui was one of the personal assistants sent by his employer to invest in mining. Ni Tui's experience suggests how bureaucrats and scholars from China proper who had no prior experience in mining were able to acquire knowledge about mining. Driven by state interests, career advancement, and promises of personal wealth, county magistrates and clerks in Yunnan became tech-savvy bureaucrats who contributed to the accumulation of mining knowledge in the eighteenth century.

Fully aware of the immense wealth mining could bring, Ni Tui nonetheless remained steadfast in his opposition to mining, a stance typical of a Confucian scholar in the early Qing. Ni forcefully pointed out the numerous drawbacks of mining in strong couplet prose. He argued that mining led to inflation of essential commodities. Air pollution from smelting and water pollution from ore dressing harmed agriculture, causing crops to wither. Mountains became barren, leading to erosion. Among the miners were criminals and rebels, who were also involved in fraud and gambling. In his view, mining had almost no benefit.⁹⁷ Ni's rhetoric sharply contrasted with state policy in Yunnan and was more aligned with the bureaucrats who administered China proper.

Ni Tui's case may be representative of classically trained Confucian scholars who arrived in Yunnan in the early eighteenth century. Though ideologically opposed to mining, he had to acquire knowledge about mining for administrative purposes. His superior, Gan Guobi, as a bannerman official, had a strong interest in technological detail, compelling Ni to include extensive technical descriptions in his reports despite his Confucian reservations. Ni's ideological disdain, however, could not withstand the prevailing political trends and the empire's urgent demand for metal resources. Gan Guobi never took Ni's advice, and the Qing empire never changed its mining policy in Yunnan.

After Gan Guobi was dismissed from office due to corruption, Ni's family chose to stay in Yunnan, carrying on the Confucian scholarly tradition. One century later, Ni Tui's great-grandson Ni Shenshu (active 1826–42) eventually passed the civil service exam to be a county magistrate in Shanxi.⁹⁸ Before being appointed to office, Ni Shenshu participated in the Yunnan Provincial Gazetteer project and contributed an essay, "The Record on Copper Mining and Smelting" (Caitong liantong ji).⁹⁹ In this lengthy essay, Ni Shenshu

detailed the processes of prospecting, excavation, and smelting, and ended with a discussion of the difficulties of mining administration. He pointed out that the success of mining depended on three key factors: the diligence of the shaft headman and mining manager, the tacit skills of the smelters, and the competence of the administrators managing the mines.¹⁰⁰ Labor management, skill, and the ability of bureaucrats formed a crucial triangle for the mining industry, with each element being indispensable.

Ni Shenshu's portrayal of the mining industry was remarkably different from that of his great-grandfather. Most of the essay focused on technological processes and management organization rather than potential problems brought about by mining. Ni Shenshu's understanding of mining technology was more engaged than that of his great-grandfather. For instance, he explained in detail the miners' unique terms for ores and shafts and described the colors of ores with different purities. His description of smelting was so vivid that it felt as if he had been present at the smelting site. He not only described different types of charcoal but also discussed the varying amounts of charcoal required for ores of various purities. His description of the empirical knowledge of smelters was particularly impressive. According to Ni Shenshu, smelters used the binary of thick (*chou*) and thin (*xi*) to evaluate the properties of ore. This binary was based on visual observation of the ore's fluidity during smelting. Depending on the fluidity of the ore, different types of ores were combined with limestone or quartz during smelting to remove the accompanying rock gangue. This empirical description reveals Ni Shenshu's close engagement with mining and his curiosity regarding technical details. The miner's vernacular naming system for ores and mining shafts, the smelter's tacit skill in judging the purity of ore, and the detailed calculation about the consumption of charcoal all suggest close involvement in the day-to-day operations of mining.

It is hard to know exactly how Ni Shenshu acquired that empirical knowledge. Perhaps his family made the rebellious decision, against the will of their ancestor, to invest in mining, as did many others. Perhaps Ni Shenshu worked as a mining management clerk before passing the civil service exam. In any case, Ni Shenshu's familiarity with mining technology represents a gradual but significant transformation among Qing bureaucrats in Yunnan. The publication history of Ni Shenshu's essay illustrates the long-term, continuous knowledge accumulation among Qing scholars. His work was included not only in Ruan Yuan's *Draft of the Comprehensive Gazetteer of Yunnan* (Yunnan

tongzhi gao, 1835), but also in volume 1 of Wu Qijun's *An Illustrated Strategy of Mines and Smelters in Yunnan*, titled *An Illustrated Strategy of Mining and Smelting Tools in Yunnan* (Yunnan kuangchang gongqi tulüe, 1844).

The Ni family's transformation over four generations exemplifies a broader trend among Qing scholar-officials in Yunnan. The eighteenth century witnessed large-scale codification of mining knowledge, as bureaucrats engaged in mining administration systematically documented the knowledge they acquired through their work. Yu Qingchang's career offers an illustration of this trend. In 1757, Yu Qingchang (1724–1800), a native of Hubei, was appointed as county magistrate of Tonghai. In the twelfth lunar month, Yu journeyed to investigate the Mansuo gold mines at the western border of Yunnan (in today's Tengchong).¹⁰¹ During this journey, Yu visited silver, gold, copper, and tin mines in Yunnan, including the tin mines in Gejiu, a town where the largest tin deposit in China is located. In his travelogue, Yu wrote, "With three horses and seven footmen . . . [I] rode south to enter the border of Mengzi County, and traveled another forty *li* to arrive at Gejiu. Merchants and traders congregated [here], smokes and fires [of smelters] were dense and blooming. [I] inspected until it got darker before I went back. This famous place produced silver, tin, and lead. The white tin was of the best quality under heaven."¹⁰²

In his travelogue, Yu Qingchang mentioned that he had several meetings with the bureaucrats who oversaw mining administration. Yu's interest in mining was different from Ming dynasty naturalists. His fieldwork was motivated by career advancement. As a county magistrate, he was responsible for the taxation and shipping of mineral resources in his county. Later in his career, he compiled an eight-volume manuscript, *A Study of Copper Administration* (Tongzheng kao), which became the first monograph on mining administration.¹⁰³

Yu Qingchang was not alone. After him, numerous bureaucrats and their assistants began to compose mining administration manuals. For example, between 1786 and 1788, the provincial administration commissioner of Yunnan, Wang Chang (1725–1806), edited a manual called *A Comprehensive Manual on Copper Administration* (Tongzheng quanshu). This manual covered tax regulations, the location of mining sites, shipping routes, costs of shipping and procurement, mining loans, and the evaluation of bureaucrats.

Unlike the Ming court, which tried to use a top-town method to spread mining technology, knowledge production in the Qing dynasty followed a

bottom-up pattern. County-level magistrates, who learned from miners, smelters, and merchants, became the main purveyors of mining knowledge. Unfortunately, knowledge about mining failed to reach the central court and remained at the provincial level. It was not until 1844, when Wu Qijun published the comprehensive mining treatise *An Illustrated Strategy of Mines and Smelters in Yunnan*, that mining knowledge in Yunnan eventually became state knowledge. In this two-volume mining treatise, Wu Qijun collected and organized the scholarly knowledge about mining that had accumulated from the 1700s to the 1840s, using illustrations of mining tools and maps to provide a more empirical understanding of technical details. His mining treatise not only allows modern scholars to understand tin mining technology and organization in Yunnan, but also served as a reference for his colleagues in the mining industry in their pursuit of wealth and power for the empire.

* * *

From the seventeenth to the eighteenth century, we see significant changes in tin mining and the production of mining knowledge. The mining center shifted to the frontiers of the Qing empire, creating significant socioeconomic change there. The Ming-Qing transition also witnessed major changes in the political economy. Compared to the ineffective Ming state, which relied on ad hoc policies and deployed eunuchs irregularly to collect mining taxes, the Qing empire established a more institutionalized tax regime and administrative system for mining operations and revenue collection. As the supervision of mining was transferred from the hands of eunuchs to state bureaucrats, county magistrates in Yunnan became the major collectors of mining knowledge. They learned about mining technology, accounting, and basic metallurgical knowledge from their service as state officials. The increasingly close relationship between power and technological knowledge that had been developing since the early Qing further fostered a technocratic culture among bureaucrats.

The official mandate to serve the state and a personal interest in career promotion intertwined to motivate these scholars to collect knowledge about mining from the words of miners and merchants. Their transformation into mining experts, however, followed a different path from modern technocrats. Technocrats in modern Europe and twentieth-century China gained power through their professional training in science and technology. In contrast,

the Qing bureaucrats in this book were Confucian classics-reading scholars who trained themselves on the job to become experts on mining administration. Despite this difference in training, these county magistrates appointed to supervise mining can be considered proto-technocrats. They shared with their modern counterparts a belief in the power of technological knowledge to manage the world. It is through their diligent documentation that we can now get a glimpse of mining technology in Yunnan during the Qing dynasty.

CHAPTER TWO

The Social Technology of Tin Mining

Gejiu is a small village nestled in the mountains of China's southwestern highlands. Hidden beneath the lush green vegetation, tin, silver, and copper mines are scattered throughout the mountainous region. In a local gazetteer published at the beginning of the eighteenth century, the author proudly described how precious minerals in Gejiu had attracted migrants from China proper to engage in mining activities, transforming this small village to an industrial town: "Mengzi County has precious mountains, with Gejiu being its most renowned. The mountain terrain there encircles Gejiu town like a long belt, with the mountains extending for a great distance, gathering the essence of heaven and earth, forming silver, copper, and tin. People from all directions come here to mine, collectively naming the mines in this region Gejiu Mine."¹

The earliest inhabitants of Gejiu were the Yi people. The village's name, derived from the Yi language, means "the place where buckwheat is grown."² Today, there are around nine million Yi people living in China, constituting one of the fifty-six ethnic groups recognized by the Chinese government.³ They are highly diverse both linguistically and culturally, living primarily in rural areas of Sichuan, Yunnan, Guizhou, and Guangxi. Originating from central Yunnan, they fanned out to other areas in southwest China and north Vietnam. The Yi people in Yunnan had much closer contact, compared to those in other regions, with the surrounding Han society, particularly after the reunification of the southwest with China under Mongol rule in the 1250s.⁴ Gejiu was home to mainly four groups, who referred to themselves as Nisu, Muji, Pula, and Lolo.⁵ During the Qing dynasty, officials grouped them together as Yi in government documents, making it impossible to distinguish

them based on textual sources. Therefore, in this book, I follow Qing officials' practice of referring to the local residents as Yi people.

Gejiu developed into a significant industrial center in the eighteenth century, although archeological evidence suggests that mining in Gejiu had begun during the Eastern Han period (25–220).⁶ The mining boom in Gejiu was catalyzed by a significant administrative change. Following the death of the last local chief, Li Shiping, in 1704, the Qing court seized the opportunity to establish direct control over the region. By 1707, the local government was systematically levying taxes on silver and tin mining, marking the transition from local to centralized, direct administration.⁷ Following Cai Yurong's policy of encouraging mining, miners migrated from China proper to Gejiu to extract silver, tin, and copper.⁸ They initially focused on silver but quickly switched to tin when the silver mine became depleted.⁹

In the eighteenth century, China experienced an unprecedented demand for tin, which became a driving force in the development of tin mining in Gejiu. Several factors contributed to China's growing need, and state coinage had the most direct impact on Gejiu's tin production. As mentioned in chapter 1, China used tin as a key component in copper coins. The 1740 monetary reform, which will be examined in detail in chapter 4, proved particularly consequential. It introduced green money (*qingqian*)—a copper alloy containing copper, tin, zinc, and lead—to replace the tin-free yellow money (*huangqian*), thereby significantly increasing tin demand.¹⁰ As a result, governors of Guangdong imported tin from Bangka to fulfill the requests of the imperial mint in Beijing, while tin from Gejiu supplied the provincial mint of Yunnan.

Another significant source of demand was pewter manufacturing. As mentioned in chapter 1, China used pewter to manufacture a wide variety of everyday objects. In the eighteenth century, population and economic growth further increased this demand. Moreover, due to copper shortages, the Qing government restricted the use of bronze and brass in everyday objects, which further boosted pewter consumption. As a result, while pewter manufacturing declined in eighteenth-century Europe due to the growing accessibility of porcelain, China followed a different trajectory: pewter production experienced steady growth throughout the period.

The last major impetus came from the tea trade, which was probably the largest consumer of tin but remains impossible to quantify. To preserve quality during long-distance shipping, people packed tea in wooden chests lined

with pewter plates.¹¹ Tea exports grew exponentially throughout the eighteenth century, creating massive demand for tin-based packaging materials. Most of this packaging was completed in Canton. Though much of the tin for packaging was probably sourced from Bangka imports, this enormous demand nevertheless indirectly contributed to shortages in the Qing empire's overall tin market.

The mining boom transformed the region's economic landscape and demographic profile. Gejiu became a migrant town filled with migrants from China proper. According to the local gazetteer, at the beginning of the eighteenth century, 80–90 percent of the population in Gejiu were not Yunnan locals. Among these migrants, approximately 70 percent were from Hubei and Hunan, roughly 30 percent were from Jiangxi, and small numbers came from Shanxi, Shaanxi, and other provinces.¹² Like all sojourning merchants and workers in Chinese urban centers, these migrants formed native place associations to nurture business connections and regulate their activities. Through the migrants' efforts, tin output increased from 0.991 million *jin* in 1707 to over 1.529 million *jin* in 1735 and remained steady until the middle of the nineteenth century, elevating Gejiu to prominence as China's foremost tin producer.¹³ The achievements in tin mining throughout this century and a half were impressive. How did these migrants, lacking local connections, kinship networks, or financial backing, organize large-scale mining operations? What mining technologies did they employ?

This chapter investigates tin mining technology in Gejiu, in both its social and material dimensions. I use the term *social technology* to refer to social organizations, institutions, and regulations in mining communities that generated both material goods and social relations. I argue that social technology enabled miners to sustain large workforces, operate expensive equipment, and undertake prolonged excavation despite uncertain returns. Moreover, social technology significantly extended the life span of mining, an industry characterized by cycles of boom, depletion, and renewal. Historian Daviken Studnicki-Gizbert shows in his work on Mexican mining that depletions and subsequent resurgences of mining operations did not necessarily arise from new mineral discoveries; instead, people reworked existing mines with enhanced extraction technologies and increased capital investment.¹⁴ China followed a similar pattern. Mines frequently closed not because ore deposits were exhausted but because miners lacked the capital or technology to continue deeper extraction. When sufficient capital or new technologies

became available, mining could resume at greater depth, thereby extending the industry's life span. Chinese miners' social technology created mechanisms to pool capital and labor for such intensified extraction. In addition, their social technology enhanced the mobility of miners, enabling them to traverse domestic and international borders and establish thriving operations across diverse cultural environments.

My reconstruction of mining in Gejiu relies primarily on written records documented by officials who administered this region in the eighteenth and nineteenth centuries. These sources include local gazetteers, court memorials, and mining treatises—particularly Wu Qijun's systematic documentation of Yunnan's mining and smelting technologies. These materials exhibit inherent biases through their state-centered perspective. Local administrators were tasked with ensuring mining productivity while maintaining social order, and these priorities significantly affected the content of their writing. The documentation heavily emphasized management structure and social organization for administrative purposes, while many technical details were omitted.

To achieve a more balanced understanding of mining, I counterpose these bureaucratic-centered narratives with material and textual evidence produced by the mining community. Unlike early modern Europe, where artisans began documenting technical processes in writing, miners and merchants in Chinese mining operations seldom recorded detailed technological information.¹⁵ Instead, they left behind stele inscriptions detailing mining regulations, native-place association halls, and temples that served as both religious and social spaces. These tangible materials and buildings help us reconstruct the organizational structure and daily operations of the migrant community. In addition, early twentieth-century surveys, interviews, and memoirs help capture the embodied knowledge of miners and their experiences.

The Limited State Administration and the Semiautonomous Mining Community

The Qing state's penetration into tin mining in Gejiu was limited. State regulations focused on taxation and heavily relied on the private sector to invest in mining. The county magistrate, the lowest level of imperial administration, stayed in the county seat of Mengzi, around thirty kilometers from Gejiu. The government appointed two clerks to oversee taxation. In the local gaz-

etteer, these clerks were referred to as “scribes” (*shuji*), serving as tax chiefs (*kezhang*) within the Seven Chiefs system, a system through which mining communities regulated themselves. Additionally, six patrol officers were employed to ensure the safety of tin mines in Gejiu and, more importantly, to prevent tax evasion through smuggling.¹⁶ Together, these clerks constituted the limited elements of state administrative presence in Gejiu’s tin mines.

Because there is limited documentation in Gejiu, we lack detailed information about the tax chiefs in this specific region. To illustrate the responsibilities and professional development of these officials, I draw upon examples from the Maolong silver mines in Yunnan. The career of tax chief Liu Shiyan (active 1761–81) offers particularly valuable insights. We have no information on Liu’s background. He was likely an experienced mining entrepreneur who enjoyed considerable local prestige and credibility, leading to his selection by the government as tax chief.¹⁷ After serving three years as an assistant at the Maolong silver mine, Liu was promoted to tax chief. Under normal circumstances, he would have rotated out of his position after three years of service. However, Liu remained in his role for over fifteen years because no qualified subordinate was available to succeed him.¹⁸

Liu’s case reveals the specialized expertise required of tax chiefs. Their role demanded comprehensive mining knowledge and experience. Clerks like Liu were invaluable repositories of technical information for Qing administrators. Though existing outside the formal imperial bureaucracy, tax chiefs were the state’s most direct presence at mining sites, functioning as crucial intermediaries between government administration and migrant mining communities. They constituted the endpoint of state regulation in these remote mining regions.

Members of the mining community, including miners, smelters, investors, and traders, came from diverse ethnic, cultural, and class backgrounds. They formed a highly mobile, exclusively male community with scarce kinship ties. Unlike the agricultural population in conventional Chinese society, where workers were bound by kinship ties and governed by gentry elites, the mining community was characterized by mobility and social instability.¹⁹ Wealthy merchants from China proper invested in mines, while the labor force was composed of rootless migrants—both from provinces across China and from regions within Yunnan itself. The local Yi people supplied miners and smelters with food, clothing, and charcoal.²⁰ Women were banned from excavation sites.²¹ This diverse workforce converged on mining areas seeking

economic opportunity and willing to take on the harsh working conditions and social instability.

Given the limited state intervention and the distinctive social composition of the mining community, the tin mining regions of Gejiu developed into what anthropologist Sally Falk Moore characterizes as a “semi-autonomous social field”—a community with its own rule-making capacities, internal regulations, and governing organizations.²² The highly mobile nature of the mining community presented challenges that required specialized self-governing structures. This population of rootless, single male migrants closely resembled Fan Yasi’s mining gang, and similarly constituted a potential source of social instability. According to the local gazetteer, internal tensions were common, with frequent and sometimes deadly conflicts over mining rights and resources.²³ In response to these challenges, the mining community relied on the Seven Chiefs system, alongside native place associations and community-based mining regulations, to maintain functional order.

The Seven Chiefs System

The Seven Chiefs system was found in mining areas across Yunnan, including tin mines in Gejiu. It involved seven positions: tax chiefs, guest chiefs (*kezhang*), smelter headmen (*lutou*), pot headmen (*guotou*), timbering headmen (*xiangtou*), mine managers (*dongzhang*), and charcoal headmen (*tanzhang*). Figure 2 shows the structure of the Seven Chiefs system. The organizational structure had likely existed since the inception of mining operations in Yunnan. However, it wasn’t until the eighteenth century that Tan Cui (1725–1801), a county magistrate with experience in copper administration, invented the name Seven Chiefs.²⁴ This terminological framework was adopted and perpetuated by scholar-officials in their administrative documentation.²⁵

The Seven Chiefs system emerged as a sophisticated social technology that functioned simultaneously as a labor organization, a social organization, and a cluster of economic institutions. The term *seven chiefs* referred not to an exact number of chiefs but rather to a hierarchy and division of responsibilities within the mining community. At the governance level, the tax chief oversaw tax collection, while guest chiefs represented and regulated migrants from various provinces, managing the diverse workforce that populated Gejiu’s mines. According to a stele inscription commemorating the

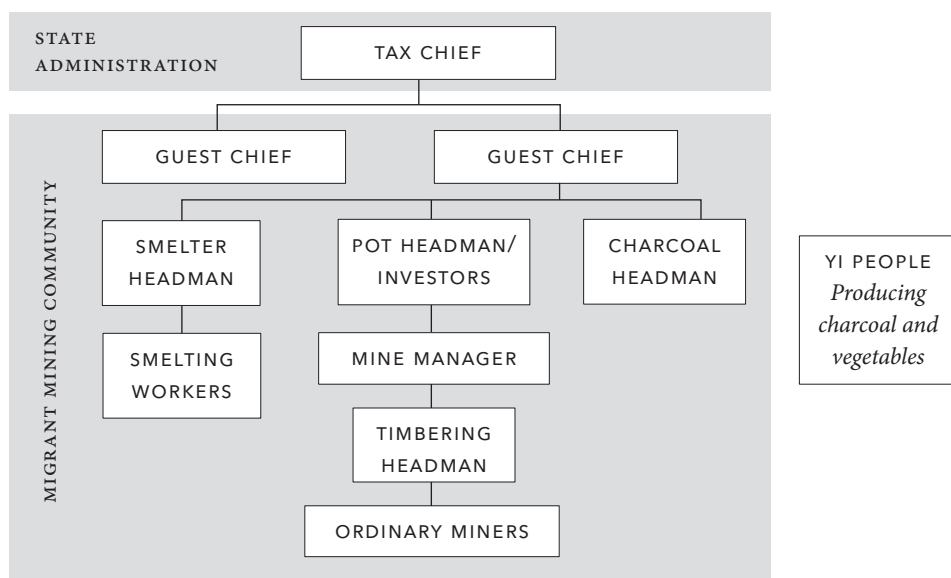


FIGURE 2. The Seven Chiefs system.

construction of a local temple, there were at least ten guest chiefs in Gejiu.²⁶ The hierarchy of pot headmen, mine managers, timbering headmen, and ordinary miners originated from the production organization of tin mining enterprises. In mining operations, mine managers supervised individual mining enterprises, while timbering headmen were responsible for installing timber supports in each mining tunnel and organizing excavation work. Pot headmen were investors who provided food for workers. The smelting sector was led by smelter headmen, who served as both the managers and technical experts of their respective smelting enterprises. Charcoal headmen ensured the steady supply of charcoal essential for smelting operations. Throughout Gejiu, hundreds, if not thousands, of mining and smelting enterprises replicated this management structure.²⁷ The hierarchical structure that developed from the production organization reveals a fundamental characteristic of the mining community: the production process and social order were intertwined. To manage production was to manage the social order.

The interface between the state and society emerged within the Seven Chiefs system, with the tax chief being the end of state administration and the guest chief serving as the highest authority in the migrant community.

Guest chief positions were assumed by influential merchants from different provinces. They were responsible for handling “all the disputes that happened in mining sites.”²⁸ In two land contracts from 1712 and 1736, ten guest chiefs and officials from Mengzi County added their signatures, enhancing the legal standing of the documents.²⁹ Thus the state acknowledged the authority of the guest chiefs and relied on them to rule the migrant community, while migrant community leaders relied on the nominal authority of the state when establishing native place associations, validating contracts, and forming mining regulations. This interdependent relationship between migrant leaders and state authority also occurred in the Chinese tin migrant community on Bangka Island, which will be discussed in detail in chapter 3.

Native Place Associations: Spaces for Regulation and Networking

The native place association, or *huiguan*, served as a space for guest chiefs to regulate the mining community. In late imperial China, the native place association was a common institution in urban centers that provided sojourners with “a place to eat, an institutional structure for burying and mourning the dead, and a sacred space for sacrificing to patron deities and ancestors.”³⁰ In Gejiu, these institutions functioned far beyond the conventional roles found in other Chinese cities. While providing the familiar comforts of cultural identity for migrants, they evolved into multifunctional hubs where community governance, business networking, dispute resolution, and industry regulation converged. Their physical and organizational structure embodied the social technology that enabled migrants to overcome capital limitations, establish authority structures, and collectively manage the mining industry in a frontier setting.

By the eighteenth century, Gejiu already had at least four native place associations, a number that would grow to over ten in the twentieth century. According to a local gazetteer published in 1791, the mining town contained three Temples of Lord Guan (Guansheng Gong). One belonged to the Hunan and Hubei Association, another to the Jiangxi Association, and a third to the Yunnan Native Place Association.³¹ Miners and merchants worshiped Lord Guan because he was not only the deity of wealth but also embodied qualities of brotherhood and loyalty—values highly esteemed in the mining community. In addition to the Temple of Lord Guan, Jiangxi merchants established another Daoist temple called the Longevity Palace (Wanshou Gong).³² This

temple originated in Nanchang, the capital of Jiangxi, and was primarily dedicated to Xu Xun (239–374), the patron deity of the Jiangxi people.

The Yunnan Native Place Association (Yunsheng Huiguan), later known as Yunnan Temple (Yun Miao), provides an excellent case study to examine the multiple functions of these native place associations.³³ During twentieth-century urban development, most native place association buildings were demolished, leaving intact only the architectural complex of Yunnan Temple. Stone inscriptions from different periods, along with the diverse functional spaces in the building complex itself, make it possible to reconstruct the multiple roles of native place associations.

A stele inscription explains the reason for founding the Yunnan Native Place Association in 1765: “The silver and tin mines in Gejiu particularly brought good fortune to the state and benefited people, therefore merchants from different provinces come and go like a constant stream. [Migrants] gathered like clouds from all over China. Migrants from different provinces set halls of native place associations as the space to regulate the mining community. Inside the hall, [they] burn incense for sacrifices and rituals. . . . However, this practice [of building native province associations] has not been adopted by those from Yunnan province itself.”³⁴

Realizing that only Yunnan lacked a native place association, Zhou Enmin, a merchant from Yunnan, partnered with ten other merchant leaders to raise over two hundred taels of silver for a Temple of Lord Guan. Their initiative received support from Tang Lian, the official in charge of the silver and tin mines in Gejiu, who allocated a plot of land. After eighteen years, they finally completed this native place association. To commemorate this achievement, the merchant leaders invited local gentry Chen Shilie, who had previously served as vice minister of rites, to compose an essay documenting their effort.³⁵ In this founding story, the initial purpose of creating a native place association was to establish a space for regulating the mining community and to provide merchants with a venue for social and religious activities.

A twentieth-century stele inscription reveals another critical function of this institution: it offered Yunnan merchants an organizational framework for collaboration, enabling them to build business networks to compete effectively against merchants from other provinces. The inscription states, “During the Qianlong era, the rights to mining and trade were monopolized by merchants from Jiangxi, Hunan, and other provinces. . . . The establishment of

the Yunnan Native Place Association was an effort to reclaim sovereignty from outsiders under the province's banner.³⁶ While this discourse of mining sovereignty may be a twentieth-century construction, the underlying theme of regional competition echoes the eighteenth-century motivation: both emphasize the strategic consolidation of Yunnan merchant networks to counter commercial rivals from other provinces.

The Yunnan Native Place Association expanded its functions from the eighteenth to the twentieth centuries. By the twentieth century, the association had evolved into a multifaceted building complex, housing a bank, Lord Guan's temple, a hall for the God of Wealth, as well as gardens and fishponds. It served as a venue for religious gatherings, a hub for trading and transporting tin, a forum for discussing mining regulations, and a provider of banking services.³⁷ These functions gradually helped the Yunnanese gain advantages in the mining competition and substantially supported growth of the mining industry.

The founding process reveals the interdependent relationship between state bureaucrats and leaders of the migrant community. The founding story itself was one of interdependence: while the merchant leaders possessed the funds to build the temple, they required endorsement from the state bureaucrats. Simultaneously, the newly appointed mine administrator likely needed the merchant leaders' support for his administrative work, which explains why he backed their petition and provided land for the Yunnan Native Place Association. The composition of the stele inscription further reveals the mutual dependence between state authority and migrant leaders. When the construction was completed in 1783, merchant leaders invited Chen Shilie, a retired high-ranking official, to compose an essay to commemorate the founding process of this building complex. The inscription concluded with signatures from administrators overseeing silver and tin mining, merchant leaders, and local scholars, marking their collective endorsement of this enterprise.³⁸ This strategic alliance illustrates how, despite limited state presence in mining sites, officials leveraged the authority of these community leaders to extend administrative control, while migrant leaders appropriated state legitimacy to maintain order among their constituencies.

Mining Regulations Discipline Miners and Protect Investors

Before the Qing court enacted its first mining law in 1898, the imperial legal system lacked comprehensive legislation governing mining operations. While

piecemeal regulations existed concerning taxation quotas, there were no statutes defining mining rights, extraction procedures, or operational standards.³⁹ Mining communities thus self-regulated through customary practices. In Gejiu, the earliest surviving codified mining regulations date to 1798, when community leaders inscribed ten rules on a stele titled “Collective Agreements on Mining Regulations in Gejiu” (Gejiu gongyi changgui bei ji).⁴⁰ According to the preface, the mining community’s leaders found that “with the constant hustle and bustle and all manner of people coming and going, mining entrepreneurs would inevitably have nothing to abide by without clearly defined regulations.”⁴¹ Therefore, they collectively created regulations tailored to local conditions to ensure compliance and proper conduct.

The term *gongyi* in the title, which can be translated as either “collective agreements” or “public opinions,” suggests the extra-bureaucratic and semiautonomous nature of the mining community. Historians Mary Rankin and William Rowe have shown that, from the late Ming period, local elites began to form a community-centered, extra-bureaucratic system to manage local services in conjunction with the state.⁴² This transformation led to a triadic concept of *guan* (state), *gong* (public), and *si* (private), with “public” occupying a distinct space between the state and the private sphere. Through collective discussion, these leaders of migrants played an extra-bureaucratic role in activities such as constructing temples and disciplining members of the migrant community.

These regulations addressed various aspects of the mining industry, safeguarding investors’ interests and thereby encouraging long-term investment, which facilitated growth of the tin mining industry. The first, second, eighth, and ninth codes established comprehensive regulations governing mining rights and formal procedures for their transfer between parties. Investors were required to lease the land and to sign the leasing contract in the tenth month of each year. If mine owners leased the right to work branching tunnels to another party, they were required to establish formal contracts clearly delineating each party’s excavation boundaries to prevent disputes over mining rights. If a mining site was abandoned for a certain period (three months for subsidiary mining tunnels and three years for major mining tunnels), the owner lost mining rights, and other investors could take over. These regulations also addressed the transfer of debt in cases of profit loss, requiring transparent accounting and prioritizing repayment to the original creditors before settling with new lenders.⁴³ These measures directly addressed the notorious

practice of what locals called “competing for branch veins and seizing deep deposits” (*zheng jian duo di*), where miners from adjacent tunnels infiltrated neighboring operations.⁴⁴ Although Wu Qijun’s mining treatise indicates that these problems persisted in the nineteenth century, the regulations represent a deliberate attempt from the mining community to minimize conflict by establishing clear temporal and spatial boundaries for mining rights.⁴⁵

The fourth, sixth, and seventh codes focused on standardizing operations by establishing uniform measurements and transaction procedures. These three regulations functioned like today’s industry standards. For instance, it was mandated that mining enterprises had to use standardized barrels to measure tin sand. All excavated ores had to be shipped to the town center for smelting, and tin had to be weighed at official weighing stations during transactions.⁴⁶ Centralized trading and smelting locations prevented tax evasion and unauthorized sales, protecting both state revenue and investor interests. Violations of these protocols, particularly tin smuggling, carried severe penalties, including capital punishment.

The third, fifth and tenth codes regulated internal management of the mining enterprise, primarily disciplining mine workers and managers. These provisions prohibited unauthorized ore sales and embezzlement of funds allocated for miners’ provisions, with harsh punishments, including the death penalty.⁴⁷ Although I cannot verify whether these death sentences were merely verbal threats or actually enforced, the regulations clearly demonstrate rule-makers’ intense focus on protecting the wealth of investors, even to the point of threatening miners with death.

The stark disparity in punitive measures reveals the hierarchical nature of the mining community’s governance. When regulating mining rights among investors in the first, second, eighth, and ninth codes, violations merited only being “discussed for punishment,” with some infractions carrying no specified penalties.⁴⁸ This leniency stands in sharp contrast to the draconian sanctions—including capital punishment—imposed on miners and managers for embezzlement or unauthorized ore sales. Rather than establishing equitable accountability for all participants, these regulations primarily served to protect capital interests. The differential treatment between investors facing minimal consequences and laborers threatened with death for similar property violations unmistakably reflects the stratified power relations embedded in the mining community’s social order.

In these provisions concerning mining rights, contracts played a decisive role. This situation parallels historian Madeleine Zelin's research on salt merchants in Qing China. In the absence of state intervention, merchants utilized contracts to structure businesses and govern conduct through a simple set of self-binding regulations.⁴⁹ These mining regulations constituted a critical component of social technology supporting growth of the industry by establishing clear ownership boundaries, minimizing operational conflict, and creating flexible financial mechanisms that allowed capital to flow when existing investors exhausted their funds. They also enabled smaller investors to pool resources for participation in capital-intensive ventures, broadening the financial base supporting mining operations.

The ten regulations were amended and extensively expanded in 1887 and 1890, with each amendment adding more provisions that increasingly favored capital over labor. New rules were added to tighten restrictions on mine managers and agents and prevent them from deceiving investors. Penalties for selling ore without investors' consent became increasingly harsher.⁵⁰ These changes reflected the growing capital intensity of tin mining, as larger investments required stronger legal protections. The cumulative effect of these amendments was to reinforce the power imbalance between investors and workers. Geologist Ding Wenjiang observed this transformation clearly during his fieldwork in Gejiu in 1914. He concluded that the customary mining regulations had evolved to a point where they "no longer defined relationships between investors, but exclusively regulated and controlled the miners."⁵¹ His assessment captured that, by the turn of the twentieth century, mining regulations had become an instrument for labor discipline and capital protection.

Such social organizations help us understand the social technology of mining at a macro level. However, the Seven Chiefs system was not a top-down organization; its basic structure grew organically out of mining production itself. To understand how the Seven Chiefs system facilitated mining and smelting, we must follow the actual production process and the roles of the timbering headman, the smelter headman, the mine manager, and the pot headman. Only then can we comprehend how the Seven Chiefs system helped migrants pool capital, recruit labor, handle risk, and sustain long-term, highly exploitative excavation.

Excavation Technology and the Timbering Headmen

Mining starts with prospection (fig. 3). An ambitious merchant or pot headman seeking to establish a tin mining operation first hired an experienced miner as a prospector to locate mineral veins. Since prospecting knowledge was primarily embodied rather than documented, our understanding of these methods comes mainly from oral histories collected in the twentieth century. According to these sources, experienced prospectors carefully evaluated soil color, rock formations, and vein patterns to determine optimal excavation sites and directions.⁵² After locating promising veins, merchants pooled resources through a shareholding system to finance excavation. Since most funds went toward purchasing food for the miners, these investors became known as pot headmen.⁵³ According to eighteenth-century mining regulations, investors were required to pay rental fees to the landowners, while nineteenth-century regulations further mandated that they report their mining sites to the Yunnan Native Place Association.⁵⁴

There were mainly two types of excavation in Gejiu—open-pit mining and underground mining. Miners in Gejiu called open-pit mining “grass cover deposits” (*caopi jian*), which meant the mine deposit was so close to the surface that it was like the grass covering the earth. For shallow deposits, the miners used the open-pit mining method, which was also used by miners in Guangdong, Hunan, and Bangka. Compared to underground mining, open-pit mining took place on a smaller scale. In Gejiu, geological conditions meant that shallow tin deposits quickly became depleted, so open-pit mining was short-lived and less profitable.⁵⁵ Moreover, open-pit mining was limited by weather conditions. Gejiu has a tropical monsoon climate, with a rainy season from May to October. Mining pits were prone to flooding during the rainy season, limiting the excavation period to six months, and were thus less productive than underground mining.⁵⁶

The mainstream and more profitable method was underground mining. Unlike the tin deposits in Guangdong and Bangka, which are usually found close to the surface, the best tin ores in Gejiu are buried deep within underground rock formations. In the early twentieth century, old mining tunnels reached depths of 2,000–3,000 *chi* (approximately 660–990 meters) underground.⁵⁷ Chinese miners employed a distinctive approach that diverged from European practices. Rather than distinguishing between vertical shafts



FIGURE 3. The production process of tin mining and smelting, showing the tasks and skills involved in each stage of production.

and horizontal adits, they constructed tunnels that followed the natural direction of mineral veins.

The underground operation was directed by the timbering headman, who determined excavation direction and oversaw tunnel construction. His title derived from his expertise in constructing underground mining tunnels and their support systems, which were made of timbers.⁵⁸ This timber support technology has deep historical roots in China, with archaeological evidence of similar systems in Hubei dating back to 400–200 BCE.⁵⁹ After identifying a tin vein, the timbering headman directed a team of two strong young men to

construct underground tunnels into the mountain. One man held a chisel or mattock and stood on the right side, while another held a hammer and stood on the left. They took turns striking the chisel with the hammer, breaking through hard rock, advancing the tunnel, and excavating ore from the mining surface.⁶⁰ After the ore was removed from the mining surface, less skilled laborers called ore haulers (*beihuang*) carried it out of the mine. Twentieth-century surveys show that to minimize the labor required for excavation, tunnels were usually very narrow, forcing miners to crawl out of the shaft while carrying sacks of ore on their backs. The ore haulers were usually children.⁶¹

The timbering headman's expertise encompassed three critical aspects of the mining operation. First, he determined the excavation strategy by assessing ore quality and predicting vein direction. His ability to "read" the mine determined whether miners would strike rich deposits or waste resources on unproductive channels. Second, he ensured safety in an extremely hazardous environment. According to the eighteenth-century local gazetteer, mining tunnels frequently faced lethal threats including structural collapse, flooding, and oxygen depletion.⁶² The timbering headman designed and implemented appropriate countermeasures for each challenge: constructing timber support systems in collapse-prone areas, supervising the installation of water pumps in flood-prone sections, and providing ventilation equipment where air circulation was poor.⁶³ Third, he organized and directed the labor force within his tunnel. Under his expert direction, he managed workers with different skill levels, enabling laborers with limited mining experience to successfully participate in complex underground operations.

The Mine Manager and Bookkeeping Technology

As the scale of excavation expanded, mining enterprises developed increasingly complex organizational structures. A single mining operation could extend from one main tunnel into dozens or even hundreds of branching tunnels and subterranean tunnels. When tunnels branched, mining enterprises contracted new subterranean tunnels (*jian*) to new timbering headmen and their excavation teams. The same organizational model was replicated across all excavation tunnels and subterranean tunnels (fig. 4).⁶⁴ This expansion required additional capital. The development of new subterranean tunnels attracted new investors who covered expenses for miners' provisions and necessary equipment.⁶⁵ When mining operations faced labor shortages, they could hire short-term

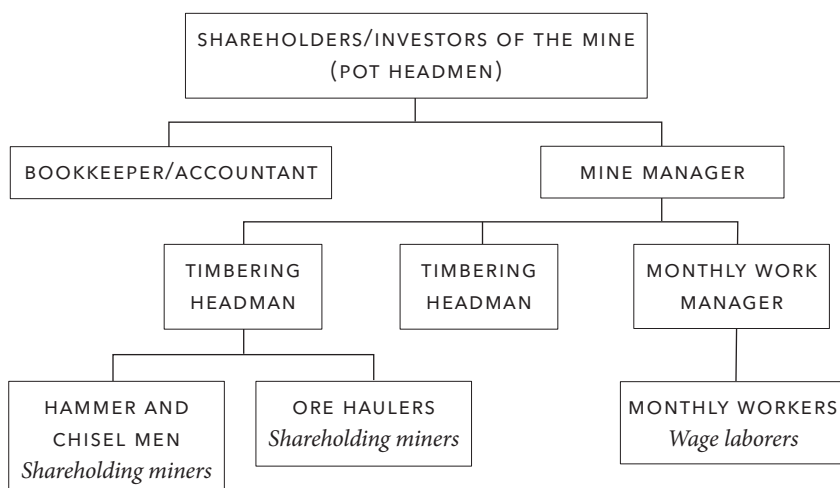


FIGURE 4. The organization of a mining enterprise.

wage laborers called monthly workers (*yuehuo*) to supplement their workforce. These short-term laborers were managed by monthly work headmen (*yuehuotou*).⁶⁶

To manage these complex financial and labor arrangements, investors hired a mine manager, known as the foreman (*shangqianren*) or mine headman (*dongzhang* or *dongtou*), to centralize management of mining operations.⁶⁷ At the same time, the mining enterprise developed a sophisticated accounting system, with dedicated bookkeepers maintaining detailed records of shares, profits, and costs of each mining tunnel.⁶⁸ Mining regulations from the late eighteenth century suggest that bookkeepers kept detailed records of debts as well as transactions regarding mining rights.⁶⁹ This centralized management and bookkeeping technology parallels what historian Patterson Giersch observed in his research on commercial corporations in Yunnan in the nineteenth century. These corporations utilized ledgers and daybooks to centralize management of dispersed business branches, keeping track of capital, expenses, income, and profit while disciplining the workforce and aligning the interests of employees and shareholders.⁷⁰ In mining operations, this bookkeeping technology served functions analogous to its use in commercial enterprises. With multiple shareholders and hundreds of miners involved in a single mining operation, centralized bookkeeping

organized scattered labor and investments into a coherent management system, maintaining order and accountability.

Ore Dressing, a Technology Omitted by Scholar-Officials

After ore was removed from the mining tunnels, the next step was ore dressing—the process of separating the valuable tin concentrate from useless rocks and earth. Interestingly, this critical phase of production largely escaped official documentation, whether in local histories, mining treatises, or essays written by local scholars. Eighteenth-century county gazetteer authors merely mentioned that washing was necessary before smelting, without elaborating on the process.⁷¹ In specialized technological records, neither the seventeenth-century scholar Song Yingxing nor the mid-nineteenth-century official Wu Qijun documented ore dressing in their texts. Xu Jinsheng (active 1840s), the prefect of Dongchuan, provided only a simplified illustration of ore dressing in Wu's *An Illustrated Strategy of Mines and Smelters in Yunnan* (see fig. 9). On the far right of the illustration, three miners stand next to a canal, using water to separate heavy metal particles from soil in a pan. This was called the panning method. However, the panning method was just one stage of the ore dressing process and was not conducted onsite. The conspicuous omission and inaccurate depiction in textual records can likely be attributed to two factors: officials seldom visited mining sites for direct observation, especially during the rainy season; further, the seasonal nature of this work, performed by temporary laborers, rendered it invisible to official documentation. To reconstruct this process, it is necessary to consult twentieth-century social surveys and miners' recollections.

Ore dressing operated on a simple principle: using water and gravity to separate heavier minerals from waste material. The heavier ore sank, while lighter waste materials were washed away. In Gejiu, this process was seasonal, conducted primarily during the rainy season, between the fourth and eighth lunar months. This seasonality shaped labor arrangements, with ore dressing typically performed by short-term workers who received monthly wages and worked under the supervision of monthly work managers.

The skills required for ore dressing were remarkably similar to the hydraulic management technology used in agriculture—constructing canals, utilizing the natural slope of terrain, and managing water flow to wash minerals. Naturally, the process was not unfamiliar to miners who came from a

farming background. It began with preparation for the rainy season. Workers constructed a series of ponds on steep hillsides, strategically positioned to collect rainwater, and connected these reservoirs with an elaborate system of canals. After seasonal rains filled these ponds, workers deposited ore into the upper ponds. As water flowed downward through the canal system, it carried the ore mixture along a carefully engineered path. Several parallel walls built alongside the canals and ponds created settling areas where the heavier tin ore accumulated at the bottom while the lighter waste material washed away. The concentrated tin ore that collected at the bottom of these ponds was subsequently processed further—crushed and ground into fine granules using stone mills to prepare it for smelting.⁷²

After grinding, workers subjected tin granules to a second round of refinement to further increase mineral concentration. They constructed another series of ponds and deposited the granules in these water-filled basins. Using wooden rakes, workers moved rhythmically back and forth through the mixture, agitating the water and ore with a motion reminiscent of massage techniques. This vivid resemblance led to the process being colorfully named massaging the ore (*rouhuang*). This method effectively separated minerals by density.⁷³ For small-scale operations, workers also employed panning methods to achieve superior results. Once this final refinement process was complete, the mine manager sold the concentrated tin ore to smelters for the next stage of production.⁷⁴

The Embodied Skill and Managerial Technology of the Smelter Headman

Tin smelting operations were concentrated in the town of Gejiu, where facilities processed ore transported from mining sites in the nearby mountains. The industry expanded considerably over time, with smelting enterprises increasing more than sixfold—from just thirteen facilities in the early eighteenth century to over eighty-five in the early twentieth century.⁷⁵ Due to limited documentation before the twentieth century, the following reconstruction draws primarily on early twentieth-century geological and sociological surveys, supplemented by an account from the manager of two mining enterprises.⁷⁶ I also consulted better-documented eighteenth-century copper smelting practices as a comparative source. The shared technical vocabulary and comparable techniques across both metallurgical

traditions validate this approach, despite tin processing using slightly simplified procedures.

The smelter headman stood at the center of tin smelting technology. Like the timbering headman for excavation, he played a dual role as both technical expert and labor manager. Successful smelting operations required embodied knowledge of metallurgical processes as well as sophisticated management capabilities to organize a complex large-scale labor force. The smelting facility's profitability depended on finding a smelter headman who excelled at both.

According to a sociological survey in the early twentieth century, smelter headmen had a maxim: "First ore, second charcoal, third bellows."⁷⁷ This craftsman's adage highlights the critical triangle determining tin smelting efficiency: the optimal blend of ores, the proper use of fuel, and skilled operation of the furnace. The smelter headman's expertise began with ore evaluation, requiring careful assessment when purchasing raw material from excavation facilities and the proper blending of ores based on their properties and purity levels prior to smelting. Early twentieth-century surveys indicate that smelters used a binary classification system of "hard" and "soft" ores to guide their processing decisions.⁷⁸ Eighteenth-century reports from copper mine administrators show that copper smelters used a comparable classification system, categorizing ores as either "thick" or "thin."⁷⁹ These terminological parallels across different metals and time periods point to enduring conceptual frameworks in Chinese smelting practices. Both classification systems described the same ore characteristics during smelting: its fluidity and heat requirements. Hard ores required greater heat, exhibited poor fluidity, and were considered "thick," while soft ores needed less heat, showed higher fluidity, and were classified as "thin." These qualitative distinctions emerged from artisans' empirical engagement with the metal.

This sensory-based language for describing material qualities resonates with what Pamela Smith calls the "material imaginary" of craftsmen. As Smith demonstrates, early modern European craftsmen used binaries such as "fat" and "lean" to describe metals and other materials. This knowledge relied on sensory interaction and intimate familiarity with matter, and could only be gained through hands-on experience.⁸⁰ The Chinese binaries of hard/soft and thick/thin reflect what I call artisans' working cognition. This practical knowledge was derived from repeated sensory experience. Smelters developed this understanding through the act of smelting itself, as ore fluidity could only be assessed in the furnace.

Correct assessment of ore properties was intimately connected with the second point of the smelting triangle: charcoal usage. Thick and thin ores needed to be properly proportioned and thoroughly blended. If the smelter headman failed to properly balance these different ore types, it would result in what smelters termed “failure to melt and separate” (*bufenzhi*), where the ore remained clumped with impurities after smelting.⁸¹ The properties of the ore blend determined which type of charcoal to use. Tin smelting in Gejiu used charcoal from three tree species: pine, oak, and alder.⁸² Each type served a different purpose. Pine charcoal, rich in resin and loose in texture, provided quick and intense heat for regular smelting. For hard and coarse ores, smelters used oak charcoal, as its higher density provided longer burning time and higher temperatures.⁸³ Since correctly judging ore properties and selecting the appropriate charcoal affected both smelting success and operational efficiency, Wu Qijun concluded in his mid-nineteenth-century mining treatise that a skilled smelter headman must be “familiar with the property of ore and conversant with the blend of the ore.”⁸⁴

The third point of the smelting triangle, operation of the bellows, was determined by both the embodied skill of the smelter headman and his organizational capabilities. To maximize productivity, he needed to coordinate labor and adjust bellows speed to the specific qualities and quantities of fuel and ore in the furnace.⁸⁵ Tin smelting operations embraced economies of scale, employing labor and equipment that were considerable by preindustrial standards. Smelters utilized large furnaces measuring approximately 1.4 × 1.2 × 1.2 meters, constructed from mudbricks made from soil and salt (fig. 5). At the furnace core was a crucible where workers loaded charcoal and tin ore. A small opening at the crucible’s bottom allowed molten tin to flow into a rectangular collection basin below.⁸⁶ Behind the furnace stood a box bellows crafted from a whole camphor tree trunk, which supplied the necessary oxygen to maintain smelting temperatures.⁸⁷

Operation of the bellows was highly labor intensive and demanded great management skill from the smelter headman. According to textual sources in the nineteenth and twentieth centuries, a complete smelting cycle required twenty-four hours of continuous operation, with labor organized into four six-hour shifts. Each shift employed two to three workers to operate the massive box bellows, with workers taking turns in a rotation pattern to maintain consistent airflow throughout the smelting process. The model in the Yunnan Tin Group Museum (fig. 5), which represents only one person operating the bellows



FIGURE 5. Model of a tin furnace in the early twentieth century in the Yunnan Tin Group Museum. Compared to textual sources, this model underrepresented the labor needed to operate the bellows. There should be two to three people instead of one operating the box bellows. Photo by Yijun Wang, 2016.

and one person loading the ore, significantly underrepresented the number of workers needed. The smelter headman monitored the fire, providing precise instructions regarding the speed of the bellows. Workers added measured quantities of charcoal and ore at approximately thirty-minute intervals. Every three hours, workers used iron pikes to open the metal gate, allowing molten tin to flow into the collection basin. Other workers used tongs and pikes to collect slag and return it to the furnace for additional processing. When the basin was filled with molten tin, workers transferred the liquid metal into molds using iron ladles, creating ingots ready for transport to market.⁸⁸

This examination of mining and smelting methods reveals that timbering headmen and smelter headmen contributed critically to mining technology through two complementary functions. First, their embodied technical knowledge enhanced production efficiency and prevented accidents during the excavation and smelting operations. Second, their organizational capabilities enabled effective management of complex labor structures. This integration of technical expertise and management skill allowed these leaders to

efficiently organize migrant workers into productive mining enterprises. As both engineers and managers, these headmen embodied social technology that facilitated large-scale mineral production. The scholar-official Wu Qijun recognized this dual importance in his mining treatise, concluding that “the success of excavation depends on the timbering headman; the success of a smelting enterprise depends on the smelter headman.”⁸⁹ The success of mining and smelting, he emphasized, required first securing the right people.

Beyond embodied skills and management technology, the success and longevity of the mining industry hinged on the ability to overcome material constraints and technical challenges. As operations expanded and resource extraction intensified, mining operators faced increasingly complex obstacles that required expensive equipment, constant labor input, and substantial investment.

Higher Costs, Greater Returns

As mining activities progressed, three critical challenges emerged to shape the industry’s development: ventilation, water management, and fuel costs. Rich tin deposits in Gejiu typically lay deep beneath the earth’s surface, making deeper excavation simultaneously more profitable and more expensive. As miners ventured further underground, they confronted increasingly hazardous conditions, with oxygen deficiency emerging as a particularly prevalent danger.⁹⁰ Miners used oil lamps to monitor these conditions, and they even created a special term, “smothering the flame of the oil lamp” (*men-liang*), to describe a state of oxygen deficiency.⁹¹ When the flame of the oil lamp went out, it was time to install ventilation equipment.

By at least the early eighteenth century, miners had developed techniques to connect poorly ventilated tunnels with better-ventilated passages nearby, though the specific tools and methodologies remained undocumented until the mid-nineteenth century.⁹² According to Wu Qijun’s treatise, miners used a device called an air duct (*fenggui*). Its structure resembled the agricultural winnowing fan, which was a wooden box with a manually operated fan installed inside.⁹³ Twentieth-century observations note that miners also used hollow bamboo conduits to extend ventilation systems deeper into mining tunnels.⁹⁴ Though installation and operational costs for these systems were substantial, the potential returns from accessing deeper, richer deposits justified such investments.

For large-scale mining enterprises, water management capability drove the potential for long-term return. The ability to pump water out of underground mining tunnels directly determined possible excavation depth and consequent profitability. While open-pit operations could utilize square-pallet chain pumps, similar to agricultural water wheels, underground mining required more sophisticated and expensive solutions. In underground tunnels, miners employed a piston pump called a dragon (*long*), which was constructed from wood or bamboo.

Wu Qijun's treatise provides an illustration of these pumping systems, though with notable inconsistencies between textual descriptions and visual representations. In Wu's illustration (fig. 6), which is likely inaccurate, miners install two levels of pumps. At each level, water is shown flowing simultaneously from the top and bottom of the piston pump, being channeled into a drainage tunnel, and then converging in an outlet canal at the mountain's base. This illustration contradicts Wu's written account, which describes a continuous pumping system with up to fifty or sixty interconnected levels that could drain water from deep excavation surfaces.⁹⁵ The actual configuration likely resembled an illustration in the eighteenth-century Japanese copper mining treatise *Kodō zuroku*, in which pumps were used in connected series to reach ground level (fig. 7).⁹⁶

Regardless of technical feasibility, economic constraints mattered in water management. Although miners could technically install as many as sixty levels of pumps, the depth of drainage significantly increased costs. In Wu Qijun's mining treatise, he specifically reminds the reader that a drainage system exceeding ten levels of pumps rendered the mining operation financially unviable. Thus he suggests that if long-term water drainage is necessary, miners should construct a new drainage tunnel instead of installing more pumps.⁹⁷ This economic limitation clearly demonstrates how capital constraints directly restricted mining depth.

In addition to excavation challenges, smelting operations faced parallel resource constraints, particularly regarding fuel consumption. Large-scale furnaces consumed more than 3,000 *jin* of charcoal per cycle to produce up to 1,500–1,600 *jin* of tin.⁹⁸ Continuous mining led to extensive deforestation. Historian Yang Yuda calculated that approximately 20 percent of northeast Yunnan's forests were destroyed between 1726 and 1855 due to mining and smelting activities.⁹⁹ Despite Qing bureaucrats' attempts to address this crisis through reforestation decrees, these policies proved inadequate in the face of



FIGURE 6. Miners using two layers of water pumps for water drainage. The water drainage methods described in Wu Qijun's mining treatise were more closely aligned with an illustration found in Japanese copper mining records (see fig. 7). Detail from Wu Qijun, *An Illustrated Strategy of Mining and Smelting Tools in Yunnan* (1844). Woodblock print, 30.5 × 20.5 cm. Courtesy of Nanjing Library, China.



FIGURE 7. Water pumps in a Japanese copper mine, showing miners operating a vertical pump system of at least three interconnected levels. The structure of the pumps and the operation are extremely similar to those in Yunnan. Masuda Kō, *Kodō zuroku* (1795), 3a. Illustration by Niwa Tōkei. Woodblock print. 13.6 × 18.1 cm. Courtesy of the East Asian Library, Princeton University Library.

the industry's massive fuel demand.¹⁰⁰ By the 1910s, deforestation had become so severe that smelters in Gejiu had to source charcoal from areas up to a hundred kilometers away. As smelters had to rely on mule caravans and, later, the railroad to ship timber, the cost of smelting ramped up significantly.¹⁰¹

These three fundamental challenges—ventilation, water management, and fuel cost—reveal tin mining's intrinsic nature as a capital- and labor-intensive industry requiring highly specialized skills. To maximize returns and extend the operational life span of mining enterprises while combating resource depletion, miners and entrepreneurs necessarily invested in more expensive equipment, pursued deeper excavation, utilized larger furnaces, and sourced charcoal from increasingly distant locations.

A Capital- and Labor-Intensive Industry

The capital- and labor-intensive nature of tin mining shaped the economic and organizational structure of the industry as well as the culture of the migrant mining community. Investors and miners had to endure long periods of hard work before seeing any returns, all while facing significant risks, in terms of both the hazardous working environment and the uncertainty of financial gain.¹⁰² Mining enterprises required high fixed capital merely to secure land access rights. Daily operations demanded considerable resources—rice, oil, timber, and charcoal—with late Qing operational costs potentially reaching twenty thousand silver taels annually.¹⁰³ Achieving greater profitability necessitated substantial upfront capital investment for equipment installation and preliminary excavation work.

Demand for the mobilization of capital and labor determined not only the success of the individual enterprise but also which demographic groups would control the mining industry. Starting in the eighteenth century, the tin mining industry in Gejiu was dominated by merchants and miners from Jiangxi, Hunan, and Hubei, who possessed greater capital and more extensive mining experience. In contrast, local Yunnan merchants, lacking sufficient capital, found themselves marginalized until the late eighteenth century. Only after establishing their own native place association to facilitate pooling of capital and labor did Yunnan merchants gradually penetrate core mining activities, eventually establishing a significant presence by the late nineteenth century.

This pattern of marginalization was even more dramatic among the Yi people. This region's long history of silver and copper mining suggests Yi familiarity with mining. However, due to their lack of substantial capital, the Yi people were relegated to less profitable peripheral roles—growing vegetables, supplying food, or producing charcoal. This situation was so pervasive that by the mid-eighteenth century, the commissioner of Yunnan, Zhang Yunsui (1693–1751), erroneously concluded that “the Yi people have no knowledge of building furnaces and smelting, and can only burn wood to make charcoal, plant vegetables, and raise livestock. They like to trade with miners to enjoy the profits.”¹⁰⁴

While Zhang's conclusion about technical capability was incorrect, his observations accurately captured the economic reality: the Yi people, despite generations of mining experience in the region, found themselves increasingly excluded from core industry activities due to insufficient access to capital. As charcoal production became more capital-intensive in the twentieth century, their position deteriorated further. Charcoal operations gradually passed to merchant groups who possessed greater resources to control mule caravans and railways.¹⁰⁵ What originated as a regional disadvantage based on disparities in social technology eventually turned into what Giersch has characterized as “ethnic inequality in Southwest China.”¹⁰⁶

Given tin mining's capital- and labor-intensive nature, successful enterprises needed effective solutions to critical questions: how to raise and manage capital, attract sufficient labor, mitigate the substantial risks, and motivate workers over extended periods without immediate returns. The industry's remarkable longevity suggests effective adaptation to these challenges.

HOW TO POOL INVESTMENT: THE SHAREHOLDING SYSTEM

To raise funds to start a mining enterprise, merchants and miners in Gejiu used a shareholding system called the rice share system (*mifen zhi*) or *dan* share system (*danfen zhi*; *dan* is a unit of weight).¹⁰⁷ The shareholding system was widely used in capital-intensive industries in late imperial China. Madeleine Zelin's research on the salt and coal mining industries in Sichuan shows the structure of typical shareholding firms.¹⁰⁸ The uniqueness of mining in Yunnan lies in the fact that these shareholders were not bound by kinship or family ties. Rather, the shareholders were all migrant merchants from different areas of China.

The rice share system got its name from the most basic need to start a mining project: food.¹⁰⁹ When merchants started a new mining project, they pooled cash to supply basic needs such as rice, oil, tools, and land.¹¹⁰ Their contributions were recorded as shares in contracts. When the mining site generated a profit, the shareholders received returns based on their shares. In the early eighteenth century, the startup capital to excavate a new mining pit in Gejiu ranged from ten to twenty rice shares, and a mining enterprise could have up to seventy shareholders.¹¹¹

As the mining enterprise grew, the shareholding system provided the means to attract more investment. One mining tunnel could develop into several sub tunnels. The original investors could transfer the sub tunnels to other investors. New partners signed a contract in which they promised to pay 10–20 percent of their profits to the former owners as rent. The sub tunnels could have several investors, and they reproduced the shareholding system in their partnership.¹¹² In this way, shareholders could expand the mining operation to tens of thousands of miners. The shareholding system served as a financial tool for the mining industry. Investors with minimal personal wealth could pool sufficient funds to begin mining excavation, and the flexible shareholding structure enabled mining enterprises to flexibly scale up or down. When funds dwindled, an investor could even transfer mining rights by selling his shares.

HOW TO ATTRACT LABOR: THE SHAREHOLDING SYSTEM AND THE FRATERNITY CULTURE

The shareholding system also functioned as a way to attract labor. The tin miners were either migrants from other provinces seeking work opportunities or impoverished farmers from other regions of Yunnan attracted by the prospect of wealth from mining.¹¹³ Official documents and mining regulations called the miners sand laborers (*shading*).¹¹⁴ The investors, by contrast, called them brothers (*dixiong*).¹¹⁵ In Yunnan, there were two types of employment arrangements: embodied labor equity (*qinshen*) and monthly workers (*yuehuo*). Monthly workers referred to wage workers who were hired temporarily for short-term, miscellaneous tasks, such as ore dressing during the rainy season. They received monthly wages. Embodied labor equity holders, by contrast, received no wages but were entitled to a portion of the profits derived from the extracted minerals.¹¹⁶ Miners in this arrangement invested their physical labor as capital, earning proportional shares of the profits. An eighteenth-century local gazetteer indicates that most miners were working under the shareholding arrangement,

whereas Wu Qijun's nineteenth-century accounts reveal a clear distinction between wage labor and the shareholding system.¹¹⁷ The predominance of embodied labor equity arrangements in the eighteenth century suggests that this system played a crucial role during the initial stages of mining operations and expansion periods when both capital and resources were insufficient.

The terms "brother" and "embodied labor equity" carried dual significance. By designating the miners as brothers, the investors created a sense of egalitarian fraternity similar to the sworn brotherhood in secret societies. As demonstrated by Fan Yasi's mining organization (see chapter 1), membership in mining enterprises often incorporated strong elements of secret societies. This characteristic was also manifest among tin miners on Bangka Island and gold miners in Borneo.¹¹⁸ The fraternity culture created the illusion that the investor, manager, and miners shared common objectives and operated without rigid hierarchies. Simultaneously the embodied labor equity system positioned miners as partners rather than mere laborers. Although the miners had no financial capital, they invested their physical bodies and skills in the enterprise. The brotherhood culture and embodied labor equity system were essentially two sides of the same coin: within this financial and labor organization system, miners functioned as shareholders, working toward the same goal and possessing relatively equal status. This fraternal shareholding system resembles equity incentives or employee stock ownership plans in today's technology companies.

Unlike today's equity incentive system, the miners had no base salary. They worked without payment (food was provided) until the mine began to generate a profit. The profit was distributed as follows in the eighteenth century: investors received 50 percent, the timbering headmen received 10 percent, and the miners shared the remaining 40 percent.¹¹⁹ Through the shareholding system, mining enterprises successfully attracted skilled timbering headmen by offering them larger shares than those given to ordinary miners. This system also allowed for rapid expansion of a mining enterprise: when rumors of rich deposits emerged, miners swiftly converged in large numbers, voluntarily joining the excavation project.

Exploitative and Brutal Fraternity

The brotherhood culture and shareholding system had their dark sides. Brotherhood did not necessarily mean miners were treated the same as investors,

and the shareholding system did not mean miners were less exploited than wage laborers. The illusion of an egalitarian relationship masked the inherent conflicts between miners and investors. The shareholding system lured miners with potential future returns, motivating them to work for long hours without pay. In this way, it minimized startup costs, as the investors did not have to set aside cash for wages. Moreover, the shareholding system extended the financial risk to the miners. When a mining site became depleted, miners had to leave, and the investors were not responsible for paying anything more.

Ironically, despite the rhetoric of fraternity, this system created a highly competitive working culture among the miners. If a mine developed several subterranean tunnels, the timbering headman and the miners could only take the surplus profit from the subterranean tunnels in which they were working. As a result, many miners exerted tremendous effort to reach the rich ore layers as quickly as possible. When two subterranean tunnels met underground, the two teams of miners often engaged in violent, and sometimes deadly, conflict. According to the local gazetteer, stealing ore from other tunnels and violent disputes over rich deposits were the most common threats to security in the mining area in Gejiu.¹²⁰ Unfortunately, there are no surviving legal records regarding conflicts among miners in Gejiu before the mid-nineteenth century. However, a murder case in a copper mine in Huize County, around 436 kilometers from Gejiu, may serve to show how these financial and distribution structures led to intense conflict, and how these disputes were managed within the mining community through the Seven Chiefs system.

In 1746, Lu Xue and Li Mao were timbering headmen working under one mine manager, Sun Liangcai. All three were migrants from other parts of Yunnan. Lu and Li worked in the same mining tunnel. Lu Xue was in charge of the No. 1 subterranean tunnel, while Li Mao directed the extraction in the No. 2 subterranean tunnel. One night, Li Mao went to steal ore from the No. 1 subterranean tunnel and was caught by Lu. The next day, the two bumped into each other in the kitchen. Lu Xue accused Li Mao of stealing his ore and threatened to report him to the investor.¹²¹

Li Mao tried to stop Lu Xue from calling the investor, and the two men began to fight. Before meeting Li Mao, Lu Xue had been pounding salt with an axe. According to Lu Xue's confession, he accidentally struck Li Mao in the head with his axe, seriously injuring him. When Sun Liangcai returned from the market, he found the dying Li Mao. Sun reprimanded Lu Xue and

went to buy medicine for Li Mao. Unfortunately, Li Mao died of his wound eight days later. Sun had no choice but to report the murder to the county magistrate.

This murder case reveals the dark side of the shareholding system and fraternity culture. Although Lu Xue and Li Mao were colleagues and were expected to share an egalitarian brotherhood, the distribution mechanism of the shareholding system turned them into adversaries. Lured by potential profits, miners continuously exploited their own labor and became entangled in cutthroat, sometimes deadly competition. In mining-related cases that reached the archives of the Ministry of Punishments in Beijing, nearly all death penalty cases involved conflicts among miners over profits.

This murder case offers a snapshot of the mining community, illustrating how the social technology of mining functioned both in the production process and in social organization. The conflict followed an escalating pattern of intervention: the timbering headmen initially threatened each other to provoke a solution from the investors, the highest authority in the mining enterprise. As tensions intensified and caused injuries, the mine manager intervened, attempting to mediate within his managerial authority. Government authorities became involved only after a miner was killed. This demonstrates that most civil conflicts in the mining community were resolved internally through the Seven Chiefs system, with minimal government intervention.

* * *

This discussion of social technology helps us understand how the migrant mining community in Gejiu managed to establish a capital- and labor-intensive industry. The Seven Chiefs system helped the mining community organize production and maintain order in the community. The native place association, as an integral part of the Seven Chiefs system, provided a platform for merchants to form networks to raise funds, make business connections, and establish community regulations to discipline the miners. Within the mining enterprises, the shareholding system enabled investors to raise funds and attract labor, while motivating miners to push themselves to their physical limits in pursuit of greater profits.

The significance of social technology in mining is reflected in the writings of scholar-officials. In their documentation of mining technology from the

eighteenth century onward, these officials allocated considerable attention to recording and analyzing the shareholding systems of mining enterprises, the Seven Chiefs and their responsibilities, along with regulatory frameworks and conflict prevention mechanisms. This emphasis is exemplified in Wu Qijun's *An Illustrated Strategy of Mines and Smelters in Yunnan*, the nineteenth century's most comprehensive mining treatise. In the first volume of his treatise, *An Illustrated Strategy of Mining and Smelting Tools in Yunnan*, nine of sixteen chapters address the social technology of mining. This focus should not be interpreted as a dismissal of mining equipment or embodied skills; indeed, Wu meticulously documented the entire mining process from prospecting through smelting, provided illustrations of mining and smelting tools, and consistently underscored the importance of recruiting experienced and skilled timbering headmen and smelter headmen. Nevertheless, he clearly regarded costs, labor management, capital sourcing, regulations, prohibitions, hazards, and taboos as equally vital—if not more so—compared to the material aspects of mining technology. Wu's approach reflects the trends among Qing bureaucrats. Across numerous mining-related memorials, officials consistently devoted more extensive discussion to drainage expenditures and capital organization than to specific technological processes.

Current research on mining often treats domestic mining and the mining businesses operated by the Chinese diaspora separately. However, if we remove this artificial distinction, it becomes clear that mining communities, whether they crossed national borders or not, were all to some extent migrant communities. When migrants from China proper arrived in Gejiu, they were just as unfamiliar with this subtropical highland, once ruled by the Yi people, as the Chinese who sailed to Southeast Asia were with that area. Many of the roles and regulations of the Seven Chiefs system have parallels in Chinese diaspora communities. For instance, the role of guest chiefs is similar in migrant communities in China and across Southeast Asia. In Sichuan, migrant merchants from different provinces were organized under the regulation of guest chiefs.¹²² In the Lanfang Republic (1777–1888), a *kongsi* formed by Chinese gold miners in western Borneo (in today's Indonesia), the president was also called “guest chief.”¹²³ It is likely that guest chiefs were a universal phenomenon among Chinese migrants, both within and beyond the Qing empire.

The shareholding system and fraternity culture were specific to the mining industry. They helped Chinese migrants who lacked local connections

or substantial capital to pool human and material resources, enabling them to launch large-scale, costly mining enterprises. The next chapter focuses on the Chinese tin mining community in Bangka. As in Gejiu, Chinese miners in Bangka formed autonomous mining organizations called *kongsi*, which shared a similar structure to that of the Seven Chiefs system. Within the *kongsi*, the Chinese miners and entrepreneurs utilized a shareholding system and fostered a fraternity culture among themselves. The social technology of mining was designed to make the migrant-based, capital- and labor-intensive mining industry work.

CHAPTER THREE

Mining Organizations in the Formation of Global Capitalism

In a contract sealed in 1760, Chinese Hong merchants purchased sixteen thousand to eighteen thousand piculs of Bangka tin from the supercargo of the Dutch East India Company at the price of twelve taels and five maces per picul, with payment made in Spanish dollars.¹ This contract offers a glimpse into the booming maritime trade in the eighteenth century. The trade and extraction of tin connected Southeast Asia to China through European intermediaries. The tin was mined by Chinese migrants, traded by European merchants—particularly Dutch and British traders—and ultimately shipped back to Chinese markets, where it completed a remarkable circuit of labor, capital, and commerce across the South China Sea.

Bangka is a small island situated east of Sumatra, west of Borneo, and south of the Malacca Strait (map 2). To its east lies the smaller island of Belitung. Both islands, administered under unified governance, possess abundant tin deposits. During the eighteenth and nineteenth centuries, European and Chinese merchants commonly employed Bangka or Banka/Banca to designate both islands. Bangka's strategic location and substantial tin reserves had captured the attention of international traders and Chinese miners, integrating this remote island into the global expansion of capitalism. The British and Dutch vied for monopsonistic control over Bangka's tin trade, while Chinese miners became active participants—albeit unwitting contributors—in European colonial expansion and capital accumulation, serving as the primary labor force in these extractive enterprises.

This chapter tells the story of Chinese mining organizations and their technology in Bangka: what motivated the transfer of Chinese mining technology to Southeast Asia, what enabled the movement of Chinese mining enterprises across borders, and most importantly, what contributed to Chinese dominance in mining. To answer these questions, I approach the movement of Chinese mining technology through the networks of trade, migration, and the social technology of Chinese migrant miners.

The Chinese tin mining organization in Bangka illustrates how the Chinese participated in and contributed to the formation of the world system of capitalism. The trade and mining of Bangka tin was by no means a European invention. Historians Janet Abu-Lughod and Hamashita Takeshi have demonstrated that a premodern world system spanning Eurasia existed as early as the thirteenth century, well before European hegemony.² However, in the eighteenth century, Europeans became the transformative power in reforming trade and the economy across Eurasia. European traders and colonizers integrated into centuries-old intra-Asian networks and fundamentally restructured them into components of a world system characterized by an unprecedented scale of exploitation of natural resources, labor, and wealth. The case of Bangka mining demonstrates how non-European actors—Chinese miners, entrepreneurs, and junk traders—became integral participants in, and inadvertent contributors to, the formation of the capitalist world system.

This chapter's examination of Chinese mining organization and technology relies primarily on reports and surveys produced by European colonial officials and natural philosophers. These reports are inherently biased, as they deliberately portray Chinese mining technology as more advanced and civilized than the mining practices of the local Bangkanese. Critical analysis of these accounts—including their descriptions of Chinese technology and their racialized portrayals of Chinese workers—shows that Chinese mining methods were not inherently more advanced, but rather were specifically suited to the large-scale, intensive mineral extraction demanded by European colonizers.

This chapter defines the Chinese mining organization—the *kongsi* system—as the social technology of mining. The Chinese *kongsi* was ideally suited to the labor- and capital-intensive nature of the mining industry and met the profit-maximizing demands of European colonizers. As in the Gejiu case, the shareholding system and fraternal culture of the Chinese *kongsi*

enabled Chinese migrants to pool capital for expensive equipment and organize a large labor force for intensive extraction. Simultaneously, the shareholding system encouraged Chinese miners to work harder, making them ideal laborers for European colonial extraction operations in Southeast Asia.

Imported Tin from Bangka: A Global Commodity in the Eighteenth Century

China became a huge market of Southeast Asian tin starting in the eighteenth century. Sources of tin included Siam, Malacca, and Palembang (Bangka), with Bangka being the largest supplier. Between 1751 and 1753, the Dutch East India Company (voc) shipped to Batavia 80,938 Dutch pounds of tin from Siam, 441,852 Dutch pounds from Malacca, and 1,057,727 Dutch pounds from Palembang. The majority of this tin was subsequently exported from Batavia to Canton.³ Since Bangka was the major source, “Bangka tin” became a convenient way for both Chinese and European merchants to refer to tin from Southeast Asia.

A mintage reform in 1740, the domestic manufacturing of pewter, and packaging needs for the growing tea trade collectively contributed to a surge in Chinese demand for tin. Guangdong was responsible for delivering 211,713 *jin* of tin to the imperial mint in Beijing annually.⁴ The domestic tin supply in the Guangdong market was far from enough to fulfill this demand. A survey conducted by Guangdong’s provincial governor in 1740 reveals that domestic tin was scarce in local markets, while imported tin (*yangxi*) brought by foreign merchants from overseas (*waiyi yangshang*) was readily available.⁵ The “imported tin” referenced by Qing officials was in fact Bangka tin, and the foreign traders from overseas were voc merchants. Two years later, the governor-general of Guangdong and Guangxi, Wang Anguo (1694–1757), reported to Beijing that despite government efforts to open additional tin mines, domestic production remained far below demand. Therefore, he suggested they “wait for the foreign ships to come to Canton in the seventh and eighth lunar months, and to purchase the rest [of the tin] to ship [to the metropolitan mint].”⁶ The Ministry of Revenue approved this proposal, establishing a regular practice of purchasing Southeast Asian tin annually for currency production.⁷ Coinage provided the most quantifiable demand for tin from Southeast Asia, reflecting the Qing court’s dependence on international trade for its monetary system.

In addition to coinage, Chinese pewter artisans also favored Bangka tin for producing pewter objects. The importation of Bangka tin transformed port cities like Chaozhou and Zhaoqing (near Canton) into nationally renowned pewter manufacturing centers. Chaozhou was particularly well positioned, given its long history of tin mining before the eighteenth century and its role as a major hub for the Chinese junk trade and emigration to Southeast Asia. Local artisans adopted new styles from export porcelain and export silver, creating heavily decorated pewter objects that gained widespread popularity. After 1860, when Shantou (Swatow), a city in Chaozhou Prefecture, became a treaty port accessible to Western traders, Chaozhou artisans further adapted their designs and techniques to cater to European consumer preferences, establishing Swatow pewter as a globally recognized brand.

The tea trade was most closely intertwined with the import of Bangka tin. Tea constituted the largest Chinese export in the Sino-European trade. In 1712, the British East India Company (EIC) imported 156,000 pounds of tea from China, which jumped to nearly three million pounds by 1738. This did not include purchases by other European traders or quantities involved in illicit smuggling.⁸ In the wholesale tea trade, merchants used pewter-lined wooden boxes for maritime shipping to keep the tea dry and preserve its aroma. Beyond wholesale packaging, pewter caddies were also employed for high-end tea products. Given these enormous volumes, the demand for tin as packaging material was correspondingly massive.

Tin served not merely as packaging material but also as a crucial commodity that European traders exchanged for tea. The tea trade stimulated material and economic flows across the world, shaping trade networks and the development of capitalism. As historian Andrew Liu points out, tea became “one of the many catalysts within expansive and interlocking commodity flows, spanning the silver mines of Potosí to the poppy fields of Malwa.”⁹ To purchase tea from China, the British initially relied on Spanish silver, subsequently replacing it with opium from India starting in the second half of the eighteenth century. The Dutch, by contrast, found tin from Southeast Asia to be an ideal substitute for silver.

The Chinese Traders Among Two Competing Colonial Powers

Tin has long been a commodity of maritime trade in Asia. Chinese merchants were already familiar with tin from the Malacca Strait through the

long-standing intra-Asia trade. Fei Xin (1388–1436?) and Ma Huan (active 1414–51), who participated in Admiral Zheng He's (1371–1433) voyages, recorded that tin was produced in Siam, Malacca, and Sumatra.¹⁰ The VOC followed the intra-Asia trade routes and established its tin trade when it took over Malacca in 1641.¹¹ In the eighteenth century, the Dutch took advantage of the internal power struggles within the Palembang Sultanate and gradually gained a monopsony over tin trade from Bangka. In 1722, Sultan Komaruddin (r. 1714–24) signed a series of agreements with the Dutch, promising to deliver to Batavia a large quantity of Bangka tin at an extremely low price.¹²

As Batavia became the center of the tin trade, Chinese junk traders began to buy tin from the Dutch in Batavia and ship it to China. In 1734, noticing that Batavia goods were being sold at much higher prices in Canton, the VOC decided to sell tin directly to China. They loaded China-bound ships with tin and other Southeast Asian goods to sell in Canton.¹³ Batavia goods, including tin and pepper, gave the VOC a great advantage over other European traders.¹⁴ Through the second half of the eighteenth century, the VOC used tin to supplement American silver in funding its China trade.¹⁵ In addition to shipments to China, the VOC also exported a portion of tin to Japan.¹⁶ From there, some tin made its way to Suzhou through the Sino-Japanese copper trade. A smaller portion entered the Ryukyu-centered trade network, where it was incorporated into Ryukyu's tributary gifts to China. The gift list of 1782 recorded *baigang xi* tin as a tribute item from Ryukyu, despite the absence of tin mines in the kingdom.¹⁷ The Chinese term *baigang* is most likely a transliteration of Bangka.

Not surprisingly, the Dutch were not the only players in this highly lucrative trade. Although the VOC tried its best to monopolize the tin trade, Chinese junks and the EIC never stopped shipping tin from Malacca and Palembang. In 1777, a Dutch report estimated that the English took over five hundred thousand pounds of tin from the Malacca Straits.¹⁸ From 1810, Sir Thomas Stamford Raffles (1781–1826), later the lieutenant governor of Java, pointed out that goods from Southeast Asia, including Bangka tin, were “the foundation of the Dutch prosperity in Europe,” and suggested that the British should take over Java and gain a monopoly over Bangka tin.¹⁹ In 1811, British forces occupied Java, subsequently controlling Bangka. The sultan of Palembang ceded Bangka to the British in 1812. The British exchanged it with the Dutch for Cochin in India in 1814, making Bangka an official European colony.

Despite turbulent regime changes and competition between the European powers, Chinese traders continued their trade with Bangka. As early as the fourteenth century, Chinese traders had established emigrant communities of considerable size in Palembang.²⁰ Although trade took a downturn after the coastal evacuation during the Ming-Qing transition, when the Qing court lifted the sea ban in 1683, junk traders quickly reentered the Southeast Asian trade network. As historian Léonard Blussé points out, the eighteenth century was the Chinese century for junk trade.²¹ During this period, ports like Xiamen (Amoy) and Chaozhou became nodes of the junk trade between China and Southeast Asia, while Canton was the only port available to European merchants.

Chaozhou merchants emerged as the new power in maritime trade, following the pioneering Fujianese and Cantonese merchants. Chaozhou is located on the border between Guangdong and Fujian, and their dialect, Chaozhounese (Teochewnese), is closer to Hokkien than Cantonese. As relatively new players, they allied with Fujianese merchants, forming commercial alliances such as the South Seas Guild and the Fujian-Chaozhou Overseas Guild.²² Their junks sailed between mainland China, Taiwan, Siam, and the Malacca Strait to trade rice, spices, deerskin, edible bird's nests, sea cucumbers, and tin.

Europeans changed the scale and nature of the tin trade between China and Southeast Asia. They brought the long-existing intra-Asia trade network into the global trade network. The European appetite for tea created an unprecedented demand for tin and motivated large-scale emigration of Chinese miners. Armed with naval forces, the Europeans gradually pushed other actors in the intra-Asia trade system, such as native seafarers and Chinese junk traders, to the periphery of the trade network through their anti-smuggling campaigns and exclusive agreements with local sultans.

Furthermore, the Europeans were not just traders; they were also profit-seeking colonizers trying to extract the island's natural resources. In 1812, Raffles sent Dr. Thomas Horsfield (1773–1859), a Pennsylvania-born physician and naturalist, to conduct a survey of Bangka to assess the potential economic value of the island.²³ In his report, Dr. Horsfield claimed that the eighteenth-century discovery of tin deposits had attracted substantial numbers of Chinese miners, who introduced systematic mining operations, agricultural development, and commercial networks to the island. Through these endeavors, multiple settlements were established, indigenous forests

were cleared for cultivation, and “the principles of civilization were offered to the rude inhabitants.”²⁴ This racially charged characterization exemplifies the developmentalist discourse prevalent in colonial records. Within this framework, the purported civilizing mission functioned as an ideological justification for resource extraction. Chinese miners, while credited with transforming the island’s natural environment, ultimately served as intermediaries in the European colonial project of converting Bangka’s landscape into a site of natural resource exploitation.

Forging Connections: The Beginnings of Chinese Mining in Bangka

There are several local stories about the origin of tin mining in Bangka, and Chinese agency is palpable in all of them.²⁵ According to the most popular narrative, tin was discovered in 1710, when the local Bangkanese slashed and burned the forest to create rice fields. The locals found melted tin in the ashes and brought the tin to the sultan of Palembang. The sultan’s Chinese expert advised him to open mines and recruit Chinese migrants to Bangka.²⁶ This narrative indicates that while the local Bangkanese may have engaged in mining prior to the arrival of the Chinese, their productivity was too insignificant to be recognized by the sultan of Palembang and international traders.

Chinese engagement in tin mining arose from marriage alliances with the sultan. Bangka became a dominion of the Palembang sultan in the seventeenth century.²⁷ During an internal power struggle in Palembang, Depati Anum, later known as Sultan Mahmud Badaruddin I (r. 1724–57), and his brother went into exile in Johor, where they met a Chinese merchant. The sultan married his daughter. In Johor, they became familiar with tin trading and smuggling. To gain Dutch support in their political struggle, the young sultan agreed to deliver tin to the Dutch. When Depati Anum returned from exile, he turned Mentok, a harbor town on the northeast edge of Bangka Island, into a retreat for his Chinese wife and her relatives.²⁸ These Chinese Muslims, who had marriage connections with the sultan, are believed to be the founders of Bangka tin mining. The intermarriages continued until the nineteenth century. According to historian Mary Heidhues’s interview with local informants, Chinese ancestry was considered an asset in Bangkanese tradition.²⁹

Alliances and collaborations between Chinese merchants and local rulers were very common in Southeast Asia. Similar patterns can be found in the

Sino-Thai tin mining enterprise founded by the Khaw family in the nineteenth century. Jennifer Cushman shows that the Khaw family, who arrived in Penang or Siam from China in 1822, built a mining empire by making key political and economic alliances with the Bangkok court. Members of the Khaw family had dual identities: they served as representatives of the Bangkok court and operated as business entrepreneurs. This dual identity enabled the Khaw family to establish two power bases in southern Siam and Penang, which gave them a monopoly over tin mining in Thailand.³⁰ Chinese mining enterprises had been established in Bangka a hundred years earlier, but the principle was the same. By forging alliances with local powers, Chinese merchants managed to secure business empires in a foreign land.

Chinese merchants' strategy of forging alliances with local authorities originated from practices back in China. Chinese merchants, especially those who invested in mining, formed interdependent relationships with local authorities. In Yunnan, leaders of the mining community eagerly forged connections with local administrators, establishing community regulations and building native place associations. These institutions supplemented the government's limited administrative presence, helping maintain local social order and ensure tax revenues. When these Chinese merchants moved to Bangka, they applied the same strategy with local rulers, and later with European colonizers.

Mining Nomads: From Chaozhou to Bangka

While Chinese Muslims gained mining rights through marriage connections, the labor force and the mining technology came from the Chaozhou region of China. Two local legends suggest the connection between Chaozhou and Bangka. According to Mary Heidhues, local tradition claims that Lin Daoqian, a famous pirate from the Chaozhou region, was an ancestor of the sultan's Chinese Muslim in-laws.³¹ Lin Daoqian was born in the sixteenth century and participated in the Japanese piracy that plagued the Chinese coast during Jiajing period (1522–66). When Ming authorities threatened to capture him during their anti-Japanese piracy campaign, he moved to Southeast Asia with a large number of followers and settled in Patani.³² In *Carita Bangka*, the Malay history written by local officials in 1861, Lin Daoqian's descendants were described as establishing the tin mining industry in Bangka and even building the first cannon on the island.³³ This description

may not be accurate, however, as Lin is not mentioned in Thomas Horsfield's survey conducted in 1812.

The association between Lin Daoqian's descendant with the origin story of tin mining represents a composite narrative that encapsulates the collective experiences of Chaozhou sojourners from the sixteenth through the eighteenth century. In official narratives of the Ming and Qing governments, Chaozhou was characterized by violence and produced some of the most notorious pirates. During the Ming-Qing dynastic transition, Chaozhou inhabitants emerged as a significant component of anti-Qing resistance movements. Following the Qing consolidation of power, imperial authorities implemented a coastal evacuation policy spanning from Zhejiang to Guangdong, driving numerous Chaozhou residents to establish permanent settlements in Southeast Asia, which in turn reinforced their stigmatization as pirates in imperial discourse.

In contrast to imperial characterizations, Chaozhou communities celebrated figures like Lin Daoqian as heroes rather than criminals. This divergent interpretation reflects the region's distinctive economic and geographic constraints. Chaozhou's limited arable land and dense population compelled residents toward alternative livelihoods: mountain dwellers pursued mining, while coastal populations engaged in maritime trade. The draconian evacuation policies during the Ming-Qing transition caused severe devastation and substantial loss of life, necessitating armed self-defense among survivors. While some turned to mining banditry, others became pirates and established themselves in Southeast Asia, where powerful figures like Lin provided protection for Chaozhou emigrants.

A story about Oen Assing also sheds light on the origin of Chinese mining technology in Bangka. According to Thomas Horsfield's survey, Oen Assing was the ancestor of one of the administrators who managed the mining district in Bangka. After the sultan's father-in-law established the first Chinese community in Mentok, Oen Assing moved to Belo to establish new mining sites. He recruited Chinese laborers from China and Borneo, an island that hosted Chinese gold mining communities.³⁴ Borneo belongs to what Melissa Macauley defines as "maritime Chaozhou." It was a destination of Chaozhou junk traders and emigrants, and most of the gold miners were Hakka from mountainous regions in northeastern Guangdong.³⁵

The story of Oen Assing varies significantly between colonial and local sources, revealing different perspectives on his involvement in mining. In

the British narrative, he is celebrated as a technological genius who brought advanced Chinese mining technology to Bangka. The Malay version presents a more complex figure: Oen Assing is described as a criminal initially expelled for stealing tin, whose mastery of superior technology eventually earned him redemption and promotion to *kapitan cina*, leader of the Chinese migrants. Despite these different characterizations, both narratives acknowledge his crucial role in introducing advanced mining technology, including the use of waterwheels and canals, as well as standardization of the tin ingot.³⁶

The legend of Oen Assing's innovations follows the typical pattern of stories that attribute complex technological developments to a single charismatic male leader. It seems unlikely that Oen Assing single-handedly introduced all these technologies. He was more likely a well-connected entrepreneur bringing in people with experience in mining. According to the Chinese mining administrators Horsfield interviewed in 1812, the people Oen Assing recruited from China and Borneo were already "acquainted with the process of collecting the ore and refining the metal."³⁷ This suggests that the real agents of technological transmission were the skilled workers themselves, who carried embodied skills and practical expertise with them.

Oen Assing's story provides important clues about the origins of these skilled workers and their connections to China's Chaozhou region and Hakka communities. His association with Borneo is particularly revealing, as many miners working in Borneo's gold mines were Hakkas from Chaozhou.³⁸ This connection is reinforced by linguistic evidence: even today, the Chinese community in Bangka speaks the Hepo dialect, which originates from Hakka communities in the mountainous areas of western Chaozhou.³⁹ These Hakkas were called *banshanke* (half mountain Hakka), meaning they dwelled between the hillside hinterland and the coastal areas of Chaozhou, and were thus more integrated into Chaozhou culture and regional identity.⁴⁰ The regional connection to Chaozhou outweighed Hakka identity when it came to maritime connections. In this way, geographic and cultural ties facilitated migration and the movement of mining technology across the South China Sea.

Geological similarities between Chaozhou and Bangka also facilitated the movement of mining technology. Despite being in different geological provinces—Chaozhou in the southeast China–north Vietnam tin province and Bangka in the Southeast Asian tin belt—both regions shared the same Malayan-type collision formation process (map 2).⁴¹ Both regions contain alluvial placer tin deposits well suited to open-pit mining methods.⁴² Miners in

northeast Guangdong, including Chaozhou, had practiced open-pit mining for centuries. When early Qing restrictions limited mining in China proper, miners from Chaozhou, experienced in open-pit techniques and seeking extra income, sailed to Bangka in their townsmen's junks to engage in mining.

Thus geological similarities between Southeast Asia and South China enabled miners to transfer their alluvial mining technology across geographical boundaries. Mining restrictions in the early Qing motivated miners to leave their hometowns for Southeast Asia. Long-established trade routes, along with marriage connections between elite Chinese settlers and local rulers in Palembang, facilitated the establishment of mining communities in Bangka. The mobility of these miners contradicted the stereotypical image of traditional Chinese people as farmers attached to their land. Miners acted more like nomads who followed mineral resources, leaving when mining resources were depleted and moving to new deposits.

Chinese Mining Technology in Bangka

European colonial observers claimed that the Chinese brought technological advancements to Bangka. In their accounts, Chinese miners possessed more efficient tools and equipment, coupled with what Europeans described as more capable and robust bodies naturally suited to mining. Due to the scarcity of Malay and Chinese records, we must rely on European sources to reconstruct the Chinese tin mining operation in Bangka. A critical reading of these colonial officials' narratives reveals that the supposed Chinese technological advancement was in fact the capacity to coordinate large-scale mining enterprises that were both capital- and labor-intensive. They were favored by European observers because they met the economic requirements of European colonizers.

There were three types of mining methods in Bangka: burrowing, *kulit* mining, and *kolong* mining. Burrowing, typically performed by the Bangkanese, operated on a very limited scale, with each mining pit functioning only briefly. These pits were no more than one digger's height in depth and four to five feet in diameter, causing them to be quickly exhausted, since miners could not access deeper ore deposits. The Bangkanese ore processing method was equally simple. Miners first sieved ore-bearing soil through braided baskets, then placed the ore into wooden boxes to wash in nearby streams. This process filtered out the soil, leaving behind the heavier ore.⁴³ This ore dressing technique imposed significant locational constraints, as

operations had to be near streams. Furthermore, the absence of proper drainage systems meant that mining pits were often abandoned after flooding.⁴⁴

The burrowing method did have its advantages, however: it was easy to start, needed minimal equipment, and cost little. Miners could abandon the mining pit with almost no loss when it was exhausted. However, due to the inherent limitations of burrowing methods, productivity remained relatively low. Therefore, this method was not favored by European colonizers and was pushed to the periphery of the island. In the nineteenth century, indigenous mining was found only in remote locations.⁴⁵

Chinese miners introduced the *kulit* and *kolong* methods.⁴⁶ Both techniques represented forms of open-pit mining practiced in Guangdong and Yunnan. Mining began with prospecting using an iron drill or borer with a small conical scoop at the bottom, called a *jian* (*ciam* in their dialect).⁴⁷ An experienced miner drove the drill perpendicularly into the ground. When he reached the ore stratum, he drew up the drill and examined the metallic particles brought up by the scoop. By evaluating these soil samples, he determined the direction for excavation.⁴⁸ The name and shape of the drill suggest a connection to mining technology in China. In Yunnan, miners employed the same type of long, pointed iron rod to work ore bodies and used the identical term *jian* to refer to excavation tunnels that followed mineral veins. This shared terminology suggests that Yunnan miners likely used similar long chisels for prospecting operations.

The main difference between *kulit* and *kolong* mines was the scale and depth of excavation. *Kulit*, meaning “skin” in Malay, referred to shallow surface mining, similar to the Chinese concept of “grass cover mining.” *Kulit* mines typically operated within a depth of ten feet and involved only a few miners.⁴⁹ In contrast, *kolong* mines were deeper and operated on a much larger scale. The term *kolong*, meaning “vault” or “underground space” in Malay, suggested deeper excavation. *Kolong* mines extended over eighteen feet in depth, with the largest *kolong* mine in the early nineteenth century measuring more than twenty-one feet deep and one hundred feet in both length and width.⁵⁰

Due to its depth, the miners working in the *kolong* mines employed sophisticated water management technology to prevent the mining pit from flooding. In Bangka, *kolong* mines began with careful planning, after which miners constructed complicated canal systems for drainage and ore dressing. Major M. H. Court, a British resident and commandant of Bangka, documented the

drainage system used by Chinese miners, recording all the technical terms in romanized Chinese and representing their pronunciation in Chaozhou or Hakka dialect. When a site was chosen, the ground was cleaned and a dam—called a *peetow* (PY: *beitou*, meaning “pond head”)—was built to create a reservoir. The dam diverted the stream into two types of canals. The first type, called a *choonchweekoo* (PY: *chongshui gou*, “flooding canal”), carried excessive water from the mining area. The second type, called *cheekow* (PY: *chegou*, “water wheel canal”), directed water to drive the water wheel. Next to the water wheel, the third type of canal, *chungkow* (PY: *chonggou*, “flushing canal”) was built to carry away the water drained from the mining pit. At the low reaches of the major canals, some small trenches called *swakow* (PY: *shuagou*, “washing canal”) were built for ore dressing.⁵¹

The most important pieces of equipment introduced by the Chinese were the water wheel and chain pumps (fig. 8). Unlike the burrowing method, where miners had to abandon flooded mines and washed ore manually in streams, Chinese miners used water wheels, chain pumps, and canal systems to effectively pump water from mining surfaces and recycle it for ore dressing. The chain pump was installed at the edge of the mining pit. It consisted of a continuous chain fitted with wooden pallets that rotated around a wheel's axis, scooping water upward as the pallets moved through a wooden trough. The water drained from the mine was discharged into the flushing canal and flowed into the washing canal, where the ore was processed. At the bottom of the washing canal, miners laid planks of wood or bark. When water passed over the wood, heavier particles containing ore sank to the bottom while lighter waste was washed away. Simultaneously, miners used large spades to agitate the ore in water, breaking up clay and refining the material. The processed ore was then dried for smelting.⁵²

The use of drainage equipment, the construction of canals, and the ore dressing process share many similarities with the mining technology discussed in chapter 2. The ore dressing trenches closely resembled those used in Gejiu tin mines. Both locations employed canals to direct water for ore washing. The structures of the ore dressing pond were also similar: miners in both areas constructed parallel walls at the bottom of the pond to separate ore from waste. The use of large spades to agitate ore in Bangka mirrored the process of “massaging the ore” (*rouhuang*) in Gejiu tin mines. The use of water wheels, although not frequently seen in Gejiu, was common in other

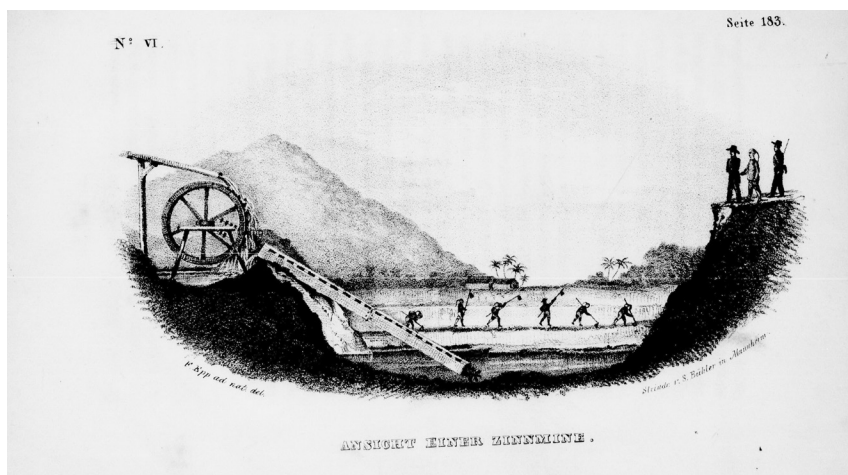


FIGURE 8. Epp's sketch of a *kolong* mine, with the chain pump on the left. Franz Epp, *Schilderungen aus Ostindiens Archipel*, seite 183. Courtesy of Leiden University Libraries.

areas in China. For instance, a memorial in 1779 mentions that miners in Hunan used similar water pumps to remove water from the mining pit.⁵³

These mining technologies share a common origin in Chinese agricultural hydraulic systems. Chinese farmers had been using chain pumps and water wheels together for irrigation since the tenth century.⁵⁴ The construction of canals was also a common practice in irrigation systems used by Chinese farmers. Transmission of these technologies occurred through the miners themselves, most of whom were originally farmers. Under the guidance of experienced miners, these farmers quickly adapted their agricultural tools and techniques for mining purposes. It is highly likely that miners from Chaozhou brought this mature system of mining to Bangka, enabling large-scale, intensive excavation.

After excavation, the ore was smelted. Bangka's smelting technology was similar to that of Gejiu. The furnace structures were nearly identical. The smelting furnace in Bangka was oblong, also built with clay and salt. The crucible occupied the middle part of the furnace, with a basin at the bottom for collecting smelted tin.⁵⁵ The bellows were installed at the back of the furnace. Like bellows in Gejiu, bellows in Bangka were double-acting force and

suction pumps, meaning miners could provide continuous airflow during both pushing and pulling motions.⁵⁶

The smelting process was also similar to Yunnan. For fuel, miners in Bangka used charcoal made from trees cleared from mining sites.⁵⁷ The miners either produced the charcoal themselves or hired specialists for this purpose.⁵⁸ Smelting was performed at night, when it was cooler. The smelters placed alternating layers of charcoal and ore in the furnace. When the ore melted, they opened a hole at the bottom of the furnace to allow the molten tin to flow into a basin. Then they removed scum and slag with long shovels, scrapers, and pikes, and used ladles to pour the molten tin into molds to create tin slabs.⁵⁹

Finally, as in Gejiu, smelting in Bangka profited from economies of scale. The furnace measured ten feet long, four feet wide, and four feet high.⁶⁰ The bellows was made from the hollowed-out trunk of large tree, providing the furnace with a powerful air flow.⁶¹ The large bellows was operated by a team of six men working in rotation, three men for each shift. During the smelting season, which ran from February to April, smelters had to work through the night.⁶² One night's work on one furnace could produce around forty slabs or twenty piculs of tin. In contrast, an indigenous furnace, which was much smaller, could smelt only three to seven piculs of tin per night.⁶³

Quantitatively, the Chinese equipment and method were more effective than the local Bangkanese and Malay methods. However, the material aspects of mining technology were not enough to explain Chinese dominance of tin mining in Bangka. Chinese water wheels and drainage systems were not hard to replicate—they were appropriated from water management technology in agriculture. Mining methods were not ethnically exclusive either. Some Chinese used the local burrowing methods, and local Malays also used Chinese water wheels in *kulit* mining.⁶⁴ Then, was it something unique about Chinese people's physical makeup that gave them this advantage?

Franz Epp, the Dutch East Indies medical officer in Bangka from 1836 to 1838, attributed the Chinese advantage to biology, citing the stronger Chinese body. His explanation came from a typical nineteenth-century racial perspective. According to Epp, "The Chinese are hard-working. A Chinese day laborer works for his pay . . . as much as possible. . . . In this regard, they show a great contrast to the domestic coolie, that during work like to sit back and take things easy, and carelessly watch how their stuff breaks under the load. The Chinese are strong and powerful. The heaviest bag of rice, which three

Bangkanese can't take together, the Chinese will bear with ease. When he gets tired, his comrades will be there immediately to help."⁶⁵

If we read Epp's description critically, it is clear that what Epp described is beyond the biological body. The alleged biological strength of the Chinese was the result of a specific work culture. Unlike the Bangkanese, the Chinese were more willing to engage in prolonged hard manual labor for very low wages. Moreover, they encouraged one another to work even harder. These characteristics made Chinese miners ideal laborers for European colonizers. The biologically strong Chinese body was a social construct; it actually means a body with a work culture suited to intensive exploitation. The Chinese work culture was not a natural virtue; it was largely shaped by the exploitative nature of the mining organization.

In sum, the European assessment of the Chinese mining equipment, methods, and body was influenced by their standpoint as employers at the VOC and EIC. In other words, the European observers' judgment was highly biased as they evaluated mining technology from the perspective of a capitalist, profit-seeking corporation. These Europeans were interested in mining technology that could maximize productivity and profit; therefore, they valued the methods that were the most capital- and labor-intensive, and the most exploitative. When we remove the lens of scientism and racism, the supposedly advantageous Chinese technology and capable Chinese bodies can be reinterpreted as the capital- and labor-intensive, highly exploitative nature of Chinese mining organizations.

Like mining organizations in Gejiu, Chinese mining and smelting enterprises in Bangka were labor intensive. Both excavation and smelting demanded a big team of workers, careful labor management, and a complicated division of labor. Operating a *kolong* mine required a team of at least twenty-five to thirty miners.⁶⁶ During excavation, miners were divided into groups to dig the pit, carry out the ore, and wash the ore. Smelting required greater skills, encompassing the construction of shelters, production of charcoal, and building of furnaces. The smelting process demanded careful coordination. The large bellows was operated by a team of six men working in rotation continuously through the night.⁶⁷

In addition to being labor intensive, mining was also capital-intensive. Since Bangka Island lacked large-scale food cultivation, rice had to be imported, making the food supply very expensive. The installation of equipment was also costly: construction of the water wheels, canals, and furnace

all required a substantial capital outlay. The most sophisticated Chinese machinery—the water wheel and the chain pump—was built by carpenters who had to be paid in cash.⁶⁸ The more technically advanced machinery was only possible with a substantial initial capital investment.

Moreover, the Chinese mining method required long-term investment with substantial risks and delayed returns. Before beginning mining, extensive preparatory work was required: miners had to clear forests, build lodging, construct dams, dig canals, install water wheels, and excavate mining pits. All this preparatory work had to be completed before the mine could produce any tin. This meant miners had to work without pay for three to four months to reach ore-bearing strata and then wait for the smelting season to produce tin ingots before receiving any return. Most Chinese miners possessed no more capital than the Bangkanese; instead, they accumulated heavy debts before the mining operation began to generate profits. They had to pay for passage to Bangka, equipment, food, and charcoal. Consequently, many Chinese miners incurred greater financial risks than the Bangkanese, who could simply abandon their small pits when productivity declined.

Like miners in Gejiu, Chinese miners in Bangka adopted shareholding and debt systems to pool resources. These financial arrangements, combined with delayed returns, shaped the work ethic of Chinese miners. The system motivated them to voluntarily exploit themselves and each other, working long hours in hope of future profits. As capital constraints prevented the Bangkanese from establishing labor- and capital-intensive mining corporations, they consequently avoided the exploitative structures that characterized these organizations. According to Thomas Horsfield, although local residents also participated in mining in Minto, they were not willing to “undertake the work on the same terms as the Chinese.”⁶⁹ Like those Zomia residents who used mobility, dispersed settlements, and strategic crop choices to escape the state, the Bangkanese practiced the art of not being exploited.⁷⁰ Not being trapped by debts, shares, and illusions of future profit, they could, as Epp has described, “sit back and take things easy.”⁷¹

Thus European traders and colonizers may have seen the Chinese mining method as superior to the Bangkanese method because it followed the logic of economies of scale in the pursuit of greater output and profits. For elite Chinese who invested in mining and owned tin mines, this demonstrated the superiority of Chinese mining technology. But to the ordinary miners, the advanced Chinese method entailed greater risk and more exploitation.

The domination of Chinese mining enterprises in Bangka resulted from the successful marriage between the European colonial project and the Chinese social technology of mining—the *kongsi* system.

Kongsi: The Social Technology That Fit Capitalism

The Chinese mining industry was organized under the *kongsi* structure. The term *kongsi* (PY: *gongsi*, “cooperative company”) is used by scholars studying Southeast Asia to describe voluntary associations that served the economic, religious, social welfare, and political needs of emigrant Chinese communities.⁷² The most famous Chinese *kongsi* in history was the Lanfang Republic (1777–1884), which was founded by Chinese gold miners in West Borneo.⁷³ These Chinese *kongsi* shared characteristics like self-governance, an egalitarian culture, and a democratic organization.⁷⁴ The *kongsi* was a socioeconomic institution that served to organize labor- and capital- intensive industries like mining. It provided a means to raise funds and organize labor, thus enabling Chinese miners to fund infrastructure like canals, waterwheels, and more powerful furnaces. This type of autonomous social structure was prevalent in Chinese mining communities across China and Southeast Asia. It shared the characteristics of capitalist institutions, providing the means to develop capital- and labor- intensive industries.

In Bangka, each *kolong* mine was operated by a *kongsi*. Each *kongsi* elected a leader, a cook, a gardener, a pig tender, and a bookkeeper.⁷⁵ The leader was responsible for managing labor, settling disputes, and purchasing necessities.⁷⁶ Once miners decided on a location, they built communal housing and purchased food and tools. The water wheel was made by specialist carpenters in the mining group. If a mining group did not have a suitable carpenter, it hired one, who earned daily wages.⁷⁷ Other specialists, such as smelters and charcoal burners, were also paid by the *kongsi*. Smelters were paid according to an established rate for each night’s work, and charcoal burners received a fixed price for each basket of charcoal.⁷⁸ Sometimes the *kongsi* also hired wage-laborers to perform temporary work, such as constructing canals.

The *kongsi* served as a business partnership and financing system for the miners. Like the miners in Yunnan, those in Bangka used a shareholding system to raise funds and distribute profits.⁷⁹ When miners voluntarily formed the mining corporation, they became shareholders of the *kongsi*. The shares, called *hun* (PY: *fen*), were equally distributed among the miners. Therefore,

the miners shared equally in the profits and risks of the mining operation. The shareholding system also allowed other investors, probably Chinese traders or wealthy residents of Bangka, to purchase shares in a mine. These nonworking shareholders hired wage workers to serve as their proxies.⁸⁰ As one can imagine, when the operation grew bigger and more investors joined the *kongsi*, the miners' share became smaller and smaller. Consequently, the democratic and egalitarian nature that came with the shareholding system also diminished.⁸¹

The shareholding system coexisted with a sophisticated bookkeeping and credit system. Since mining required a long-term investment, miners had to borrow money from their administrators—the *tikos*. *Tikos* were descendants of a Chinese father and Malayan mother. They were responsible for governing the Chinese miners in their districts, advancing money, and purchasing tin ingots for the sultan.⁸² Horsfield describes the *tikos* as absolute rulers. They wielded power over the lives and property of the Chinese.⁸³ The term *tiko* shows the close connection between Bangka and Chaozhou: it is likely a transliteration of the Chinese term *dage*, “big brother,” a term used by miners in Guangdong to refer to the leader of the mining organization.

Tikos in Bangka had dual identities: they were leaders with authority over the miners, but also supplied the capital for mining. Unlike big brothers like Fan Yasi, who were driven out by the Qing government, *tikos* received support from the local authority. They neither resided at the mining site nor participated in the actual labor; instead, they lived in Palembang and visited their districts only occasionally. Each year, the sultan advanced five to ten thousand Mexican silver dollars to each *tiko*, and contracted with them for the delivery of tin at the price of eight dollars per picul.⁸⁴ *Tikos* lent money to the miners to purchase necessities such as food, construct water works and furnaces, buy charcoal, and hire smelters.⁸⁵ At the end of the smelting season, *tikos* bought the tin from the miners at six Mexican silver dollars per picul, earning a two-dollar markup when they delivered the tin to the sultan. This was when the miners cleared their debts. According to Major Court's observations in the early nineteenth century, two-thirds of this payment was made in provisions and merchandise received by the miners for their work, and the remaining one-third was paid in tin coins, called *petis*, also issued by the *tikos*.⁸⁶

Since *tikos* seldom came to the mining sites, the day-to-day administration was carried out by their agents in Bangka—the *congsee*.⁸⁷ A *congsee* was

the regional administrator of a mining district.⁸⁸ While the miners lived in scattered itinerant mining sites, *congsees* lived in fixed establishments or villages. The village was home to those that supported the mining industry: carpenters, blacksmiths, charcoal burners, smelters, shopkeepers, and fishermen. The *congsee* provided the miners with rice, salt, oil, clothing, and tools; he also acted as the middleman in employing skilled workers, such as carpenters and smelters.⁸⁹ These expenses were recorded in the accounting book as debts. At the end of the smelting season, after the miners sold the metal, debts were settled in the following sequence:

1. Monthly advances of cash and necessities like food and tools.
2. Pay for the smelter and his assistants.
3. The price of the coal used in refining.
4. Rental of the furnace and implements.
5. Transportation for the metal.⁹⁰

After the balance was cleared, the remaining profits were divided among the miners according to the shareholding system. The *congsee* also kept accounts for individual miners. If miners had taken private advances from the *congsee*, they were called upon to pay them off from their individual shares.⁹¹

The *congsee* was also in charge of recruiting laborers by sending a Chinese agent from Palembang to China to recruit people to emigrate to Bangka. The agent chose laborers from his hometown, selecting the most capable men. The *congsee* paid the cost of the voyage in advance, and the miners then repaid the *congsee* from their individual shares or wages. Until they had cleared all their debts, they were not permitted to leave the mine.⁹² By the middle of the nineteenth century, a contracted laborer with debts had to work for up to three years before he was free to join a *kongsi* as a shareholder.⁹³

As a result of the shareholding system, the free miners who participated in the corporation enjoyed equal status and received an equal share of the profits. Just as in Gejiu, shareholding miners shared a bond of brotherhood in the mining corporation. The headman of a mine was elected in a *kongsi* meeting, which happened when the *kongsi* conducted its final settlement of accounts. The meeting was a boisterous event: each shareholder could shout out his opinion and vote for his preferred headman. Sometimes the meeting lasted for eight days, until the *congsee* or former headman intervened.⁹⁴

As an autonomous social organization and a business corporation, the Chinese *kongsi* had several advantages over Bangkanese or Malay organizations. First, as a social organization, Chinese *kongsi* offered protection to the miners and mining corporations. Like mining bandits in Chaozhou, Chinese miners in Bangka mobilized to build forts and fortresses to protect themselves. When the Rayads—indigenous ethnic groups who engaged in fishing, shipping, smuggling, and petty piracy—ravaged the coastal areas of Bangka, the Orang Gurung (hill people) and Orang Darat (land people) had to abandon their land and villages to move inland. Chinese miners, by contrast, were able to defend themselves against the pirates so that the mining operation could continue.⁹⁵

Furthermore, the mining organization met the needs of a labor- and capital-intensive industry. *Tikos* connected the sultan's court and the miner community, and acted like a bank to finance the mining operation. *Congsees* provided the network of trade, labor, and artisans to facilitate the mining industry. The bookkeeping technology and credit system provided necessary financial tools. With money loaned from *tikos*, labor forces recruited by the *congsees*, and the shareholding system, the Chinese *kongsi* was able to expand the mining industry to a larger scale and to excavate deeper into the earth.

The shareholding system not only encouraged miners to pool their resources; it also created a highly exploitative system that motivated miners to work longer, share risks, and sometimes work for free. Unlike local Bangkanese, who could just leave mining to go back to swidden agriculture, Chinese miners started with debt for emigration, tools, charcoals, and rice. As shareholders, miners were motivated to work longer and harder to pay off their debt and earn greater profits through their own labor.

Bangka's mining organization resembled mining organizations in Guangdong and Yunnan. First, they shared a similar organizational structure. The *tikos* in Bangka were similar to the big brothers in Chaozhou and the pot headmen in Yunnan; they were the authority in mining enterprises and provided the capital. The head of a *kolong* mine in Bangka was like the mine manager in Yunnan; both organized the labor and were responsible for maintaining order.⁹⁶ Second, miners used a similar shareholding system to pool limited resources and distribute risks as well as profits. In both locations, shareholders enjoyed a degree of democracy: in Bangka, the headman was elected by the miners; in Yunnan, mining regulations were decided through collective agreements. Third, the leader of the mining district mediated between the

government and the mining community. The roles of *tikos* and *congsees* in Bangka were similar to that of the guest chiefs in Yunnan. Both maintained a connection with the state, while governing the mining community.

Beyond organizational and financial structures, miners in Bangka and Yunnan shared similar fraternity cultures that appeared egalitarian and democratic. While some scholars have interpreted the brotherhood culture in Chinese *kongsi* as an embryonic form of Chinese democracy, I believe this egalitarian brotherhood culture was more directly related to the shareholding system and the organization of the mining industry, which was shared among miners across Yunnan, Guangdong, and Bangka.⁹⁷

As the mining industry developed, Bangka and Yunnan witnessed similar changes in power dynamics: miners' rights increasingly gave way to investors' interests. In Yunnan, successive revisions of mining regulations increasingly favored regulating mining labor while protecting investors' interests. In Bangka, the *kongsi* gradually transformed into organizations for the *tikos* and their agents to control the miners. *Tikos* profited enormously from high-interest loans to miners, while *congsees* controlled miners through debt. The *congsees* sold necessities like rice and oil to miners at inflated prices and operated gambling and opium houses under the same credit system to further exploit the miners. By the early nineteenth century, a miner could work an entire year and still fail to earn enough to repay his debt to the *congsee*.⁹⁸

The democratic and egalitarian organization in Bangka disappeared by the mid-nineteenth century. As miners required more expensive European machinery to exploit deeper deposits, mining costs soared. Shareholders shifted from miners to merchants with greater capital. By the second half of the nineteenth century, shareholding was concentrated in the hands of a few investors, most of whom were not miners. These bosses preferred hiring cheap laborers called coolies who received monthly wages.⁹⁹ The coolies had no claim to equality in the *kongsi*. The once-egalitarian *kongsi* became blatantly exploitative.

The comparison of mining organizations in Bangka and Yunnan demonstrates that this kind of proto-capitalist, autonomous social organization was not specific either to Yunnan or to Chinese immigrants in Southeast Asia. Similar mining organizations and partnerships were found in Guangdong, Hunan, north Vietnam, Myanmar, and Malaysia. Miners on the frontiers of the Qing empire were not much different from the miners who emigrated to Southeast Asia: both groups were nomads who followed the resources,

and both were isolated from the local society. On these mining frontiers, an autonomous social organization, a shareholding system, and a fraternity culture made possible the mobility of Chinese miners and helped them form a capital- and labor- intensive industry.

Prioritizing Social Technology: Sino-European Parallels

The central role of social technology led to remarkable similarities in how Chinese and European administrators understood mining technology and approached policy reforms. Unlike modern approaches, which emphasize the use of labor-saving machinery, both Chinese and European administrators before the mid-nineteenth century prioritized social technology. When they tried to boost mining productivity, their first choice was to reform the financial and organizational structure of the mining enterprises. The emphasis on improving machinery only emerged as a consensus after the mid-nineteenth century.

Social technology occupied a central position in the knowledge system of Qing bureaucrats. In their administrative practice, they regarded fund-raising methods, supply of necessities, and logistics as the keys to increasing productivity. For example, in a routine memorial in 1772, the minister of revenue reported that after several rounds of communication with local officials, he had concluded that the decline of tin productivity in Yunnan was due to a lack of capital. He explained that due to the Qing-Burmese War (1765–69), which had exhausted the transportation capacity to ship tin out of Yunnan, the number of merchants coming to purchase tin decreased. This led to a shortage of investment, which caused many mining sites to close. At the end of the memorial, the minister proposed a solution: “Strictly instruct the mining administrators to find ways to adjust and attract merchants to come to Gejiu for mining, aiming for a prosperous mining site and abundant mining taxes.”¹⁰⁰

In this memorial, the key to boosting mining output was not equipment, but rather finance and logistics. This approach reflected a broader pattern that characterized Qing mining policy. When mining output declined, Qing officials consistently sought solutions through social technology: finding additional investment, providing state loans, improving shipping routes, reducing administrative costs, or removing corrupt tax collectors. The systematic turn to social technology gradually produced technocrats who pos-

sessed not only practical knowledge of material production but also expertise in management. In the nineteenth century, codified knowledge became the foundation in the political and intellectual movement known as “ordering the world with practical learning” (*jingshi zhiyong*), well before China’s modernization and industrialization projects.

The emphasis on social technology over tools and machinery was not unique to the Chinese. British and Dutch colonizers before 1850 could not have agreed more with their Chinese counterparts. Before the mid-nineteenth century, they never thought to replace Chinese technology with what we now consider more advanced European machinery. Even though the English had adopted steam pumps in tin mines in Cornwall in the early eighteenth century, they were not introduced in Bangka until the end of the nineteenth century.¹⁰¹ When the Dutch engineer Dr. Crookewit visited the tin mines in Bangka and Belitung, he concluded that the Chinese had managed to get the most and purest ore for the least cost and that their means of working and smelting ore could hardly be improved upon, given the conditions in Bangka, even by the introduction of machines.¹⁰²

Both the Dutch and the British sought to increase mining productivity using two primary approaches: importing more Chinese labor and reforming financial and organizational structures to increase investment in Chinese mining enterprises. When the British took over Bangka in 1812, their first priority in reviving the mining industry—which had declined due to smallpox epidemics and piracy—was to import more Chinese from Canton. In 1814, nearly 1,600 men arrived in Bangka.¹⁰³ Following the British approach, the Dutch continued recruiting Chinese laborers from Canton after they regained control of Bangka.

To increase productivity, the British and Dutch reformed the organizational and financial structures surrounding the Chinese *kongsi*. As early as 1803, the Dutch representative in Bangka, van den Bogaart, had suggested the VOC provide advances to the miners to develop more new mines.¹⁰⁴ When the British took over Bangka, they eliminated the sultan, *tikos*, and *congsees*. Instead, the British provided capital directly to miners, while the British resident and his officers assumed the former *congsee* responsibility of supplying food to miners. The government also took over unliquidated debts from the *congsees* and allowed miners to repay advances with profits from metal sales.¹⁰⁵ When the Dutch assumed control of Bangka, they followed the British model. By providing greater capital and improving both the financial

system and the supply chain, the Dutch and British increased mining output from 1800 to 1850.

The Europeanization of machinery only happened after 1858, when the ore in superficial strata had been depleted. In 1858, the mining engineer Akkeringa invented the Bangka drill, which could take larger and deeper samples. The improvement of prospecting technology led to excavation of deeper deposits, which consequently increased the difficulty of drainage. In 1891, steam pumps were introduced in large mines so that the excavation could be conducted longer. The Dutch also introduced the Vlaanderen oven, which used less charcoal and produced more metal from the same amount of ore.¹⁰⁶ The Europeanization of machinery greatly increased the demand for investment. As a consequence, miners could no longer afford to be shareholders, and the egalitarian relationship between shareholders was replaced by brutal exploitation of coolies.

* * *

This chapter has examined Chinese mining in Bangka as a manifestation of Chinese participation in the maritime trade and the global expansion of capitalism. The broader context reveals how global trade dynamics created the demand that drove Chinese migration to Bangka. The Qing state's monetary demand and the growing need for pewter manufacturing generated significant demand for tin, while the flourishing maritime tea trade with Europe further intensified Chinese tin consumption due to its packaging requirements. Against this global backdrop, the Qing government's mining restrictions served as the immediate catalyst that prompted miners from Guangdong to emigrate to Bangka for their livelihoods.

The analysis of Chinese mining enterprises in Bangka demonstrates how social technology made possible the mobility of Chinese mining organizations and facilitated the establishment of autonomous, capital- and labor-intensive mining operations. This social technology laid the foundation for what appeared to be more advanced Chinese equipment and methods, as well as more capable Chinese workers. Collaboration between Chinese leaders and local authorities secured mining rights for Chinese miners. The *tikos* and their agents supplied capital, enabling miners to afford expensive equipment for intensive excavation. Self-governance in mining communities provided the organizational means to manage a large labor force. The shareholding

system simultaneously created relatively egalitarian relationships among miners while fostering a highly exploitative working culture that Europeans found favorable.

Comparing the Chinese *kongsi* in Bangka with the Seven Chiefs system in Gejiu reveals surprising similarities between these organizations. Both depended on connections and collaboration with local authorities, both employed shareholding systems, and both enjoyed similar egalitarian brotherhood cultures. These social technologies of mining, due to their proto-capitalist nature, facilitated Chinese miners' expansion to mining frontiers in the eighteenth and nineteenth centuries.

The centrality of social technology also produced a remarkable convergence in administrative approaches between Chinese and European administrators. Before the mid-nineteenth century, both Chinese and European officials viewed reforming financial and organizational structures, securing investment, and attracting labor as keys to increasing mining productivity. This perspective persisted until the second half of the nineteenth century, when attention shifted toward European mechanical technology.

The experience of Chinese miners should be understood as part of the global expansion of capitalism. The dominance of Chinese mining enterprises in Bangka was an inevitable step in this process. As European colonizers incorporated the tin island into the world system, they found proto-capitalist Chinese mining organizations to be ideal partners. Chinese miners provided an exceptionally self-disciplined labor force for natural resource extraction.

This history also speaks to a broader scholarly debate on the "great divergence" between Europe and China. Kenneth Pomeranz argues that England's access to what he calls "ghost acreage"—namely, land and resources in the overseas colonies—was a decisive factor in Europe's economic takeoff. Melissa Macauley complicates this thesis by demonstrating that the Chaozhouese similarly expanded their enterprises beyond China, exploiting various natural resources, including minerals, across Southeast Asia and channeling wealth back to China.¹⁰⁷ However, the story of Chinese miners in Bangka reveals that the majority of Chinese emigrant workers did not benefit from this wealth transfer. Instead, they provided extremely cheap labor, extracting natural resources for European colonial powers. In other words, their condition was akin to that of slaves toiling on North American plantations. They were the "ghost laborers" working on ghost acreage in the Dutch East Indies. Miners and merchants in Bangka served as intermediaries for the Dutch and

British in extracting mineral resources from Southeast Asia. Their blood and sweat contributed to the formation of the capitalist world system and European hegemony.

In different ways, these ongoing changes affected not only Chinese migrants and maritime merchants but also the Chinese state and its bureaucrats. As China became increasingly integrated into global trade networks, the Qing empire grew more dependent on global markets to source its metal supplies, including tin, lead, copper, and silver. As a monetary metal, tin began to receive particular attention in the eighteenth century. To understand and manage tin supply, officials had to accumulate and develop knowledge about the metal's material properties and trade dynamics, as well as practical knowledge of accounting, alloy composition, and related technical matters.

CHAPTER FOUR

Thinking Like Artisans, Seeing Like Merchants

On the sixth day of the seventh lunar month of the third year of the Qianlong reign (1738), Nasutu (?–1749), the governor-general of Jiangsu, Jiangxi, and Anhui, wrote to the Qianlong emperor, proposing he change the alloy content of copper coinage by adding tin.¹ In this palace memorial, Nasutu wrote:

I observed that the coins used in the Jiangnan area are mostly green money [*qingqian*] issued in the Kangxi period [1661–1722]; sometimes there was even green money minted in the Shunzhi period [1644–61]. The yellow money cast in recent years is rarely seen. I investigated carefully to find that the physical property of the green copper [*qingtong*] is brittle. It cannot be used to produce other vessels except for mirrors. As a consequence, no one melts down green money, so it keeps circulating. Yellow copper [*huangtong*] is easy to melt down, so there is a huge demand on the market. . . . Those people don't buy the copper metal; they all melt down copper coins to make [copper objects]. I heard that money exchange shops in Jiangsu and Zhejiang only exchange silver with green money. If they encounter yellow money, they take the coins out and sell them to copper shops. . . . I secretly ordered Zhang Qu, the provincial administration commissioner of Jiangsu, to consult smelters and coppersmiths. [From them] I learned that green copper is also made from red copper [pure copper] and zinc. Once tin from Guangdong is added, the alloy becomes green copper. . . . I humbly think the circulation of copper coins is meant to be convenient for everyday use, and [the

state] expects the coins to last for a long time. If yellow money disappears as soon as [we] issue it, then it is not as long-lasting and durable for circulation as green money.²

In this palace memorial, Nasutu suggests changing the alloy content of copper coinage from yellow to green copper to prevent the recycling of copper from copper coins. This proposal aimed to solve the monetary crisis from which the Qing empire had suffered since the beginning of the eighteenth century. Due to an influx of American silver and a restriction on copper exports imposed by the Japanese government, the Qing empire experienced a shortage of copper coins. Nasutu therefore proposed to change the alloy content of the copper coins to ensure that enough copper coins remained in circulation. The yellow copper Nasutu mentioned was a copper-zinc alloy, similar to modern brass—a malleable, golden, shiny alloy widely used for musical instruments, jewelry, and utensils. Green copper was a copper-zinc-tin alloy, now known as naval brass. It was more resistant to corrosion than ordinary brass.³ Nasutu explained to the emperor that based on his observations of the circulation in the market, and according to money changers and smelters, green money was more difficult to illegally melt down to produce bronze or brass vessels. Therefore, by changing the alloy content to green copper, the Qing state could solve its monetary crisis.

This proposal was eventually accepted by the emperor after a series of lab tests and information exchanges between provincial-level mints and capital mints in Beijing. Consequently, in 1740, the Qing empire changed the alloy content of its copper coins. Nasutu's memorial presents an interesting parallel to those officials mentioned earlier in this book: both based their arguments on technical knowledge. While county magistrates used their technical and managerial knowledge to facilitate routinized administrative work, provincial officials like Nasutu used artisanal knowledge about the physical qualities of the alloy to influence the emperor's policy-making.

This chapter centers around the copper coin crisis and the subsequent monetary reform in 1740. To a modern reader with basic knowledge of modern economies, Nasutu's solution is unusual—instead of increasing the money supply, he tried to solve the problem by using what we today refer to as materials science or alloy technology. Many economic historians have studied the Chinese monetary crisis to demonstrate the limits of the premodern Chinese state.⁴ In this chapter, I do not analyze the monetary crisis and the

reaction of the Qing state using economic theories. Instead, I follow the flow of court memorials to investigate Qing bureaucrats' problem-solving style. I approach copper coinage not just as a fiscal policy, but as a manufacturing process in which the state produced copper coins to meet a particular quality standard at a notable cost. Mintage formed a network that connected mints across the empire, artisans, metal markets, merchants, and state officials. The flow of metals, information, personnel, and money produced not only copper coins but knowledge. In this way, coinage, especially the mints, became a contact zone between technology and statecraft, and between the market and the state.

The integration of technical knowledge into policy-making and routinized administration reflects the broader technocratic turn in Qing governance. Historians Dorothy Ko and Kai Jun Chen show how the Manchu court developed a technocratic culture in the early Qing. Manchu elites had a particular interest in craft technologies and exercised control over craft skills such as porcelain, inkstone, and silk manufacturing through the Imperial Household Department. Bondservants who rose within the Imperial Household system as managers of artisans developed a culture distinct from that of traditional Chinese scholar-officials. Their power derived from their mastery of technical knowledge and management expertise rather than solely from a command of Confucian classics. This unique relationship between craft knowledge and power produced a series of bannermen elites, including figures like Tang Ying and the Cao Yin family.⁵

Technocratic culture was not limited to the bannermen. As subordinates and colleagues of Manchu officials, Han bureaucrats—from high-ranking provincial governors to lower-level prefectural and county officials—also cultivated this technocratic culture. To finalize the alloy content of the copper coin, the Qing state replicated the technology networks of the Imperial Household Department, employing models, artifacts, or even personnel to transmit craft knowledge across administrative units. Similarly, the state's mineral procurement and reimbursement system necessitated development of advanced accounting and auditing procedures, compelling officials to develop expertise in cost estimation, accounting practices, and metal trade operations.

These practices fundamentally shaped Qing administrative culture, leading bureaucrats to develop a distinctive approach to statecraft that incorporated artisanal and commercial knowledge. While these officials could have

delegated such technical matters to professional assistants, they displayed in their memorials a personal mastery of commercial and accounting expertise—regardless of whether this reflected genuine competence or strategic self-presentation. This transformation reflected a broader shift in statecraft culture, where artisanal and commercial knowledge became a source of enhanced credibility, argumentative authority, and competence.

The Qing Monetary System and the Copper Coin Crisis

To understand Nasutu's proposal, we must start with some basic financial principles of Qing monetary policy. A modern person would be bewildered by the currency system in eighteenth-century China. The market was filled with copper coins of various qualities issued in different periods, silver ingots of varying weights and purity, Spanish silver coins, notes from various financial institutions, and even privately minted small coins to supplement exchanges.⁶ The key was the bimetallic system of copper coins and silver. From the end of the sixteenth century, with the introduction of American silver, China began to use a bimetallic system: silver for wholesale transactions and tax payments, and copper coins in the retail market and for wage payment.⁷ The government issued round copper coins with a square hole in the middle so they could be strung together, while the global market supplied the silver.⁸ People exchanged copper coins for silver in private money exchanges operated by merchants. To maintain a healthy economy, the Qing government had to keep a relatively stable exchange rate between silver and copper coins.

The official exchange rate was fixed at one treasury tael of silver to one thousand coins of legally cast standard money.⁹ However, in reality, the market exchange rate changed daily in response to monetary conditions. From the beginning of the eighteenth century, the Qing empire suffered from a shortage of copper coins, which drove up their value. From 1705 to 1722, the exchange rate dropped from 1,400–1,500:1 to 780:1.¹⁰ The Qing officials called this problem “high cash value” (*qiangui*) or “cash dearth” (*qianhuang*). High cash value caused a lot of problems. For example, it increased the peasants' tax burden. Grain was sold in copper coins while the tax was measured and paid in silver. To pay their taxes, peasants had to exchange copper coins according to the fixed official rate (1,000 copper coins to 1 tael of silver). Since the market value of copper coins was higher than the official ratio, peasants ended up paying more in taxes. The tight money supply also created liquidity prob-

lems, which hindered intraprovincial trade and led to rampant proliferation of illegally minted coins. Private mints illegally melted down copper coins to cast “small money” (*xiaoqian*)—coins with less copper content.

In classical Confucian monetary theory, a capable ruler should be able to regulate the monetary supply and control the amount of money in circulation.¹¹ Following the same thread of thought, rulers of the Qing empire considered maintenance of the official exchange rate and monopoly of coinage to be central to financial administration. Therefore, Qing emperors and bureaucrats struggled to solve the problem caused by the shortage of coinage. They identified the root of this problem as “copper dearth” (*tonghuang*).¹²

Copper Dearth

There were three reasons for the shortage of copper coins, and not all of them were identified by Qing officials. The first was increased demand for cash in the wake of economic and population growth since the late seventeenth century.¹³ The influx of American silver further exacerbated this problem. As China became integrated into the global economy, more silver from Latin America entered the Chinese market, accelerating monetary circulation. The supply of official copper coins could not keep pace.

A Japanese restriction on copper exports made the situation even worse. The Qing empire had previously relied on Chinese merchants and Dutch traders to supply Chinese mints with Japanese copper.¹⁴ In 1715, the Japanese government restricted copper exports to China as its copper mines became depleted. Even after the copper restriction, Japanese copper, which arrived in China through both legal and illegal means, still accounted for more than 60 percent of the copper for coinage in China during the Yongzheng period (1723–36).¹⁵ To reduce reliance on Japanese copper, the Qing court encouraged copper mining in Yunnan. Copper from Yunnan gradually replaced Japanese copper over the course of the eighteenth century. However, a distant remedy cannot address an immediate crisis, and the increased copper output fell significantly short of meeting the demands of mintage in the early eighteenth century.

Finally, the limited capacity of the Qing fiscal system also contributed to the monetary crisis. In the eighteenth century, the Qing empire had not yet developed the concept of monetary sovereignty.¹⁶ The Qing court was not interested in controlling the circulation of silver and had no efficient means

of preventing copper coins from traveling out of China through maritime trade. Despite the decline of Japanese copper imports, the amount of coinage, according to economic historians, was not necessarily low.¹⁷ Therefore, the monetary crisis was more likely rooted in the Qing state's failure to control the flow of silver. In the nineteenth century, this lack of control over silver led to other problems. As silver flew out of China due to the opium trade, the Qing empire began to experience a shortage. The rapid change in global trade thus decreased the value of copper coins, causing further social and economic problems. Qing soldiers suddenly found the purchasing power of their wages decreasing, and the country suffered an economic depression. In sum, the monetary crisis was a combination of a high inflow of silver, a shortage of copper, and the vulnerability of a premodern state.

Further complicating the crisis was the Qing empire's heavy reliance on trade networks to source raw materials for minting currency. Before the mid-eighteenth century, copper for mintage mainly came from Japan through the global trade network. After Japanese imports became untenable, the Qing court, despite its nominal monopoly on copper mining, still relied heavily on merchant networks to procure and transport monetary metals such as copper, zinc, lead, and tin to Beijing.¹⁸ As the Qing government was neither interested in nor capable of fully controlling the circulation of raw materials, it had to look for ways to prevent the already minted and circulating coins from disappearing from the market. Before the 1740 monetary reform, the Qing court tried to tackle this problem through an administrative approach: they banned the production and consumption of brass objects and tried to recycle copper from the market. This administrative approach, which followed the traditional approach of Ming bureaucrats, sharply contrasted with the technical character of the 1740 reform.

The Brass Ban: A Traditional Administrative Approach

China experienced a shortage of copper coins as early as the Ming dynasty (1368–1644). Ming bureaucrats used three strategies to resolve the crisis. The first was to ban the use of brass vessels and private coinage so that the government could recycle copper from the market to produce more copper coins.¹⁹ The second was to change the weight of coins to increase the copper content, hoping that the high material value of the coins issued by the government would drive out less valuable coins issued by private mints.²⁰ The

third was to open more official mints.²¹ The weak administrative capacity of the Ming state doomed the first method. The second method only worsened the situation: according to Gresham's law, if two forms of commodity money are in circulation, and those two forms of money have the same nominal value, the more valuable commodity will gradually disappear from circulation.²² Therefore, the money issued by private mints, which contained less copper, ended up driving out the coins issued by the Ming state. The third method seemed effective but had to be suspended due to a shortage of copper.²³ By the end of the Ming dynasty, all solutions proved futile. People lost trust in official copper coins and turned to silver and private money instead. The chaotic monetary system caused further economic problems, ultimately contributing to the fall of the Ming dynasty.²⁴

Early Qing rulers adopted similar solutions. As early as 1679, the Kangxi court noticed the shortage of copper and banned production of brass vessels and illegal melting of copper coins.²⁵ In the eyes of the Qing court, copper coins were disappearing from the market because people melted down the money to produce brass vessels. The Yongzheng emperor continued his father's policy and intensified the ban on brass as his empire felt the effects of the decreasing supply of Japanese copper. Blaming the copper dearth on "wicked profit-searching bastards [who] illegally melted down copper coins" to produce brass, in 1726 the Yongzheng emperor prohibited both the production of brass vessels and the use of brass in households and shops.²⁶

In the first lunar month of 1727, the Yongzheng emperor issued an imperial edict to Manchu soldiers, ordering them to hand over brass vessels in their households to the government.²⁷ Eight months later, when he discovered there was still a shortage of money and brass vessels were still sold in local shops, the furious emperor blamed the incompetence of his bureaucrats and threatened retaliation. He also added new restrictions on the use of brass: "To ban the usage of brass is a fundamental solution to prevent illegal melting down of copper coins. . . . In the past, I considered allowing bureaucrats above the third rank to use brass vessels. Now I find there are too many people abusing this regulation. From now on, only bureaucrats of the first rank are allowed to use brass."²⁸ Unfortunately, regardless of the Yongzheng emperor's intense anger and his officials' diligent work, the brass ban was minimally effective.

Previous attempts to prevent counterfeiting had relied on administrative decrees to end the monetary crisis. The rationale was that the high value of

copper coins was caused by a shortage of cash, which was due to the shortage of copper. Once people stopped using brass, the government could recycle copper from the market to issue more copper coins. In other words, however ridiculous the brass ban appears to modern economists, it was an administrative attempt to solve the monetary crisis on the supply side. However, because of the inefficiency of the Qing government, administrative orders failed to curtail the use of brass, not to mention the fact that copper output in the Qing empire never caught up with the increasing demand for copper coins. When the Qianlong emperor ascended the throne, he and his bureaucrats took a technological approach: in addition to controlling the use of brass, they changed the alloy content of coinage to make copper coins harder to recycle.

Coinage as a Manufacturing Process and the Mints as Contact Zones

To understand the material turn in Qing monetary policy, we need to view coinage as a production process. Economic historians tend to treat the coinage of money as part of the state's fiscal system, so they view the monetary system through the lens of institutional history and economic policy. But minting coins entailed an extensive exchange of materials, information, and knowledge. To cast copper coins, the Qing government had to source, prepare, and ship monetary metals to mints. Merchants, smelters, and bureaucrats had to work together to ensure the proper casting process. Therefore, coinage involved not only policy changes on paper but also a manufacturing process in which the state mobilized its various departments to extract resources and produce physical currency. Because this manufacturing process required a network that connected the mines, the market, and the logistical management of monetary metals, mints created a space for bureaucrats, artisans, and merchants to exchange information and knowledge. In this sense, mintage—which lies at the heart of statecraft—is a craft, and a highly sophisticated one.

Mintage was a contact zone where knowledge and cultural exchanges happened. Mary Louise Pratt defines contact zones as spaces “in which peoples geographically and historically separated come into contact with each other and establish ongoing relations,” often “within radically asymmetrical relations of power.”²⁹ Although Pratt developed this concept to analyze colonial encounters, it proves equally useful for understanding how groups separated

not by geography but by social hierarchy and epistemic tradition came to interact. Scholar-officials and artisans lived in the same time and space, but their knowledge systems and mentalities rarely intersected before the Qing dynasty. Ming bureaucrats, when discussing fiscal and monetary policy in their memorials, never mentioned the actual craft process involved in coinage. However, in the eighteenth century, although still very confused about the technical details, Qing officials felt the urge to bring artisanal knowledge into their policy-making process. In other words, the coinage system and mints created a contact zone where technology met statecraft.

The Qing empire cast its copper coins in some thirty mints dispersed around the empire. The central court had two mints in Beijing: Baoquan Ju, administered by the Ministry of Revenue, and Baoyuan Ju, administered by the Ministry of Works.³⁰ From 1726, the minting operations of these two bureaus were dispersed across seven separate foundries in the eastern inner city of Beijing.³¹ In addition to the two capital mints, the Qing empire had several provincial mints across the empire. These provincial mints were supervised by the administration commissioner of the province to which they belonged. During the Qianlong reign (1736–95), the two capital mints cast 48 percent of all copper coins in the Qing empire; provincial mints cast the remaining 52 percent. Copper coins issued by the capital mints were used to pay soldiers and finance public works around Beijing. The copper coins issued by the provincial mints funded the soldiers' and subordinate officials' salaries, public works, and other provincial expenses.³²

The two capital mints sourced monetary metals through three major channels: taxation, internal tribute, and procurement. Each year, tin, copper, zinc, and lead arrived in Beijing from all corners of the empire, and numerous memorials were sent to the court describing the productivity of mines, the quality of the metal, the cost of shipping, and the market price of the metal. The provincial mints were supplied through taxation and procurement from the market; the origin of metals varied in different provinces.³³ The circulation of information as well as the metal itself indicates the exchange of information among the central court, provincial governors, and the local metal market. The sourcing, preparation, and shipping of metals created a network that connected the center and the local, bureaucrats and merchants, the state and the market.

Manufacturing copper coins required technical knowledge and skilled craftsmanship. The Chinese had used sand casting to mass-produce coins

since the Qin dynasty (221–206 BCE), and the basic idea remain unchanged until the twentieth century.³⁴ According to Song Yingxing's *Tian gong kai wu* (1637), artisans used mother coins (*muqian*) and a sand mold to cast copper coins. The mother coin was made of pewter on which artisans had carved patterns. The sand, a mixture of extremely fine earth and charcoal powder, was packed into a wooden frame. The artisan spread cedar or charcoal ash over the sand mold or smoked the wood using resin or clear oil so that the mother coins could be detached easily from the sand. The artisans then pressed one hundred mother coins into the sand to make impressions for the obverse side. Channels were created to let the molten metal flow into the impressions. The artisan then quickly turned the frame over so the mother coins fell onto the second frame to create the reverse impression. The two frames were tied together tightly with a string. After creating ten pairs of frames, the artisans poured molten copper alloy into the frames. When cool, the copper formed a sort of coin tree. The artisans broke the coins off the tree and filed the edges. The alloy content determined the quality of the coins.³⁵

Mintage in the Qing dynasty required a complex division of labor. The government recruited artisans from local markets to work in the mints and registered their household information for supervision.³⁶ Each furnace had one smelter headman (*lutou*) who oversaw eight types of artisans: the fire watcher (*kanhuo jiang*), the sand mold maker (*fanshajian*), the ash spreader (*shuahuijiang*) who applied the ash to the sand mold, a miscellaneous assistant (*zazuo*), the edge filer (*cuobianjiang*), the edge polisher (*gunbianjiang*), the coin polisher (*moqianjiang*), and the polisher of the central hole in the copper coins (*xiyanjiang*).³⁷ In this way, a mint incorporated several branches of craft knowledge, including smelting, alloying, sand mold casting, and filing. The Ministry of Revenue, the Ministry of Works, and provincial governors took responsibility for the coinage process and financed the cost of the coinage in each mint, making the mint a contact zone where bureaucrats acquired knowledge about casting techniques, alloying, metallurgy, and cost control. What happened in the mints was very similar to the knowledge exchange that happened in state-owned workshops across the empire during the Ming and the Qing dynasties.³⁸

During the Qing dynasty, the coinage system formed a network of information and material exchanges between capital mints and provincial mints. The Qing court reformed the casting technique in 1728 and invented the system of master coins (*zuqian*) to standardize the forms of coins.³⁹ The master

coin, carved in pure copper, was used to cast the mother coin. The mother coin was then used to cast sample coins, which used the standardized formula for the copper alloy.⁴⁰ The capital mints produced master coins, mother coins, and sample coins, and sent a copy of each to every provincial mint as the standard of production. The mother coin, made from a more durable alloy, was used as the model for casting, while the sample coin served as a reference for the alloy content.

The circulation of master coins, mother coins, and sample coins facilitated information exchanges between Beijing and the provincial mints. This system of quality control and standardization resembled the *yang* system widely used in the Imperial Workshops and other state-owned industries. A *yang* is a prototype for objects to be produced. It could be a painted blueprint, a wooden model, a bundle of cardboard, or even an antique from a previous dynasty. In the imperial porcelain industry, for instance, technocratic supervisors used *yang* to communicate with emperors about budget, measurements, shapes, and decorative patterns, and then employed them as templates to transmit designs across media and regions.⁴¹ The mother coins and sample coins that traveled between Beijing and the provincial mints served a similar function.

The mints, then, were more than administrative units. They were contact zones where bureaucrats encountered artisanal knowledge. Through the daily operations of coinage, Qing officials absorbed practical information about metalworking, alloying, and cost calculation. Over time, this exposure transformed how they approached monetary policy. The monetary reform of 1740 shows this transformation in action: Qing bureaucrats identified and solved the monetary crisis through empirical observation and experiment, utilizing artisanal knowledge in their decision-making process. Their claims about empirical observation and hands-on experience became the most persuasive arguments in their palace memorials to the emperor. Here, power and technological knowledge began to intertwine.

Nasutu: A Manchu General's Technical Approach to the Monetary Crisis

In the Qianlong court, various solutions were proposed to stop the illegal melting down of copper coins. Some officials suggested lifting the ban on the copper trade to encourage merchants to import more Japanese copper. At the

same time, the Qing court started to use special commissioners (*weiyuan*) to oversee the purchase of Japanese copper.⁴² Other officials suggested lifting the mining ban in China proper and opening more mints to issue more copper coins.⁴³ One proposal stood out: a group of bureaucrats proposed changing the alloy content of the copper coins. This proposal, which won the approval of the Qianlong emperor, hinged on the physical properties of the metal. With this reform, the Qing court changed the alloy content of copper coins from a copper-zinc alloy to a copper-zinc-tin alloy, thus making it both more expensive and harder to melt down. What distinguished this reform from earlier ones was the decision-making process, which was based on empirical observation, information exchange between artisans and bureaucrats, and experiments in local mints. This leads us back to Nasutu, the Manchu official we met at the beginning of this chapter.

In Nasutu's memorial, his idea of casting green money had two sources of inspiration. The first was his own empirical observation. Nasutu said he had noticed that green money issued in earlier decades had been more durable than the present yellow money. This observation led to his inquiry regarding the difference in the metal. The second source was the physical nature of the alloy, which merchants and artisans described to him. Nasutu learned from money changers that they sold yellow money to smelters for recycling, while green money remained in circulation. Curious why green money was not recycled, he then turned to the artisans. The smelters explained that green money was made from green copper, an alloy of copper, zinc, and tin, which was harder to recycle.⁴⁴

The terms *green money* and *yellow money* were likely created by smelters who recycled copper coins, naming them based on actual alloy composition rather than visual color differences. In premodern Chinese metallurgical terminology, copper-tin alloys were referred to as bronze (*qingtong*, literally "green copper"). Although green money contained far more zinc than tin, the presence of tin made its composition resemble bronze in the eyes of artisans. Yellow money, by contrast, was made of brass (*huangtong*, literally "yellow copper"), an alloy of copper and zinc without tin. It is likely that money changers learned these technical terms from smelters and subsequently conveyed them to Nasutu.

Nasutu's empirical observations and the expert opinion, however, did not provide a sufficient basis for his proposal. He needed more convincing experimental evidence and more detailed data about the alloy formula, so

he turned himself into the principal investigator of a lab engaged in alloying experiments. He asked experienced coppersmiths with skilled and tacit knowledge (*shu'an tongjiang*) to duplicate the green money issued in the early Qing. According to his memorial, he conducted at least two alloying experiments in the provincial mint in Suzhou. The second test, which used 70 *jin* of copper, 25 *jin* of zinc, and 5 *jin* of tin, was considered a success. When the sample coins arrived in his office in Nanjing, Nasutu examined them and claimed that he had found the coin to be indeed “green and smooth.” But visual appearance was apparently not enough for Nasutu. He then ordered the artisan to hammer the coins. When the coin was struck, the sound was “loud and clear,” just like green money cast in the early Qing.⁴⁵

Yet Nasutu was not entirely confident about this formula and decided to do more experiments to test the resilience of the green money. He ordered a coppersmith in Nanjing to beat the green copper ingots that came with the sample coins. The green copper “broke into pieces when it met the hammer.”⁴⁶ This brittleness meant that coppersmiths could not simply hammer the green copper into copper wares using traditional cold forging techniques. To reuse the metal, they would have to melt it down and separate the copper from the tin. Then he asked the smelters to try to separate the metals. As expected, they were unable to do this without a specialized metal-separating furnace (*fenjin lu*). This furnace was so large that the government could easily discover any illegal recycling workshops. Moreover, the cost of charcoal and labor would exceed any profit from the recovered copper.

Convinced that recycling green money was both technically difficult and unprofitable, Nasutu calculated the cost of minting it. He concluded that although casting green money cost more than yellow money, it benefitted the common people. As the governor-general of Jiangsu, Jiangxi, and Anhui, Nasutu ordered the Jiangxi provincial mint in Nanchang to replicate his experiment. Smelters in Jiangxi found that adding 5 *qian* of tin per *jin* of copper to the existing yellow money formula could produce coins with identical properties: durable and unprofitable to recycle.⁴⁷ Through this series of experiments, Nasutu systematically tested the alloy’s appearance, sound, durability, resistance to recycling, and cost-effectiveness in three places: first at the Suzhou mint, then in his office in Nanjing, and finally at the Nanchang mint. The replication of the results demonstrated that the formula worked beyond its original site. The result, whatever Nasutu’s intentions, resembles what modern scientists would call reproducibility. Finally, Nasutu sent two alloy formulas

with two boxes of sample coins cast by provincial mints in Suzhou and Nan-chang to Beijing for the central court to discuss his proposal.⁴⁸

Nasutu's repeated claims to firsthand observation, however, raised a question. The copper coins held in the China Numismatic Museum show no visible color difference between green and yellow money. Copper coins cast during the Kangxi, Yongzheng, and Qianlong periods all share the same brownish gold color. Nor could he tell the difference between the newly minted green and yellow money, since brass, naval brass, and bronze all appear golden before oxidation. Therefore, Nasutu's newly cast sample coins could not have been green. Why, then, did Nasutu insist on describing what he could not have seen? The answer likely lies in the rhetorical power of empirical claims. In palace memorials, firsthand observation was not merely a sign of diligence but a testament to the official's credibility. By framing his proposal as grounded in personal observation, Nasutu made his argument far more persuasive.

Although the Qianlong emperor did not respond, Nasutu's proposal revealed the technocratic culture of the Qing government: high-profile officials used technological knowledge from artisans and merchants to solve problems in governmental administration. To make their arguments persuasive to the emperor, officials had to emphasize or even fabricate empirical engagement with the material and personal participation in the experiments.

Nasutu's approach marks a sharp departure from earlier modes of policy-making. Ming bureaucrats' discussions of monetary policy typically began with a thorough review of precedents from the legendary Confucian sage kings of the Xia dynasty (before 1600 BCE) to the present. They grounded their arguments in classical texts like *Guanzi*, from 26 BCE, and judged past monetary policies by Confucian moral standards.⁴⁹ For them, authority derived from the Confucian sages and the classics. Nasutu, by contrast, based his argument on purported empirical observation, systematic experiments, and advice from artisans. For him, authority came not from ancient wisdom but from expert knowledge and reproducible results. The validity of his proposal rested on experiments conducted in the present, not theories inherited from the past.

In making his case, Nasutu created an information network that connected the local market, provincial mints, and the court. He gathered knowledge from money changers, merchants, and artisans, then tested that knowledge through experiments in multiple locations. He also sent more

than just textual information to the emperor. The two boxes of sample coins that accompanied his memorial represent a new means of transmitting technical knowledge. This practice was borrowed from the Imperial Household Department, where physical models had long been used to communicate specifications across distances.⁵⁰ Nasutu's use of material models shows that this practice was neither exclusive to the bannermen nor limited to the Imperial Household Department. It had been adopted by provincial bureaucrats in the outer court to serve the interests of the state.

It would be an overstatement to assert that Nasutu possessed the spirit of modern science, but his memorial does reflect a particular statecraft culture. Nasutu's background may have contributed to his particular approach. As a bannerman from an aristocratic military family, he joined the Qing court as an imperial guard and rose to governor-general on merit instead of taking the civil service exam.⁵¹ Unlike most Han Chinese bureaucrats, who trained in the Confucian classics to pass the exam, it is very likely that Confucian learning did not play a crucial role in Nasutu's early promotions. His practical and technical approach to financial problems may be related to his experience as a military commander. As a Manchu aristocrat with marriage connections to the imperial family, Nasutu may also have been very familiar with the operation of the Imperial Household Department, which inspired him to conduct experiments and transmit technical information through material models.⁵²

This new mode of knowledge production and policy-making originated in the early Kangxi reign, emerging in response to imperial preferences and priorities. The Manchu emperors played a pivotal role in cultivating this technocratic culture by establishing institutional structures and physical spaces for producing and transmitting technical knowledge. Yet this phenomenon extended far beyond individual cases like Nasutu or the bannermen. The technocratic approach penetrated everyday administrative practice, becoming a shared methodology among both Manchu and Han officials. When the monetary reform was actually carried out, both Manchu and Han bureaucrats relied on empirical observation and experiments to guide and document their work.

Technocratic Culture Among Civil Officials

Though Nasutu's proposal did not get a positive response from the emperor, it set the direction for monetary reform. One year after Nasutu submitted his

memorial, the provincial administration commissioner of Zhejiang, Zhang Ruozhen (?–1755), sent another memorial proposing to change the alloy content. This report finally caught the emperor's attention. In this memorial, Zhang wrote,

I investigated the issue with intense personal attention. I interviewed old smelters; they all said that “for every picul of copper and zinc, if [one] adds three *jin* of tin [*diantong*, high-quality tin], it will become green money. If one does not add tin, then it will be yellow money. *Diantong* is the mother of copper and zinc; once added, even though one puts the alloy into the smelter, copper and zinc cannot be separated. . . . That is why no one melts down green money. Yellow money, which does not contain tin, can be melted down to cast other objects.” I did not wholly believe in [this claim], so I secretly commissioned a smelter to come to our office to cast several coins as an experiment. Once tin was added, the coins became green in appearance, and their quality was similar to those issued in the Shunzhi and Kangxi periods, which could last longer. I calculated the cost, and it was almost equal to the cost [of casting yellow money] in capital mints. If the capital mints cast green money, then the long-lasting problem of illegal melting down can be solved. The value of copper coins will thus stop increasing day by day.⁵³

Historians tend to credit Zhang Ruozhen with the monetary reform because the Qianlong emperor responded to his proposal.⁵⁴ However, Zhang copied Nasutu's proposal almost verbatim. Like Nasutu, Zhang first blamed illegal smelters for the scarcity of copper coins and proposed issuing green money, which was harder to recycle into vessels. Zhang repeated the smelters' claim that “tin is the mother of copper and zinc,” so when tin was added to brass, copper and zinc could not be easily separated.⁵⁵ Like Nasutu, Zhang ordered experiments in provincial mints and confirmed the physical quality of sample coins through empirical examination of color and sound. In this memorial, Zhang proposed adding 3 percent tin to the brass formula, which would not tremendously increase the cost of mintage. To confirm whether this formula was effective in preventing recycling, Zhang ordered experiments in the provincial mint, just as Nasutu did. The experiment showed that melting down four strings of green money (equivalent to four taels of silver at the official exchange rate) yielded only five *jin* and eight taels of pure

copper, worth one tael six mace of silver at market price. Moreover, the labor and charcoal cost more than one tael of silver, making the attempt to recover copper from green money completely unprofitable. Finally, Zhang sent sample coins with older coins to the Qianlong emperor so that he could compare them.⁵⁶

Zhang's memorial shows that he acquired knowledge about the physical properties of the alloy and smelting techniques from artisans. His careful calculation of the cost of smelting demonstrates that he had profound knowledge about the market price of the metals, the cost of labor, and the cost of smelting. It is hard to identify the origin of Zhang's obsession with technical details and his technocratic mentality. As a Han scholar trained in Confucian classics, Zhang's interest in observation and materiality may be related to a trend toward evidential scholarship. This intellectual movement, which dominated Qing scholarship, emphasized rigorous textual analysis and the "investigation of things" (*gewu*) as the path to true knowledge. Although evidential scholars primarily applied these methods to philological studies, the Confucian ideal of investigation of things could extend beyond texts to encompass natural phenomena. Zhang's meticulous attention to technical details and empirical data may reflect this broader intellectual climate.

More likely, Zhang was shaped by his working environment. In the eighteenth-century Qing bureaucracy, bannermen and Han officials were colleagues, and Han officials often reported to bannerman superiors. Zhang may have absorbed a technocratic approach from figures like Nasutu, or he may have learned that such an approach was necessary to earn the favor of the Manchu monarch. Regardless of the origins of Zhang's technocratic mindset, the responses to Zhang's proposal in the imperial court and among other provincial officials show that the bureaucracy in the Qianlong court had adopted this technocratic culture of governance.

After receiving Zhang's memorial, the Qianlong emperor forwarded it to his ministers for discussion.⁵⁷ The ministers approved Zhang's proposal. Numismatic historian Wang Xianguo points out that the most important reason for its acceptance was its low cost.⁵⁸ When Zhang's proposal was forwarded to the ministers, their conclusion was that "the cost of casting green money was similar to the cost [of casting yellow money] in the capital mints." By contrast, Nasutu's formula, 70 percent copper, 25 percent zinc, and 5 percent tin, used far more copper than the contemporary yellow money formula, which only had 50 percent copper. Copper and tin were much more

expensive than zinc, so Nasutu's formula cost more than the previous yellow money formula.⁵⁹ Zhang's formula, based on the original yellow money formula, used the same amount of copper and therefore controlled the cost of mintage.

The Qing court ordered the capital mints to start a series of experiments to finalize the alloy formula based on the information in Zhang's memorial. However, smelters in the capital mints failed to produce green money comparable to the samples Zhang had sent to Beijing. Casting entailed a complicated collaboration among smelters, mold makers, and polishers. The embodied knowledge of smelters was necessary for the formula to work. Fully aware of the importance of artisans and their embodied skills, the Ministry of Revenue ordered Zhang Ruozhen to send two or three smelters who had participated in the production of the sample coins to Beijing, where they would teach the smelters in the capital mints how to cast the green money.

Four days after receiving the request from Beijing, Zhang Ruozhen sent three smelters, four skilled assistants, and their tools to Beijing at his own expense.⁶⁰ Thanks to his prompt action, the capital mint quickly worked out a new alloy formula: 50 percent copper, 41.5 percent zinc, 6.5 percent lead, and 2 percent tin. The alloy formula of green copper in historical texts matches the chemical composition of surviving copper coins issued during Qianlong's reign. Based on the chemical analysis of copper coins kept in the China Numismatic Museum, on average, coins issued during the Qianlong period contain 1.81 percent tin, 54.76 percent copper, 35.67 percent zinc, 0.59 percent iron, and 4.87 percent lead.⁶¹ The average metal content totals approximately 97.7 percent. The remainder consists of trace elements (cadmium, silver, nickel, and cobalt) and oxygen bonded to metals through centuries of oxidation.

The new alloy formula was effective even by today's standards. Based on lab experiments conducted by Zhou Weirong, tin forms a compact layer of tin oxide (SnO_2) on the surface of the copper alloy. This layer provides an anticorrosive seal on the copper coins. Therefore, adding tin to a copper alloy decreases the corrosion rate of the green money. The 2 percent tin content in the green copper alloy worked out by artisans in the capital mints was also highly effective in preventing recycling. When the tin content is around or over 2 percent, it forms a brittle chemical compound with copper, making the copper alloy less forgeable. During the Qing dynasty, artisans used hammering and forging to produce brass vessels. If they wanted to produce brass

vessels using green money, they had to use casting, which was more expensive than forging, so adding over 2 percent tin to copper efficiently increased the cost of recycling copper coins. Moreover, tin was more expensive than zinc and lead, so the final formula, which reduced tin content from 3 percent to 2 percent, reduced the cost of mintage without altering the physical properties of the green copper.

The addition of tin also makes recovery of pure copper from the alloy more difficult.⁶² Zinc can be easily removed from most copper-zinc brass at a relatively low temperature because zinc evaporates at 907°C, leaving behind pure molten copper. Tin, however, has a much higher boiling point at 2,602°C, even higher than the boiling point of copper, at 2,562°C.⁶³ Copper thus evaporates before tin does. Therefore, retrieving copper from an alloy required more sophisticated metallurgic technology, better equipment, and more fuel. Just as Zhang Ruozhen suggested, the cost of separating copper from the alloy far exceeded the value of the pure copper that would be recovered.

In 1740, the Qing court officially changed the alloy formula for its copper coins. The formula developed by the capital mints was sent, along with sample coins, to provincial mints to implement the minting of green money throughout the empire. Based on the standard formula and sample coins, different provincial mints developed their own local formulas and sources for metals. For example, the standard formula used tin from Guangdong, but Kingfu (?–1749), the governor-general of Yunnan and Guizhou, found that tin shipped from Guangdong was too expensive due to transportation costs. He ordered the artisans to experiment with cheaper local tin from Gejiu. When the experiment proved successful, Kingfu proposed using Yunnan tin instead. The Qianlong emperor approved his proposal and praised Yunnan's local adaptation of the standard formula as “exceedingly appropriate.”⁶⁴

Mobilizing Technical Knowledge for Monetary Reform

The 1740 monetary reform lasted fifty-four years. This reform may seem pointless to modern economists, since changing the alloy content did not solve the coin shortage. Nor did the new alloy formula stop rampant counterfeiting. Copper artisans did not need to recycle *pure* copper from copper coins because they could also work with copper alloys. For average users, the alloy content of coins was not a big issue as long as the money was accepted. Therefore,

private mints continued to produce small coins using different copper alloys to fulfill the demand for circulation. Scholars have shown that the Qing court's war against counterfeiting continued throughout the eighteenth century.⁶⁵ The monetary crisis finally ended in the last few years of the eighteenth century, when silver began to flow out of China due to the opium trade.

However, the way Qing bureaucrats arrived at a solution showed a gradual but distinct technocratic turn in statecraft. Bureaucrats attempted to solve the monetary crisis by using what they had learned from artisans, and they incorporated artisanal thinking into their policy-making process. Empirical observation, experimentation, and trial and error became important problem-solving methods for bureaucrats. At the same time, they adopted the mentality of merchants. Cost control became a cornerstone of monetary policy. The Ministry of Revenue approved Zhang Ruozhen's green money formula because it was inexpensive, and the emperor complimented Kingfu's local adaptation for reducing the expense of mintage. Thus, everyone in the bureaucratic system addressed the problem by thinking like merchants and artisans. Technical knowledge, in this monetary reform, replaced Confucian classics as the source of practical solutions and political persuasion, through which bureaucrats accrued political capital and advanced their careers.

The monetary reform shows that the Qing court had developed a network that connected and mobilized the knowledge of artisans, traders, and bureaucrats for administrative ends. In addition to the well-known court memorial system and textual transmission, the center and the local were connected through the movement of materials and artisans. The alloy formula was communicated through the movement of materials and personnel. Reforming coinage required more than the correct alloy; it depended on tacit knowledge about alloying, smelting, temperature control, casting, and polishing. Qing bureaucrats transferred the tacit knowledge of artisans by moving artisans around the empire.⁶⁶

When the Qing court carried out the new monetary policy, it had to do more than merely send the alloy formula from Beijing to local mints. Communication of the alloy formula between the center and the local involved transmission of artisanal knowledge as well as localization of monetary metals based on knowledge of the local market. The monetary reform led to collaboration between the Qing government and the metal market. The Qing government functioned like a corporation that had to work seamlessly with the domestic market and global traders to secure its metal supply. Because

local bureaucrats were responsible for sourcing, purchasing, and shipping monetary metals, Qing officials and their assistants increased their knowledge about the trade, purification, and shipping of the metal. In the same process, bureaucrats gained the knowledge and mentality of accountants and auditors. This expertise proved equally useful for detecting corruption and for concealing it.

Bureaucrats as Merchants, the Empire as a Corporation

The monetary reform brought new demand for tin, as well as increased demand for other kinds of monetary metals, such as copper, lead, and zinc. To increase the metal supply, the Qing government partially lifted mining restrictions in China proper after the 1740s. Merchants were encouraged to invest in mining, but the number of miners and the location of mining sites had to be registered and strictly monitored by the local government. Although the Qing government imposed taxes of 20 percent of mining output for its mints, this supply proved insufficient. The government still had to rely on domestic and international traders to supply metals for its mintage.

The Qing state supplied capital mints and provincial mints differently. Capital mints received monetary metals through taxation, irregular procurement (*caiban*), or domestic tribute (*tugong*) from several provinces. For example, the Qing court required the Guangdong government to supply 211,713 *jin* of tin to Beijing annually from 1741.⁶⁷ Meanwhile, other provinces, such as Jiangsu, purchased tin, among other kinds of goods, to send to Beijing as domestic tribute.⁶⁸ Provincial mints relied entirely on procurement for monetary metals.⁶⁹ In this way, the Qing empire functioned like a manufacturing corporation. It purchased raw materials, including copper, tin, and zinc, from the market and used them to produce coins.

Each provincial government appointed *weiyuan*, or special commissioners, to purchase monetary materials from the metal market. These special commissioner positions were not standard bureaucratic posts in the Qing ranking system, but ad hoc appointments that enabled officials to take on specific responsibilities beyond their regular duties, including metal procurement and mining administration. The purchase of metals was a highly specialized operation, which involved lengthy trips to distant trading hubs, connections with metal traders and shops, and management of secure packaging and shipping. The experience of Tong Hua (1675–1739) can give us a

comprehensive understanding of how these Qing bureaucrats gained technical knowledge about this trade and applied the knowledge into their work.

In 1729, Tong Hua was appointed as the prefect of Suzhou Prefecture and remained in the position for two years. In addition to daily administration chores, he was also responsible for administering the procurement of Japanese copper.⁷⁰ To secure the declining supply of Japanese copper, the Qing court issued special licenses to merchants to sail to Japan to import copper and even loaned money to merchants with close ties to the Imperial Household Department so that they could offer a higher price for the copper. After the merchants shipped the goods back to Suzhou, bureaucrats like Tong Hua procured the copper and shipped it to Beijing. Therefore, Tong Hua was not only responsible for administrative tasks, such as the recruitment of merchants, management of licenses, and issuance of loans; he was also responsible for the quality of the copper, the shipping cost, and secure transportation between Suzhou and Beijing.

In his published essay “A Discussion on the Regulations of Copper Administration” (Tong zheng tiao yi), Tong Hua made a great effort to detail all the possible scenarios for stealing copper and provided solutions to each. For example, Tong pointed out that junkmen, carriage porters, and warehouse keepers might use a pair of pliers to pull copper bars out of the cargo. Therefore, he suggested tightly binding the copper bars, putting them in wooden buckets, and wrapping the buckets in cloth bags.⁷¹ According to Tong, warehouse managers, dockers, junkmen, and even smelters of the imperial mint all had the chance to steal copper. Therefore, in addition to using special packaging methods, special commissioners had to weigh the copper during each transaction and bring additional copper to compensate for losses during transportation. Tong Hua’s story shows that special commissioners gained tremendous knowledge about the quality of the metal, transportation costs, and even packaging methods. Since the Qing government extensively used this procurement system to extract different kinds of minerals, a large group of bureaucrats became experts on the metal market.

But expertise in procurement was only half the picture. To prevent these knowledgeable officials from exploiting their positions, the Qing government employed a sophisticated accounting and auditing system to minimize state expenditure and prevent officials from lining their own pockets with the state’s money. This process, known as *zouxiao*, had deep historical roots, originating in the accounting system of the Tang and Song dynasties.

It reached maturity during the Ming dynasty, when *zouxiao* documents were first formally introduced as standardized accounting records that enabled the central court to audit financial activities across local and central government offices.⁷² Building upon this framework, the Qing government further expanded and refined the *zouxiao* system, establishing stricter submission timelines and document formats, while implementing more rigorous auditing procedures.⁷³ The process governed all major fiscal categories, such as land revenues, salt taxes, custom duties, official salaries, administrative expenses, and military expenditures. The regulations of the Ministry of Revenue stipulated that local administrators, governors, and officials responsible for specific tasks had to report their tax revenues and expenses to the ministry on a regular basis, usually once a year.⁷⁴

Because the specific ledgers for metal procurement are no longer extant, the detailed archive of the Imperial Household Workshop provides a useful parallel for understanding how this accounting system operated. The Imperial Household Workshop adopted this *zouxiao* system to manage cash and materials in its production activities for the imperial family. The *zouxiao* process followed a systematic hierarchy. Individual transactions involving money and materials were documented using tickets, which were then compiled into daily transaction logs. Each month, the accounting office produced monthly ledgers and sent them for auditing, while annual ledgers were compiled at the end of the year. Each warehouse also produced corresponding ledgers periodically for cross-checking purposes.⁷⁵ Each annual ledger was organized using a four-column balancing system (*sizhu jiesuan*)—a long-standing accounting system dating to the Song dynasty—which comprised a beginning balance, new receipts, actual use, and ending balance.⁷⁶

If a *zouxiao* report passed an audit, it was forwarded to superior administrative units. If it did not pass the audit, it was sent back to the submitters for correction. Administrative departments at every level preserved comprehensive records of annual expense reports spanning multiple years for future verification, cross-referencing, and auditing purposes. Through cycles of reporting, recording, ledgering, auditing, and cross-referencing, this accounting system functioned as a comprehensive mechanism of checks and balances designed to prevent corruption and ensure efficient use of resources.⁷⁷

The procurement of metals operated in similar fashion. Before actual procurement, the price of the metal, based on market rates, was reported to the Ministry of Revenue for approval. After procurement, the expenditures and

accounting documents were sent from provincial-level accounting offices to the ministry for auditing.⁷⁸ If irregularities were discovered, the person conducting the procurement was punished for inflating costs. As the following corruption case and its ramifications reveals, Qing bureaucrats, from the ministers of revenue to low-level bureaucrats who conducted procurement, all manifested a profound understanding of accounting, bookkeeping, cost estimation, and logistical management. Thus in the sourcing of monetary metal, Qing bureaucrats acted as merchants and the Qing government functioned like a corporation.

A Corruption Case in 1770

In the fall of 1770, the governor of Jiangsu, Sazai (1720–1786), received an interrogatory from the Ministry of Revenue asking why Jiangsu had purchased tin in 1769 at a higher price than Fujian. Both provinces sourced tin from Suzhou. Suzhou served as the center of the metal trade between Japan and China, facilitating complex international supply chains that connected Southeast Asian resources with Chinese markets. The tin that Jiangsu purchased likely originated from Bangka and followed an indirect route: the Dutch East India Company first shipped it to Japan. According to Shimada Ryuto's research, the Dutch East India Company dominated Japan's tin supply. The scale of this trade was substantial. Between 1751 and 1753, it imported 1,057,727 Dutch pounds of tin from Palembang and exported 60,370 Dutch pounds to Japan.⁷⁹ Then, through Chinese copper merchants, this Southeast Asian tin made its way from Japan to Suzhou's markets. Consequently, Suzhou's copper shops housed not only Japanese copper but also Bangka tin, making the city a convergence point for diverse Asian metal resources.

Both Jiangsu and Fujian procured tin from the same market in Wu County, Suzhou. The auditing process in the *zouxiao* system allowed the Ministry of Revenue to compare the procurement records across provinces. Based on annual accounting records and reports, the ministry discovered that Jiangsu had paid a higher price than Fujian for tin from the same market. This discrepancy suggested possible fraud. The Ministry of Revenue thus ordered Sazai to carry out a thorough investigation of tin procurement in the previous year.

Upon receiving the interrogatory from Beijing, Sazai was petrified. He promptly ordered the provincial administration commissioner, Li Hu

(1713–81), and the provincial surveillance commissioner (*ancha shi*), Wu Tan (1724–1780), to investigate.⁸⁰ Thanks to the *zouxiao* system, the provincial government had kept detailed ledgers and journals of the procurement, which enabled the investigators to locate the responsible personnel and pinpoint their activities. The 1769 procurement was conducted by two special commissioners, Li Xuan, the assistant magistrate of Jintan County, and Kang Ling, the vice magistrate of Qingpu County. Their purchase price for tin in 1769 looked reasonable at first glance: the price was based on previous years, and the Ministry of Revenue had approved the quote in 1769. However, further investigation into the accounting documents revealed potential wrongdoing: the Jiangsu government and the Fujian government had purchased tin from the same shop: Qi Zhengchang in Wu County. Having located the shop, Li Hu and Wu Tan secretly ordered local officials who were not involved in the procurement—the prefect of Suzhou, Zhong Guangyu, and the magistrate of Wu County, Chu Bangli—to go to Wu County in person (*qinfu*) to collect and examine the accounting journals and ledgers of all shops that traded tin, including Qi Zhengchang.⁸¹

The investigation of accounting documents had two purposes. The first was to find Qi Zhengchang's actual sales price and volume to see if Li Xuan and Kang Ling had inflated the procurement price. The second was to compare Qi Zhengchang's price with other regional traders to see if Qi Zhengchang had falsified its accounting records. As the palace memorial demonstrates, officials who participated in the investigation were fully aware that traders might collude with officials (*huwei biaoli*) and create fake accounting in anticipation of future investigations. After a thorough comparison, the investigators confirmed the credibility of the market price offered by Qi Zhengchang and reassessed the procurement price provided by Li Xuan and Kang Ling.⁸² However, this was not the end of the investigation.

Utilizing the Knowledge of Accounting and Trade

As the investigation proceeded, officials drew on expertise typically possessed by merchants engaged in long-distance trade: knowledge of shipping, material refinement, and subtle differences in measurements across regional markets. The journals of Qi Zhengchang show Li Xuan and Kang Ling purchasing tin in 1769 at an average price of 14 taels 7 *qian* 1 *fen* of silver per hundred *jin*.⁸³ The investigators also learned through a close reading of the

shop ledgers that the tin sold in Wu County required refinement to meet the Ministry of Revenue's standards, a process that led to a 3 percent loss in weight.⁸⁴ The accounting records also show that the steelyard used by tin shops only had 14 taels per *jin*, which was lighter than official standards.⁸⁵ To compensate for this discrepancy, the appointed officials had to add seven *jin* for every hundred *jin* of tin purchased.⁸⁶

Not believing the one-sided story presented by the merchants, Sazai ordered Li Hu and Wu Tan to verify these claims in person. Their examination of the steelyards and a smelting experiment confirmed the 3 percent refinement loss and the measurement discrepancy, raising the total cost of tin accordingly. In addition to the loss in weight, the investigators factored in the cost of refinement and packaging. Based on the accounting records of the Qi Zhengchang, after adding the cost of refining (5 *qian* of silver per hundred *jin*) and packaging (2 *qian* of silver per hundred *jin*), the total purchase cost came to 16 taels 8 *qian* 8 *fen*, very close to the procurement price of 17 taels 1 *qian* provided by the two suspects.⁸⁷

However, the minimal discrepancy in the accounting books did not save the two corrupt officials. The investigators eventually discovered their scheme: the two had exploited differences in silver tael standards. In the Qing empire, the silver circulating in different regional markets varied in weight and purity. Although accounting books consistently used the tael as a unit, the actual value of a tael differed from region to region, and an exchange rate applied in real transactions. The treasury tael (*kuping yin*) was the standard unit used in state ledgers to record government income and expenditures.⁸⁸ Meanwhile, different markets in the provinces had their own standard, called the transfer tael (*shiping yin*), which merchants used in daily transactions. In Wu County, the conversion rate between the transfer tael and the treasury tael was 100:93.⁸⁹ Li Xuan and Kang Ling made their purchase in transfer taels but reported their expenses in treasury taels, pocketing the difference. Qi Zhengchang's accounting book recorded a cost of 16 taels 8 *qian* 8 *fen* in transfer taels. Once converted to treasury taels, this came to no more than 15 taels 7 *qian*, much lower than the 17 taels 1 *qian* the two officials had reported. When they delivered 16,238 *jin* of tin to Beijing in 1769, they had embezzled 227 taels 3 *qian* of silver in total. The investigators also identified in the ledgers of Qi Zhengchang that Li Xuan and Kang Ling purchased 20,006 *jin* of unrefined tin, which could yield 18,005 *jin* after refinement. As the Ministry of Revenue had ordered only 16,238 *jin*, 1,767 *jin* of tin was missing.⁹⁰

Convinced that the evidence was enough to convict Li Xuan and Kang Ling, Sazai ordered their arrest. Kang Ling was immediately imprisoned. In the eleventh lunar month of 1770, Li Xuan, who had retired and returned to his hometown in Zhili, was arrested and sent to Jiangsu by the governor-general of Zhili. When interrogated, the two insisted that it was customary to bring extra tin to Beijing to compensate for the short weight (as Tong Hua suggested in his work), but the investigators rejected this defense, noting that the weight loss due to refinement and measurement differences had already been factored into their procurement expenditure. One month later, they were each sentenced to “one hundred strokes with the heavy bamboo and exile to 2,000 *li*.”⁹¹

But the investigation did not stop there. When the Jiangsu officials investigated this case of tin procurement in 1769, they reviewed all the *zouxiao* records related to procurement from 1764 to 1770 and found even more cases of corruption and embezzlement. Following the same pattern, the provincial government sent county magistrates to collect all the journals and ledgers of local metal shops that contracted procurement and cross-referenced the merchants’ accounting records with the official *zouxiao* records. In addition to the paperwork, these county magistrates visited shops in person to examine the physical quality of the material and confirm the cost of refinement. At the beginning of 1771, the anticorruption campaign came to an end, with eight more bureaucrats removed from office and punished for corruption.⁹²

Technological Knowledge for Administration (and Corruption)

Compared to the famous corruption case of Hešen (1750–99), who was accused of embezzling 1.1 billion taels of silver, the anticorruption campaign that ended in 1771 was just a tempest in a teapot. However, the crimes of Li Xuan and Kang Ling and the ensuing investigation offer a glimpse of how the Qing government functioned at the provincial and county levels, and how officials at different levels applied their knowledge of bookkeeping, auditing, trade, and materiality (both tin and silver) to their administrative practice.

The *zouxiao* procedure of the Qing government required scholar-officials to develop expertise in bookkeeping and auditing. Memorials cannot tell us which officials truly mastered these technical skills themselves and who depended on knowledgeable assistants to produce these technical reports, but this distinction may be less important than the broader pattern. Both

approaches reflect Qing bureaucrats' increasingly technocratic approach to governance. The first instinct of the Qing bureaucrats during the investigation was to review and cross-reference accounting records. Their accounting literacy extended beyond governmental records: the investigators in Jiangsu proved adept at reading and interpreting arcane journals and commercial ledgers. The two criminals, Li Xuan and Kang Ling, nearly outwitted them: they were so proficient in false accounting that their supervisors and officials at the Ministry of Revenue had trouble pinpointing the fraudulent entries in the *zouxiao* documents.

The craft of these bureaucrats entailed much more than producing standardized and routinized paperwork. The crimes Li Xuan and Kang Ling committed arose from their engagement with de facto procurement and logistical management activities. Everyday practices such as government procurement enabled county- and provincial-level bureaucrats like them to work closely with merchants to acquire knowledge of commercial activities. In addition to possessing extensive knowledge of shipping costs, refinement costs, and the physical qualities of tin, they were fully aware of regional differences in measurements and currency standards. They knew that the differences between regional and imperial standards in currency units could not be easily identified simply by reading the documents, and they made use of this loophole for personal gain. Li Xuan and Kang Ling learned the art of trade from the merchants who handled long-distance trade across the Qing empire. Unfortunately, the bureaucrats investigating their crimes possessed an equally extensive understanding of long-distance trade. The investigators used their practical knowledge to bring their colleagues to justice. The practical knowledge and bookkeeping technology they had acquired from merchants served as a double-edged sword: it enabled the state to fight corruption, while helping some bureaucrats embezzle government funds and cover up their crimes with almost impeccable paperwork.

* * *

The monetary reform and the anticorruption case demonstrate the increasingly intertwined relationship among technical knowledge, expertise, and power. In palace memorials and actual practice, the status of Confucian didactics from ancient classics steadily diminished, while artisanal knowledge, experimentation, and empirical investigation became sources of cred-

ibility and power. Even though some claims about empirical evidence and technical expertise might have been exaggerated or performative, this only underscores a subtle yet significant shift in statecraft: only empirical evidence and verifiable technical approaches were considered reliable and could secure the emperor's trust and political advancement.

When we turn our attention from the institutional structure of the Qing empire to the actual actions of bureaucrats, we find that they acted like engineers and merchants working in a gigantic corporation. One of the many products of this corporation was copper coins. This corporation was obsessed with the technical details of its products, maintained a rational and impersonal bookkeeping and auditing system, focused on cost control, and employed people passionate about transmitting practical knowledge regarding craft and trade. In this sense, the Qing empire invites comparison with another gigantic corporation of its time, the British East India Company.

Scholars of the British Empire and the East India Company have shown that the East India Company evolved from a commercial entity into a modern rational-legal authority in the mid-eighteenth century.⁹³ It acquired the requisite administrative skills and developed institutions of modern rational bureaucracy through noncommercial activities in its colonies.⁹⁴ Its employees developed a rudimentary commercial bureaucracy, and its training for merchants and traders later became standard for British bureaucrats.⁹⁵ Like their British counterparts, the bureaucrats who served the Qing empire (and their teams of assistants) also had to master both commercial and noncommercial knowledge to conduct their administrative work. But their professional trajectory was the opposite of their British counterparts: Qing bureaucrats were familiar with noncommercial duties at the start of their careers, but to serve the empire (and their private interests) better, they had to acquire knowledge of commercial activities and actual manufacturing processes.

At the institutional level, the Qing empire and the East India Company also moved in opposite directions. The East India Company extended its activities from commerce to administration, while the Qing empire extended its administrative realm to commerce and trade. This expansion into the sphere of commerce was partially due to the characteristics of the Manchu court and partially to the political and institutional constraints of the Qing empire. As Qing historians have shown, the Manchu emperor intentionally appointed his bondservants to important positions and used merchants with connections to the Imperial Household Department to manage the salt monopoly

and expand economic influence.⁹⁶ The close collaboration between the Manchu monarch and the merchants was not limited to the salt monopoly. Even though the Qing court claimed to monopolize copper mining and trade, copper merchants played a major role in supplying copper for coinage.⁹⁷ Rather than directly extracting resources via a coercive government apparatus and thus facing the moral censure of “competing with the people for profit,” Manchu rulers developed merchant-based supply networks. This system allowed the Manchu rulers to access natural resources through commercial channels, with this merchant-court collaboration eventually extending from the Imperial Household Department to the entire Qing administrative system.

The Qing state mirrored the Imperial Household Department in producing and transmitting practical knowledge. As the monetary reform demonstrated, the Qing state utilized models, personnel, and artifacts to transmit practical knowledge between the capital mints and local mints to produce copper coins. The way the Qing state made its monetary policy work was the same way the Imperial Household Department ran its imperial workshops. The fine line between the Qing state and the imperial household blurred: the state and the Imperial Household Department were just two sides of the same coin.

The mintage system reveals the Qing empire’s peculiar approach to extraction of mineral resources. With the development of domestic markets and a flourishing global trade, the Qing state never had to develop institutional capacity to monopolize its natural resources. The copper merchants who sailed between Suzhou and Nagasaki, the Dutch merchants who shipped tin from Batavia to Canton, and the Chinese junks that traveled between Xiamen and the Malacca Strait provided tin and copper to the mints in Beijing. The Qing empire was not interested in getting its hands dirty by involving itself in direct extraction of natural resources either. The failure of the Ming empire taught Qing rulers to rely on merchants and local elites to buffer the conflicts between state and society. With protocapitalist institutions like the Seven Chiefs system and Chinese *kongsi*, Chinese miners “voluntarily” worked themselves to death, extracting natural resources from the periphery to the center of the empire. This perspective suggests that the Qing empire and its bureaucratic system not only responded to the expansion of global trade but were able to benefit from the global expansion of capitalism. However, unlike their European counterparts, Qing bureaucrats were less interested in making structural changes. The dynasty’s founding commitment

to Confucian political rhetoric—emphasizing a provident state devoted to agricultural paternalism—prevented Qing officials from openly discussing profit. It was not until the nineteenth century, when the empire was plagued by ecological and economic crises, that Qing officials began to directly seek profit from mining.

CHAPTER FIVE

Transcribing Mining Technology for the Empire

On the ninth day of the fourth month of the twenty-fourth year of the Daoguang reign (1844), the emperor issued a secret imperial edict to his provincial governors. In this edict, the emperor began by celebrating the greatness of the providential approach to mining that had been carried out by his ancestors:

Since ancient times, the way to ensure the prosperity of a state lies first and foremost in satisfying the needs of its people. . . . The beneficence of heaven and earth are intended to be used for the benefit of all people. Only with proper management can the implementation proceed without any drawbacks. In the case of mining, in the previous dynasty [the Ming], mining was repeatedly carried out, and as a result, [corrupt] officials took advantage of the situation to engage in wrongdoing for a long time. Consequently, both the state and the people suffered from it. In our dynasty [the Qing], there have always been silver mines in Yunnan, Guizhou, Sichuan, Guangxi, and other regions, from which a silver tax is collected regularly. Over the years, this tax has been collected as usual, without causing any disturbance or burden to the people. This demonstrates that when officials are in charge of management, it may not be as effective as allowing the people to engage in mining on their own. This is a way to store wealth for the people.¹

For readers in today's Europe and America, the Confucianist rhetoric of the Daoguang emperor (1782–1850) may sound like a classic liberal politician

supporting minimal intervention from the state. Believing that the greedy Ming court's active engagement in mining was part of the reason for its collapse, Qing rulers tried to distance the state from direct involvement in the industry. Before the middle of the nineteenth century, the Qing mainly relied on merchants to supply mineral resources. European traders, Hong merchants, private investors, and special commissioners of the Qing state established an integrated system that allowed access to mineral resources.² This system worked smoothly in the eighteenth century, thanks to the increasingly interconnected global and domestic market.

However, this approach was no longer viable in the mid-nineteenth century. By the time the emperor issued his edict, the Qing government was facing multiple challenges. They had just lost the Opium War and paid Britain a large indemnity. The opium trade absorbed the silver of the Qing empire, creating scarcity in the Chinese market, which led to the so-called Daoguang depression.³

In addition to external pressures, the Qing empire also faced long-term internal crises. Scholars refer to the late eighteenth and early nineteenth centuries as the Qianlong-Jiaqing transition, marking the turning point from prosperity to decline. During this period, the Qing experienced a Malthusian check of "flood, drought, and plagues" due to population growth in the eighteenth century.⁴ Overfarming led to ecological degradation, flooding along the Yellow River, and silting of the Grand Canal. River management and canal dredging imposed an enormous fiscal burden.

Endless internal rebellions and uprisings caused by decades of corruption, maladministration, and excessive spending on external wars further depleted the central treasury. In 1795, conflict between migrants from China proper and local Miao people sparked the Great Miao Rebellion in Guizhou, followed by the more devastating White Lotus War (1796–1804).⁵ The uprisings began in Hubei and Sichuan and swept across northern China. The Qing empire never fully recovered from this multifaceted disaster. Military expenditure to suppress the rebellion exhausted the treasury of the central court. Even worse, the war led to fiscal and political decentralization. As provinces became more assertive in their fiscal relations with the central government, the central court's control over local fiscal and military forces eroded.⁶ After the White Lotus War, numerous uprisings further intensified pressure on the central government.

Facing these pressures, the Qing state implemented a series of reforms. Fiscal policies shifted towards frugality, military spending was reinstitutionalized,

literary censorship was gradually relaxed, and the Imperial Household Department and the Grand Council underwent a series of reforms. These changes predated the late Qing reforms and influenced a generation of reformers.⁷ The revitalization and development of mining as a means of generating fiscal revenue formed part of these reforms. It also directly addressed the practical need to raise funds to suppress insurgencies. Therefore, after announcing his commitment to minimal government intervention in mining at the opening of his edict, the Daoguang emperor went on to reveal his true intention, which somewhat conflicted with his previous claims:

Considering in Yunnan and other provinces, besides the current mining areas, there are still many places that can be exploited, thus I order Boohing [the governor-general of Sichuan], Guiliyang [the governor-general of Yunnan and Guizhou], Wu Qijun [the provincial governor of Yunnan], He Changling [the provincial governor of Guizhou], and Zhou Zhiqi [the provincial governor of Guangxi] to investigate the local situation, prospecting the potential mining sites. . . . It is strictly forbidden to rely on corrupt clerks, as it would lead to negative consequences such as encroachment, disturbance, and obstruction. . . . The ultimate goal is to benefit the livelihood of the people and the development of the state, as these are mutually beneficial concerns.⁸

The emperor articulated his objective clearly: he sought to leverage mining resources to augment state income and pressured his governors to actively develop mining operations. This was a drastic shift from the previous policy of minimal intervention. By the second half of the nineteenth century, the Qing state's active engagement in mining production became a central topic of discussion in the court.

Upon receiving the secret edict, Wu Qijun quickly responded by submitting a series of court memorials to report on the current situation at the mining sites of Yunnan.⁹ Moreover, during his appointment in Yunnan (1843–45), Wu compiled a two-volume mining treatise, titled *An Illustrated Strategy of Mines and Smelters in Yunnan* (Diannan kuangchang tulüe). The first volume, *An Illustrated Strategy of Mining and Smelting Tools in Yunnan* (Yunnan kuangchang gongqi tulüe), includes fourteen illustrations of mining and smelting technology. The second volume, *An Illustrated Strategy for the Routes to Mines in Yunnan* (Diannan kuangchang yucheng tulüe), contains

twenty-three maps. The illustrations in both volumes were contributed by Xu Jinsheng, the prefect of Dongchuan since 1840. Historian Peter Golas considered Wu's mining treatise to be "the single most useful account of mining practice by an official in traditional times."¹⁰ The detailed information in *An Illustrated Strategy of Mines and Smelters in Yunnan* make it the most important text for historians studying mining technology in eighteenth- and nineteenth-century China.¹¹ However, Wu Qijun, the author of the treatise, as well as his motivation for writing it, remained understudied.

In this chapter, I use Wu's treatise as a window to explore the knowledge culture of its contributors and intended readers. What motivated Wu Qijun to compile such a mining treatise? What inspired him to combine illustrations and text? This chapter posits that Wu Qijun aimed to add practical knowledge about mining and its administration to the knowledge system of state officials. In this way, he centralized highly localized knowledge and codified it into state knowledge. Simultaneously, Wu endeavoured to make less accessible knowledge about the frontiers more readily available to ordinary bureaucrats and scholars.

The depiction of Wu Qijun and his mining treatise presented here does not seek to elevate him as a hero of mining technology in late imperial China. Rather, this chapter examines what I term the Wu Qijun moment in the mid-nineteenth century: an apex of the long-term, diachronic knowledge accumulation that had been building since the eighteenth century, an era when an increasing number of prominent scholar-officials turned to technological knowledge as a means of saving the world. This moment marked the end of one era and the beginning of another. It foreshadowed the eclipse of the Confucianist, providential state and the transition to a new age in which exploitation of mineral resources became the central focus of state officials' work.

Copper Administration and Monetary Laws: Mining Knowledge Before the 1840s

Throughout the eighteenth century, Qing bureaucrats produced a steady flow of texts recording knowledge about mining administration. These were either presented as copper administration manuals or dispersed in local gazetteers. Qing bureaucrats used "copper administration" (*tongzheng*) and "monetary laws" (*qianfa*) as organizing categories in these texts. These terms not only

served as headings but also defined the boundaries of what knowledge was deemed relevant to record.

The most influential book on copper administration was *A Comprehensive Manual on Copper Administration in Yunnan*, compiled by Wang Chang, the provincial administration commissioner of Yunnan from 1786 to 1788. In a poem reflecting on his motivations for compiling this manual, Wang Chang wrote:

The mighty mountain, famed for minting coins since ancient times,
Opening the mines in the South of Clouds, production increased
 manyfold.
For thousands of miles, the roads hummed with the sounds of
 transportation,
Throughout the seasons, the clamor of hammers and chisels as many
 competed.
The prices of rice and firewood fluctuated without certainty,
While the value of ores varied and required careful evaluation.
Gathering diverse opinions as sources for verification,
So that future officials may avoid ambiguity.¹²

According to Wang Chang, he compiled this manual to provide information and technological references for officials, with special emphasis on transportation, the cost of mining, and the evaluation of ores. The purpose was to avoid ambiguity for future officials. In the preface, Wang Chang explained that he had modeled his book on the structure of monetary law as established by the Ministry of Revenue and divided it into eight sections: taxation, mining sites, transportation of copper to Beijing, monetary policy, procurement, debts and loans to the copper merchants, the evaluation of clerks, and an appendix.¹³ The framework of this mining manual, which prioritized the taxation, procurement, and shipping of copper, established the structure of the knowledge system before the middle of the nineteenth century.

Although Wang Chang's manual itself has been lost, its content was copied, cited, and reused in other mining administration treatises and local gazetteers. In the first half of the nineteenth century, Yunnan provincial government clerks compiled two more manuals, *A History of Copper [Mining] in Yunnan* (Yunnan tongzhi) and *A Convenient Guide to Copper Administration* (Tongzheng bianlan). Both shared the same structure as Wang's manual.¹⁴

In sum, by the first half of the nineteenth century, Qing officials' understanding of mining, as reflected in the mining administration manuals, was centered around copper administration and monetary laws. In the eyes of high-profile officials, the focus on copper administration lay not in the details of mining production but in the regulations surrounding taxation quotas, procurement of copper, financial support for state-licensed copper merchants, planning of transportation routes, and cost control during transport.

The Diachronic Process of Knowledge Accumulation

The codification of mining knowledge in the eighteenth and nineteenth centuries followed a line of continuous knowledge accumulation involving multiple participants across different administration levels. Many of the authors of these mining-related texts belonged to an interconnected intellectual network. They cited and referenced one another, creating a shared body of knowledge.

The clearest genealogy of knowledge production starts with Wang Taiyue (1722–85), who served as the provincial administration commissioner of Yunnan in 1772. He composed a long memorial to the throne in which he thoroughly discussed the advantages and shortcomings of copper administration in Yunnan. His memorial was widely circulated in Yunnan and subsequently incorporated into He Changling's influential *Collected Essays About Statecraft of the Qing* (Huangchao jingshiwen bian) and later reprinted in Wu Qijun's mining treatise. Wang Taiyue was Wang Chang's examiner in the civil service exam and thus became his political mentor.¹⁵ His keen interest in mining administration probably influenced Wang Chang.

Wang Chang's mining treatise was also closely related to Yu Qingchang, the county magistrate we encountered in chapter 1. Yu not only wrote the first copper administration manual, *A Study of Copper Administration*, but also participated in the composition of Wang Chang's *A Comprehensive Manual on Copper Administration*. Wang Chang's treatise not only set up the framework for subsequent copper administration manuals but also incorporated practical information about technological details. Its appendix contains an essay titled "Responses to the Consultation About Each Mine" (Zixun gechang dui), which suggests that county magistrates were summoned by higher authorities, probably Wang Chang's office, to answer questions about technological details and difficulties in mining and smelting. The content of

Wang Chang's treatise was extensively cited in *Draft of the Comprehensive Gazetteer of Yunnan Province* (1835), sponsored by Ruan Yuan (1764–1849).

Local gazetteers at both provincial and county levels also served as crucial repositories of mining knowledge. Key sources include the gazetteers of Mengzi and Dongchuan Counties, the provincial gazetteers of Yunnan (1736 and 1835), the unofficial local history *Concerning Yunnan* (Dianxi; 1802), compiled by the Yunnanese scholar Shi Fan (1751–1811), and the unofficial history *A Well-Balanced History of Yunnan* (Dianhai yuheng zhi) by a former county magistrate, Tan Cui (1725–1801).

The most comprehensive gazetteer was *Draft of the Comprehensive Gazetteer of Yunnan Province*, completed in 1835. Ruan Yuan, the governor-general of Yunnan and Guizhou, sponsored its compilation and appointed Wang Song (1752–1838), a local Yunnanese scholar, as the chief editor. Ni Shenshu, the great-grandson of Ni Tui, also participated in the compilation process. Both Wang Song and Ni Shenshu contributed detailed essays on mining and smelting technology, which Wu Qijun cited in his mining treatise.

Ruan Yuan's provincial gazetteer exemplifies the connection among Yunnan's intellectual networks: Wang Song was a student of Tan Cui, the author of *A Well-Balanced History of Yunnan*. Wang Song and his colleagues drew extensively on unofficial local histories, including Tan Cui's *A Well-Balanced History of Yunnan* and Shi Fan's *Concerning Yunnan*, to supplement official records of mining administration. They also cited previous administration manuals, such as Wang Chang's copper administration treatise. This synthesis of official and private sources made the Ruan Yuan edition of the provincial gazetteer the most comprehensive repository of mining knowledge before Wu's mining treatise.

These records in local gazetteers were well-organized compendiums of administrative information rather than ethnographic or journalistic impressions. In the 1736 provincial gazetteer of Yunnan, mining administration appeared as a subsection under "Taxation," listed under "Monetary Law." In the nineteenth-century edition, mining knowledge was grouped under the independent heading "Mining Industry Complexes" (*kuangchang*), with five entire chapters devoted to this subject. This organizational change between the two editions of local gazetteers demonstrates that mining emerged as an independent administrative category during the period from the eighteenth to the nineteenth century.

Thus county-level bureaucrats, administrative assistants, local intellectuals, and provincial governors all participated in collecting and codifying mining knowledge during this period. The texts they produced may have served slightly different but complementary purposes: assistants in provincial yamen compiled unpublished manuals for their own reference; governors sponsored the publication of large-scale administration manuals and local gazetteers, which were designed to provide administrative guidance for officials; and local intellectuals published unofficial local histories to fulfill Confucianist ideals of effective governance. Despite these different motivations and audiences, these works collectively formed a shared body of knowledge among bureaucrats and scholars in Yunnan.

However, this accumulated body of knowledge had its limitations. The circulation of knowledge was limited to the provincial level. None of the copper administration manuals mentioned above circulated widely before the twentieth century. Wang Chang's manual was lost in the twentieth century, and other administrative manuals were kept in provincial government archives for internal reference. County-level gazetteers had very restricted distribution, with some existing only as hand-copied manuscripts. Unofficial local histories, such as *Concerning Yunnan*, had only limited circulation due to financial constraints.¹⁶ The 1835 edition of the Yunnan provincial gazetteer was never officially published—it remained in the proof stage without being formally released.¹⁷ Therefore, only officials and clerks who had immersed themselves in mining administration for years possessed knowledge about mining technology and management.

Further, this body of knowledge was organized around mining administration rather than technological process, with scholar-officials prioritizing institutional changes and administrative regulations while omitting technological details. In Wang Chang's mining treatise, while county magistrates demonstrated their in-depth knowledge of the mining and smelting process, these technological details were handled as supplementary materials.¹⁸ The same pattern appears in Ruan Yuan's provincial gazetteer. Ni Shenshu's "The Record on Copper Mining and Smelting" described technological details in copper mining and smelting, including the appearance of different copper ores and the use of charcoal.¹⁹ Wang Song's "An Essay on Mining and Smelting" (*Kuangchang cailian pian*) not only introduced the miners' organization and the underground excavation process, but also delineated the physical

and financial risks in mining.²⁰ Despite the quality of these two essays, they were attached as appendices and printed in a smaller font, clearly marking their subordinate status.

Wu Qijun: Expanding the Scope of Knowledge

Wu Qijun's mining treatise broadened the comprehension of mining among Qing officials, encompassing not only administrative policies but also the technological aspects of mining production. Volume 2 of his mining treatise, *An Illustrated Strategy for the Routes to Mines in Yunnan*, is similar to earlier mining treatises in its focus on copper administration and monetary policy. It contains twenty-three maps showing the location of mines and shipping routes from Yunnan to Beijing. Following the maps are textual explanations that provide detailed locations of copper, silver, gold, tin, iron and lead mines, the annual tax quota, transportation methods, and the costs of shipping and procurement.

Volume 1 of Wu's mining treatise, by contrast, introduces a new field of knowledge to Qing officials. *An Illustrated Strategy of Mining and Smelting Tools in Yunnan* documents both mining and smelting technology as well as the social organization of miners. Its sixteen chapters cover the full scope of mining operations: from prospecting and excavation, to tools and ore differentiation, to smelting and refining furnaces. The text also addresses labor and its management, including types of workers, workforce control, and provisions for miners, as well as regulations, mining disasters, and miners' rituals and beliefs. It equipped its readers, primarily other officials, with the knowledge to understand the day-to-day operations of mining production, both above ground and below (table 1).

Wu Qijun's book partially relied on the accumulated knowledge of mining in Yunnan since the eighteenth century. Aside from quoting excerpts from Song Yingxing's *The Works of Heaven and the Inception of Things* from the Ming dynasty, all of the essays in the appendices are drawn from writings by Yunnan bureaucrats and scholars. For example, Wu Qijun's book incorporates "Responses to the Consultation About Each Mine," taken from Wang Chang's mining manual. Wu also includes essays by Ni Shenshu and Wang Song, probably taken from Ruan Yuan's provincial gazetteer. In volume 2 of Wu's treatise, he also includes Wang Taiyue's memorial on copper administration.

TABLE 1. Contents of *An Illustrated Strategy of Mines and Smelters in Yunnan* (Dian-nan kuangchang tulüe) by Wu Qijun

VOL. 1 <i>An Illustrated Strategy of Mining and Smelting Tools in Yunnan</i> (Yunnan kuangchang gongqi tulüe)	
Chapter 1	Prospecting for Ores
Chapter 2	Opening a Mine
Chapter 3	Mining Tools
Chapter 4	Differentiation of Ores
Chapter 5	Furnaces
Chapter 6	Smelting Tools
Chapter 7	Furnaces for Smelting Silver
Chapter 8	Provisions and Necessities for Mine Personnel
Chapter 9	The Labor Force
Chapter 10	Managers for the Labor Force
Chapter 11	Regulations
Chapter 12	Prohibitions
Chapter 13	Mine Disasters
Chapter 14	Language Taboos
Chapter 15	Unusual Occurrences
Chapter 16	Rituals
Appendix 1	Excerpt from Song Yingxing, <i>The Works of Heaven and the Inception of Things</i> (Tian gong kai wu), 1637
Appendix 2	Wang Song, “An Essay on Mining and Smelting” (Kuangchang cailian pian), reproduced from Ruan Yuan et al., <i>Draft of the Comprehensive Gazetteer of Yunnan</i> (Yunnan tongzhi gao), 1835
Appendix 3	Ni Shenshu, “The Record on Copper Mining and Smelting” (Cai-tong liantong ji), reproduced from Ruan Yuan et al., <i>Draft of the Comprehensive Gazetteer of Yunnan</i> , 1835
Appendix 4	“Responses to the Consultation About Each Mine” (Zixun gechang dui), reproduced from Wang Chang, ed., <i>A Comprehensive Manual on Copper Administration in Yunnan</i> , 1786–88
VOL. 2 <i>An Illustrated Strategy for the Routes to Mines in Yunnan</i> (Diannan kuangchang yucheng tulüe)	
Chapter 1	Names, Locations, and Output of Copper Mines
Chapter 2	Names, Locations, and Output of Silver Mines

Chapter 3	Names, Locations, and Output of Gold, Tin, Lead, and Iron Mines
Chapter 4	Government Appropriation for Mining Administration
Chapter 5	Salaries and Wages
Chapter 6	Evaluation of Officials
Chapters 7 & 8	Transport Routes and Stations
Chapter 9	Water Transportation and the Use of Boats
Chapter 10	Rules on Transportation Loss
Chapter 11	Ways of Economizing on the Entire Operation
Chapter 12	Coinage
Chapter 13	Procurement
Appendix	A Memorial by Wang Taiyue (1722–85), Provincial Administration Commissioner of Yunnan in 1766, on Advantages and Shortcomings of the Copper Administration of this Time

Wu Qijun did more than simply reproduce previous sources: he reorganized this body of knowledge, prioritizing technological details over administrative regulations. This represents a departure from the established hierarchy of mining knowledge. The responses of county magistrates are moved from the appendix of Wang Chang's mining treatise to the main body of Wu's treatise. Wang Song and Ni Shenshu's essays are also incorporated into the main text with equal prominence. Most significantly, Wu Qijun's structural choices reflect a new prioritization of technological knowledge. Volume 1 of his mining treatise focuses on mining and smelting technology and tools, while volume 2 addresses metal management, taxation, and shipping. This arrangement reverses the previous order, marking a conceptual change among the contributors and its targeted readers.

Although Wu Qijun's mining treatise is built on mining knowledge accumulated since the eighteenth century, this does not imply that he relied solely on book knowledge as his source. On the contrary, his treatise emphasizes empirical information from miners and smelters, likely collected and reported by magistrates overseeing mining operations. Wu did not follow the organization of previous mining administration manuals. Instead, he broke with conventional structure by using a dictionary format, explaining each term related to the mining and smelting process. The goal of this dictionary style was to transcribe and explain the vernacular knowledge of miners

and smelters. In the compilation process, Wu Qijun performed two types of translation: translating the miners' dialect into classical Chinese that could be recorded in writing, and translating the miners' vernacular knowledge into a knowledge system understandable to his potential readers, officials educated in the Confucian classics.

For instance, Wu Qijun used the character *dong* 洞 to refer to underground mining tunnels. This character is a combination of the semantic compound representing "stone" and the phonetic compound representing the sound "dong." It is mostly likely a transliteration of the miner's dialect, as its usage was not standardized before Wu's mining treatise. In palace memorials in the eighteenth century, officials sometimes used *dong* 洞, a more commonly used Chinese character with a water compound, to refer to mining tunnels.²¹

The names of mining tunnels recorded in Wu's mining treatise were highly colloquial, suggesting that they were directly drawn from miners' vernacular. Many names were derived from the miners' underground experiences or analogies to agricultural practice. For instance, a horizontal tunnel was called "horizontal pushing" (*pingtui*). A slightly inclined tunnel was called "cattle drinking water" (*niu chi shui*), using the metaphor of a cow drinking water from a pond to represent a slight downward angle toward the mining surface.²² This faithful transcription of the miners' colloquial language demonstrates Wu's appreciation for empirical knowledge directly derived from miners' production experience. It also suggests that in Wu's opinion, miner's direct experience validated the reliability of the mining knowledge presented in his book.

Unlike many earlier works, which frequently referenced *Xunzi*, a Confucian classic, to theorize mining knowledge, Wu Qijun directly adopted miners' explanations of ore formation, which sometimes contradicted the traditional Confucian theory of the Five Elements. In the theory of the Five Elements, which used the transformation of wood, fire, earth, metal, and water to explain cosmic cycles, metal creates water.²³ However, the relationship between mineral deposits and water was different in the miners' experience. As rich metal deposits were often located deep underground, miners frequently encountered groundwater when digging deeper. Based on their experience, the miners believed that this groundwater was an indicator of high-quality, large ore deposits. Therefore, they claimed that "metal and water mutually generate each other, in a son-mother relationship; thus, mines with groundwater are of higher quality."²⁴ Since the presence of water indicated the

presence of ore, the miners' logic implied that water gave rise to metal. This reversed the classical Five Elements theory. In Wu Qijun's treatise, he chose to record the miners' vernacular interpretation of the Five Elements theory, which was based on their experience in underground excavation. Through carefully considered transcription and explanation, Wu Qijun conveyed the miners' vernacular knowledge to his fellow scholars, while faithfully preserving the highly empirical content.

Wu Qijun put a lot of effort into recording the social technology of mining and smelting. Wu's emphasis on social technology was based on his deep understanding of mining and smelting technology. He recognized that social organization, financial tools, and labor management were the foundation of successful large-scale mining. For instance, when introducing the water pump, he explained at length labor management and the high cost of water drainage.²⁵ Since the cost and capacity of drainage were often a pivotal factor in determining the profitability of a mining site, Wu dedicated an entire page to illustrating how miners construct a terraced water pumping structure, drawing water from the underground mining tunnel to the mountain surface (see fig. 6). This emphasis on labor management, cost control, and social organization suggests that the treatise did not aim to teach Wu's fellow bureaucrats how to excavate ore so much as how to manage day-to-day production, raise funds, and maintain security at mining sites. Yet to be a savvy administrator, familiarity with policies and finances was far from sufficient. Competent officials also needed to familiarize themselves with specific mining and smelting processes to enhance their managerial ability.

An emphasis on managerial knowledge and technological details also affected the illustration of mining technology in Wu's treatise. The illustrations are nothing like modern technical drawings. The structure of the tools is inaccurately depicted, and several distinct activities appear together in one scene. In figure 9, the artist combines scenes of different stages of mining production. In the upper right, miners sort ores on the mountainside. In the lower right, workers wash ores using the panning method beside canals. In the lower left, miners transport ore in bags or with shoulder poles. In the upper left, officials inspect the ore and collect taxes. However, these actions could not have occurred simultaneously in one location. Historian Francesca Bray has explained the "non-realism" of technical illustrations in China, pointing out that they were meant to encode processes and relationships, translating sequences into spatial terms.²⁶ Therefore, the layouts of such illustrations

were not intended to show viewers how to practice each process or how to build a certain tool. Rather, they were designed to help managers understand the production process. The coexistence of these various mining stages suggests that figure 9 diagrams a *chaîne opératoire*, helping readers comprehend both the technological processes and the social relations involved in mining production. Furthermore, all the scenes in Wu's illustration are shown from overhead, providing the panoramic viewpoint of a manager overseeing the mine.

In this way, Wu Qijun's mining treatise significantly expanded the scope of knowledge of Qing officials in mining administration and technology. It provided officials with the means to comprehend the language of the miners and enough technological details to carry out their management duties. Furthermore, in this mining treatise, Wu Qijun not only included macro-level taxation and logistics policies but also delved deeply into the actual mining and smelting production processes, placing significant emphasis on empirical knowledge related to mining and smelting technology. In this way, Wu's treatise transformed Qing officials from policy-savvy administrators to technocrats with a mastery of managerial and production technology. But what motivated Wu Qijun to pay attention to the technological aspects of mining? What influenced his empirical approach? What led to his transition from a conventional administrator to a technocrat? We have to look into his career and life experiences to find the answers.

The Birth of a Confucian Technocrat

Wu Qijun was born in Beijing in 1789 to a prominent Confucian gentry family from Gushi County in Henan.²⁷ His father, Wu Xuan (1760–1821), and elder brother, Wu Qiyan (1779–1823), received *jinshi* degrees, the highest degree in the civil service exam, and began their careers as compilers at the Hanlin Academy, responsible for drafting and editing ceremonious imperial pronouncements and imperially sponsored histories. Both served for years as provincial education commissioners.²⁸ Continuing in the family learning tradition, Wu Qijun was awarded a *juren* degree in 1810 and became his father's colleague as a secretary in the Grand Secretariat (Neige Zhongshu). Seven years later, he emerged as the highest-scoring candidate in the metropolitan examination and was appointed to a prestigious position in the Hanlin Academy. In the 1820s and 1830s, Wu Qijun's major activities were at

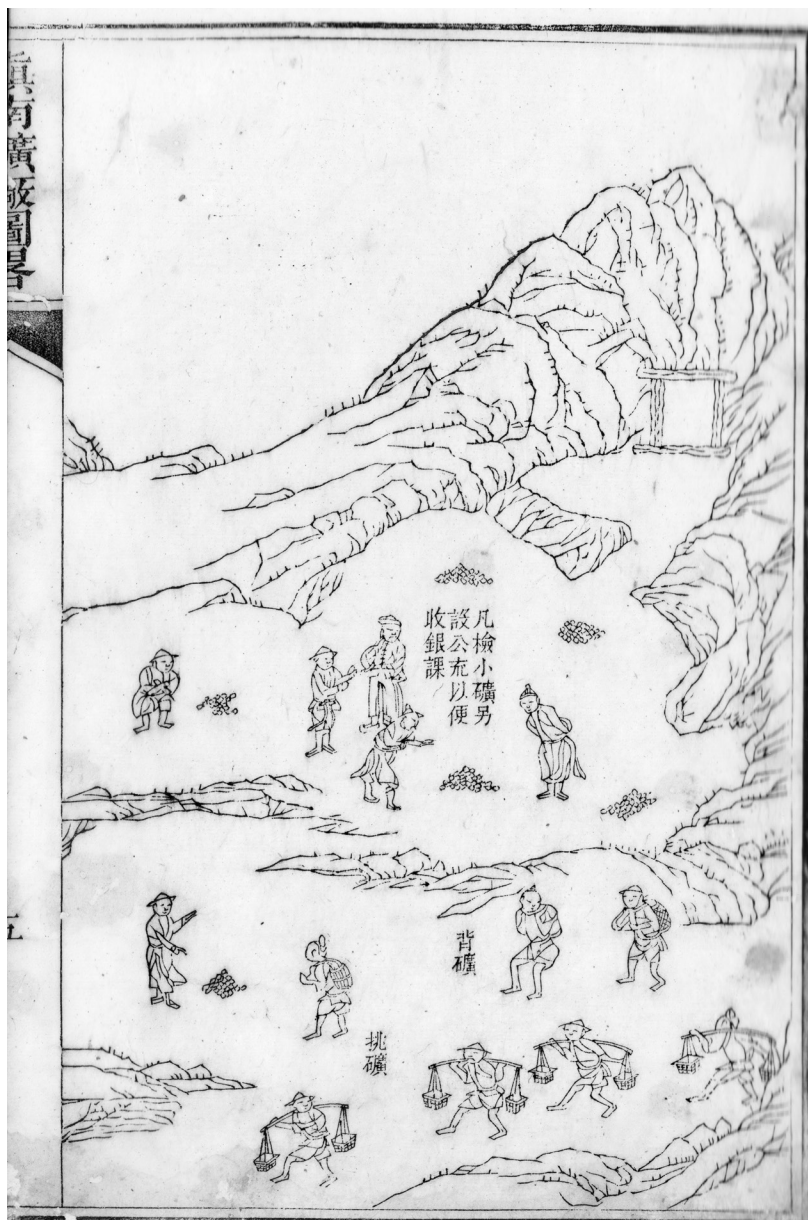


FIGURE 9. An illustration depicting multiple stages of mining production. Upper right: miners sorting ore on the mountainside. Lower right: workers washing ore using the panning method beside canals. Lower left: miners transporting ore in bags and baskets on carrying poles. Upper left: officials inspecting ore and collecting taxes. The overhead perspective provides a managerial view of the production process. Wu Qijun, *An Illustrated Strategy of Mining and Smelting Tools in Yunnan* (1844). Woodblock print, 30.5 × 20.5 cm. Courtesy of Nanjing Library, China.



the central court in Beijing, where he served as the compiler of the *Veritable Records of the Qing Dynasty* (Qing shilu) and as the emperor's personal secretary in the Southern Study (Nan Shufang). In the late 1830s, he received several promotions at the central court, becoming a member of the Ministry of Revenue and the Ministry of War, and occasionally overseeing the provincial examinations of the empire.²⁹

While Wu Qijun's educational background marked him as a typical Confucian scholar, he had a keen interest in knowledge about nature. From 1821 to 1828, he took leave for filial mourning and returned to his hometown in Henan. During this period, he purchased a farm named Eastern Villa (Dongshu) and indulged himself by studying plants with the local farmers there.³⁰ Wu's approach to botanical knowledge strongly relied on the firsthand experience he gained from interactions with local farmers. In his botanical treatise *Illustrated Investigation of the Names and Facts of Plants* (Zhiwu mingshi tukao), he frequently references information provided by elderly farmers and gardeners, and proudly called himself "a farmer of Yulou" (*yulou nong*)—Yulou being the historical name for his hometown.³¹ This approach to scholarship was also applied in his mining treatise, leading him to collect and codify the empirical knowledge of the miners.

Wu Qijun's scholarship on botanical knowledge received attention from the Daoguang emperor. In 1835, while serving as the emperor's personal secretary in the Southern Study, the emperor asked Wu Qijun about cactus, a plant that came from the Americas to China through the Columbian Exchange. Since this plant is not mentioned in the historical classics, Chinese scholars had no systematic understanding of it. The emperor ordered the eunuchs to display the cactus from the imperial garden. The eunuchs informed Wu Qijun that the cactus had once bloomed in the imperial garden, producing flowers as vibrant as roses, which many in the palace regarded as an auspicious sign for the emperor. The Daoguang emperor ordered Wu Qijun to study this plant to supplement the *Catalog of Myriad Flowers* (Qun fang pu), an encyclopedia of plants compiled in the mid-seventeenth century.³² While the exact impact of Wu Qijun's botanical knowledge on his career advancement is difficult to determine, this small episode undeniably reflects the high regard for knowledge about nature in the Manchu court. In such an environment, Wu Qijun's pursuit of empirical and technological knowledge helped strengthen his connection with the center of power.

Aside from his personal interest, the career of Wu Qijun's father, Wu Xuan, also influenced his interest in technological knowledge. Although Wu Xuan was trained in the Confucian classics, he was assigned to various positions that required a high level of technological and managerial knowledge. In 1814, four years after Wu Qijun joined the bureaucracy in Beijing, Wu Xuan became the head of the Archives of Yellow River Management (Zhihe Fanglüe Guan). In this position, he compiled archives of hydraulic engineering along the Yellow River, which led him to become expert in hydraulic engineering and water management.³³ Two years later, Wu Xuan was put in charge of the imperial mint, Baoyuan Ju (see chapter 4), overseeing coinage and managing the artisans at the mint. Unfortunately, due to financial and managerial disorder at the mint, the artisans launched a violent strike, ultimately resulting in Wu Xuan's dismissal. In the final year of his life, Wu Xuan regained the emperor's favor due to his expertise in geomancy and was assigned to find an auspicious burial site for the emperor.³⁴

Wu Xuan's life encapsulates the close relationship between technology and power. His promotions were driven by his mastery of hydraulic technology and geomancy, while his career decline was a result of mismanagement in production. In many ways, Wu Xuan's career mirrors that of bannermen technocrats like Tang Ying, whose influence came from practical, technological expertise rather than scholarly knowledge of Confucian classics.

Wu Qijun took a clear lesson from his father's career: technological expertise was critical for effective statecraft and could also advance one's standing at court. Committed to pragmatic governance, Wu Qijun cultivated technological knowledge as a means to address real administrative challenges, following the path his father had charted. After his father passed away, Wu Qijun carried on his interest in hydraulic management. During his mourning leave, Wu Qijun even conducted on-site inspections of flood-prone areas along the Huai River. Based on his fieldwork, Wu Qijun wrote "An Essay on Upper Huai River Management" (Zhi Huai shangyou lun), in which he proposed shifting the focus of river management from Jiangsu to the Huai River's upper and middle reaches in Anhui.³⁵ In this essay, his rationale for this new approach was not based on historical records, nor did he use Confucian discourse to bolster his arguments. Instead, his conclusions were supported by his own on-site geographical surveys. The shift in discourse in Wu's essay mirrors a broader transformation in the culture of statecraft:

empirical knowledge began to replace book knowledge and Confucian moral didactics as the primary basis for an official's justification of their solutions.

The technocratic culture among bannermen officials also influenced Wu Qijun's approach to statecraft. Since the Kangxi period, Manchu rulers fostered a new culture of governance through their particular interest in and control over knowledge of crafts and technology. Bannermen who were knowledgeable about materials and manufacturing technology became technocrats and, as historians Dorothy Ko and Kai Jun Chen have pointed out, were highly favored by the Manchu emperors.³⁶ Within this context, Han scholar-officials like Wu Qijun, his father, and those Han officials mentioned in chapter 4, who worked side by side with Manchu high officials, naturally sought to leverage the connection between power and technology for their own purposes. Continuing along this trajectory, Wu could have become a conventional Confucian scholar-official with a keen interest in hydraulic engineering and agriculture. What made mining so special to him? The answer lies in a suicide in Hunan in 1841.

A Tragic Suicide Reveals a Gap in Knowledge

Wu Qijun's career took off in 1840, when he was dispatched to Hunan to serve as provincial governor. Soon after his arrival, he was confronted with a suicide case that had drawn the attention of the emperor. It involved a bannerman named Hengshan (?–1841), who had killed himself within ten days of taking up a new position as the prefect of Guiyang. As the provincial governor, Wu Qijun was responsible for investigating the matter. Wu summoned Hengshan's personal assistant and discovered that Hengshan had taken his own life, overwhelmed by anxiety over uncollectable merchant debts.³⁷

Hengshan's anxiety involved a problematic copper administration policy. To secure copper for mintage, the Qing government provided loans to merchants for investment in copper mines. In return, these merchants were expected to repay the loans from their profits after selling the copper. However, in some cases, merchants defaulted because either the mining deposits became depleted or the cost of operation rose. Failure to repay created issues for local officials, since they were responsible for managing the loans.

There was an underlying problem in this system. To prevent regionalism, the Qing government tended not to appoint locals to govern their hometowns. As a consequence, most bureaucrats appointed by the central court

had little understanding of local conditions, not to mention specialized knowledge about mining. Hengshan had spent all his life in Beijing before coming to Hunan and had very little knowledge about mining.³⁸ While he could learn about taxation policies through the copper administration manuals, he had no means to judge whether a mining business was losing money or in good condition. The necessary information regarding mining production and its management was monopolized by local clerks. This knowledge gap created an opening for embezzlement and corruption: mine owners could collude with local clerks to falsify mining output to evade taxes and avoid loan repayment.

When Hengshan arrived in office, he found the situation to be grave. The copper merchants had accumulated significant debt, and most of them had been relentlessly pursued for payment without any success. The local clerks were “unusually cunning and malicious, and had used their leverage to exert control over the official in charge for years.”³⁹ The experience of Hengshan’s predecessor, Cunfen (active 1821–44), made him even more fearful. Cunfen was also a bannerman and, like Hengshan, lacked any prior experience in mining. Failing to recover overdue copper debts and taxes, he was subsequently dismissed from office. To make matters worse, his entire family’s assets were confiscated to cover the shortfall.⁴⁰ Witnessing the misfortune of his predecessor, Hengshan realized there was little chance for him to avoid a similar fate. Overwhelmed by despair, he took his own life.⁴¹

The fate of these two Manchu officials suggests the declining capacity of bannermen technocrats and the Imperial Household Department system in the nineteenth century. Historians have noted that the Qing court’s Imperial Household Department had a well-established system for training bannermen, especially bondservants, in the skills of production management, accounting, financing, and resource management. These bannermen, serving as technocrats, assisted the Qing emperors in overseeing important industries such as silk and porcelain manufacturing, as well as production in the imperial workshops. These bannermen also acted as the emperor’s personal spies, gathering information from across the empire, and served as accounting and financial specialists, managing the Canton customs and salt administration.⁴²

However, this culture began to change in the late eighteenth century. As historians Ma Zimu and Nathan Vedal point out, the Manchu translation exam was an imperial institution for recruiting officials. By the nineteenth century, increasing numbers of bannermen in local garrisons were taking

the translation exam to enter the bureaucracy. This exam created a wave of literary-intellectual activity among banner literati, fostering a new culture among Manchu scholars. They began to integrate Chinese literati forms and Confucian metaphysics, culminating in a distinctive aesthetic in literature. They also became fascinated with Chinese policy essays. Many of the most prominent names in late eighteenth- and nineteenth-century Manchu literature either took the translation exam themselves or framed their writings as relevant to it.⁴³ These changes in examination culture meant that bannermen in the 1830s and 1840s lived in a different cultural environment from technocrats like Tang Ying. Their entry into power was based on book knowledge and literary skill rather than practical knowledge.

The knowledge gap between the central court and local administration also explains the failure of these two bannermen bureaucrats. Both officials had experience in production management and accounting. The first failed official, Cunfen, for example, had been in charge of architectural renovation and maintenance in the palace, overseeing various construction projects and excelling in managing artisans and materials.⁴⁴ The one who committed suicide, Hengshan, had a family background similar to that of Cao Yin, the bannerman specialist who managed the Imperial Silk Factory for the Kangxi emperor. Hengshan's father served in the Jiangnan Imperial Silk Factory, and Hengshan himself held a position as the manager of the Imperial Household Department in Beijing.⁴⁵ Both of these officials had experience in managing industrial production, accounting, and resource management. However, they failed in local administration. The once powerful and effective system that had enabled Qing emperors to extract resources, manage precious materials, recruit skilled artisans, accumulate wealth, and gather information began to break down in the copper mines of Hunan in the nineteenth century.

Lack of technological understanding of the actual production process contributed to the failure of these two officials. The challenge posed by this knowledge gap was shared by all state-appointed officials, Manchu and Han alike, including Wu Qijun himself. After his investigation, Wu Qijun concluded that it was very likely the local clerks and tax collectors had colluded with the merchants to create fraudulent information to resist the collection of debt. Therefore, he ordered all clerks to be brought to the provincial government to be interrogated.⁴⁶

The Daoguang emperor could not have agreed more with Wu Qijun. Three years later, in his edict on mining in Yunnan, he instructed his pro-

vincial governors that “it is strictly forbidden to rely on corrupt clerks, as it would lead to negative consequences such as encroachment, disturbance and obstruction.”⁴⁷ The emperor had learned from the case in Hunan and was trying to get rid of the middlemen who mediated between the state and the local mining community. At this point, the codification of mining and smelting technology became urgent. Before Wu’s mining treatise, the circulation of mining knowledge never went beyond Yunnan. Now Wu Qijun’s goal became clear: he was aiming to transfer technological and managerial information from the hands of local clerks to the knowledge system of scholar-officials and eliminate intermediaries between the state and local society.

To do this, Wu Qijun employed an innovative method to encode practical knowledge. Unlike previous mining manuals, none of which contained illustrations, Wu Qijun’s work utilizes both technical illustrations and maps to visualise mining technology and shipping routes. The reason lies in part of the title that he picked, *tulüe*, which I translate as “illustrated strategy.”

Tulüe: Creating an Illustrated Strategy for Mining

The term *tulüe* is common in modern Chinese, but it was unusual during Wu Qijun’s time. Only two books with *tulüe* in their titles were printed before Wu’s mining treatise. One is a Yuan dynasty work titled *An Illustrated Strategy for Managing the Yellow River* (Zhihe *tulüe*). It records past river management strategies in order to provide a reliable guide for hydraulic works in the future. Six maps are included to illustrate the course of the Yellow River, each accompanied by a detailed description.⁴⁸ The other book is *An Illustrated Strategy for Tibet* (Xizhao *tulüe*), compiled by Sungyūn (1752–1835), who served as the Manchu resident minister in Tibet in 1798. It includes twelve maps, each of which marks mountain passes, rivers, military garrisons, and borders, providing information for military strategic planning. The maps are complemented by a detailed description of military strategies and routes.⁴⁹

By comparing the contents of these two books, we can gain insight into what Wu Qijun meant by “illustrated strategy”: the provision of visual information for future strategic planning. He probably took inspiration from both books. His father’s job in the Archives of Yellow River Management must have familiarized Wu with the visual language in *An Illustrated Strategy for Managing the Yellow River*. It is likely that Wu Qijun applied the same

approach to the management of mining and transportation. Sungyūn's illustrated strategy for Tibet, by contrast, inspired Wu Qijun to make accessible the lesser-known geographical information on the frontier, previously locked in the palace archives.

The maps Wu Qijun included in his mining treatise were appropriated from an album created by Belin (1747–1824), a Manchu official who was governor-general of Yunnan and Guizhou.⁵⁰ In 1818, Belin submitted two albums to the Jiaqing emperor. These featured colored illustrations depicting ethnographic groups and detailed maps of Yunnan, accompanied by introductions written by Belin.⁵¹ A comparison of the map of Lin'an (the prefecture that Gejiu belonged to) in Wu's treatise with Belin's album shows that Wu drew directly from Belin's map. He even adopted the same legend, using an upside-down *U* to represent mining sites. Belin's two albums belong to a genre known as the Miao album, which was part of the imperial project to bring the southwestern frontier regions into the Qing administrative fold.⁵² However, like many other cartographic projects on the Qing frontier, Belin's albums were kept in the imperial archives as imperial knowledge that was only accessible to a few Manchu military elites. It is highly probable that Wu Qijun gained access to these frontier maps during his service as compiler of the *Veritable Records*. Wu's deliberate choice to disseminate knowledge about frontier geography follows the larger intellectual trend after the Qianlong-Jiaqing transition. As Matthew Mosca points out, after Qianlong's death, Han scholarly elites began publishing frontier materials, and a huge corpus of frontier works appeared in print. Knowledge that had once been the preserve of Manchu and Mongol administrators now became available to all literati through print media. Chinese scholars no long needed imperial appointments to access such information.⁵³

Through a combination of text, technical illustrations, and maps, Wu Qijun was able to counter the monopoly of local clerks, turning their local mining knowledge into state knowledge. Conversely, he made formerly confidential geographical knowledge about the southwestern frontier more accessible to average scholars. Wu Qijun's mining treatise was a culmination of knowledge production in the Qing empire during the eighteenth and early nineteenth centuries. He collected and published the practical knowledge accumulated by Yunnan officials through years of interactions with merchants and miners; applied the *tulūe* format to better transcribe mining knowledge; and drew upon the Qing empire's extensive achievements in

cartography and ethnography to complete his mining treatise. Wu Qijun's mining treatise was an attempt to save the empire through practical learning. By collecting and systematizing practical and technological knowledge, Wu aimed to turn Confucian bureaucrats into technocrats who could efficiently exploit mineral resources for the sake of the empire.

The Wu Qijun Moment: Saving the Empire Through Practical Learning

Wu Qijun should be considered one of the pioneering technocrats and polymaths of the nineteenth century. During his appointment in Hunan (1840–43), while managing the suppression of bandits and overseeing copper mining, he also took charge of the extraction of saltpeter, a key ingredient in gunpowder, to support the ongoing Opium War.⁵⁴ Later, during his appointment in Yunnan (1843–45), while compiling his mining treatise, he reorganized the management of copper mines.⁵⁵ Additionally, he was involved in salt administration. He investigated the salt wells and gypsum mines in Yunnan, reduced redundant staffing, and cut related taxes to alleviate the burden on salt and gypsum merchants.⁵⁶ After two years of service in Yunnan, he was transferred to Shanxi (1845–46), where he oversaw salt administration. Within four months of taking office, he inspected the salt ponds in person and initiated reforms in local salt administration. At the time of his death in 1846, he was expected to collaborate with officials in Xinjiang to organize migration from Shanxi for a land reclamation project.⁵⁷

Wu Qijun's career bears a striking resemblance to that of his predecessor from half a century earlier, Chen Hongmou (1696–1771). As historian William Rowe clearly demonstrates, scholars like Chen Hongmou were already practicing a hardheaded “learn truth from facts” approach to technocratic social management. His pragmatic, hands-on approach to governance stood in stark contrast to the amateur ideal of the late imperial Confucian elite. Facing various challenges, such as rapid population growth, ecological degradation, and intensified agrarian commercialization, Chen Hongmou and other Confucian elites creatively combined pragmatism and moralism in their efforts to “save the world.” They were deeply invested in collecting, applying, and disseminating agricultural and hydraulic engineering technology, and they closely collaborated with local elites and merchants.⁵⁸ Yulian Wu and Jane Kate Leonard have demonstrated this pattern in the realms of salt administration and grain transportation, respectively.⁵⁹

This eighteenth-century trend provided the context for changes in Wu Qijun's era, yet significant differences separate the two officials. Chen Hongmou's approach to statecraft was still deeply rooted in the Confucian classics and ethics. He identified with the school of Song learning, and his commitment to solving socioeconomic problems was ultimately grounded in the *Great Learning* (Daxue), a Confucian classic, with its emphasis on the interrelatedness of internal moral cultivation and external world ordering. Therefore, in Chen's discussions of salt administration and mining, he consistently had to justify and reconcile the relationship among merchant profits, state revenues, and the people's well-being, a relationship traditionally seen as contradictory in Confucian thought.⁶⁰

Wu Qijun faced more urgent crises and developed a more technocratic response. The moral dilemma in Confucianism regarding the balance between private interests, the people's benefit, and state extraction of resources did not trouble Wu as it had troubled Chen. Most of Wu Qijun's writings were rooted in empirical surveys, in-person investigations, and firsthand technological knowledge from county-level bureaucrats rather than classical texts and moral principles.

Wu also pioneered a new category of specialized official knowledge: mining technology and administration. His mining treatise differed from the ethical admonitions or *guandu* anthologies typically produced by high-profile officials like Chen Hongmou. While it belonged to Pierre-Étienne Will's category of "handbooks specializing in particular techniques," it created an unprecedented subcategory.⁶¹ Building on Wang Chang and other Yunnan bureaucrats' foundational work in copper administration, Wu established mining administration as a distinct field alongside the traditional specializations in law and justice, water conservation, famine relief, public works, schools and examinations, salt administration, and military affairs. In doing so, Wu incorporated mining into the official knowledge system and exemplified the shift toward the more empirically grounded statecraft (*jingshi*) that characterized the first half of the nineteenth century.

Wu Qijun's mining treatise had long-lasting influence. The provincial gazetteer of Yunnan published in 1898 reproduced Wu's *An Illustrated Strategy of Mining and Smelting Tools in Yunnan* almost in its entirety.⁶² His book also became a core source in the emerging discipline called "the study of mines" (*kuangxue*), which combined mining technology, geology, geography, and mineralogy. This new field developed in the late nineteenth century as

a result of Sino-Western scientific exchanges.⁶³ In 1902, Song Gengping, a Sichuanese, published *Newly Compiled Core Principles of the Study of Mines* (Kuangxue xinyao xinbian), in which he extensively quoted Wu's mining treatise while supplementing it with his own experience. Song argued that the failure of the mining industry in China resulted from Western machines being too expensive and Western technology being poorly adapted to Chinese conditions. He therefore sought to reintroduce indigenous Chinese mining technology, which he claimed was more cost effective and practical.⁶⁴ Wu's mining treatise served as his source. As the author of the 1949 edition of the provincial gazetteer of Yunnan aptly noted, Wu's mining treatise had indeed become "an indispensable book for mining practitioners."⁶⁵

The protagonist of this chapter is not just Wu Qijun. He is representative of his colleagues, the bureaucrats who were originally trained in Confucian classics but turned to pragmatic expertise to solve the crisis of the empire. Wu Qijun was not alone in collecting, codifying, and disseminating practical knowledge. His son's father-in-law and close political ally, He Changling, sponsored the compilation and publication of *Collected Essays About Statecraft of the Qing* (Huangchao jingshiwen bian) in 1827, which started the trend of *jingshi* in the late Qing. The chief editor of this collection, Wei Yuan (1794–1857), meticulously compiled writings from scholar-officials prior to the nineteenth century in areas such as hydraulic engineering, agronomy, fiscal administration, and military logistics. This collection became the bible of the reformist movement in the nineteenth century. It marked a significant ideological shift away from the normative Confucian style of administration, rooted in moral admonition, toward renewed emphasis on a pragmatic approach to statecraft, along with "an unapologetic embrace of wealth and power as legitimate political goals."⁶⁶ The shift from self-cultivating, morally transforming Confucian administrators to knowledgeable technocrats reflected a broader transformation in Qing statecraft. Technocratic governance, which had initially emerged in the seventeenth century as a practice largely confined to bannermen, evolved into a widely adopted approach shared by officials across ethnic lines and administrative ranks.

Paving the Way for Industrialization

Wu Qijun and his like-minded colleagues were undoubtedly predecessors to the reformists who advocated for industrialization in the latter half of the

nineteenth century. In 1847, Lin Zexu was appointed governor-general of Yunnan and Guizhou. When he took office, increasing mining productivity had already become a clear state policy aimed at boosting state revenue. Lin submitted a memorial on trial mining operations in Yunnan. In this memorial, Lin, drawing on his knowledge of mining technology, proposed four regulations to increase productivity: lifting restrictions on the lead trade, reducing miscellaneous administration fees, enforcing stricter regulations, and curbing fraud.⁶⁷

The first regulation demonstrates Lin's knowledge of copper, silver, and tin smelting technology. He noted that lead was often a by-product of these metals, and therefore advocated for the free trade of lead to boost the income of merchants investing in mining. The second regulation, based on the Seven Chiefs system, was intended to support the self-governance of the mining community and reduce government bureaucracy to lessen the burden on merchants. The third and fourth regulations, grounded in his understanding of the shareholding system and the ore trade, called for stricter rules on shareholding rights to reduce potential disputes, as well as greater regulation of fraud in the ore trade.⁶⁸ It is difficult to determine to what extent Lin Zexu directly referenced Wu Qijun's treatise when writing his memorial, but it is likely that he benefited from Wu's codification of technological knowledge. He used many of the specific terminologies and technological details mentioned in Wu's mining treatise in his memorial. Lin Zexu's emphasis on these four aspects was also likely not coincidental, as Wu Qijun had highlighted these issues three years earlier in his mining treatise as key aspects of social technology.

Moreover, Lin Zexu used empirical investigation and technological knowledge to formulate his argument on taxation policy. Lin noted that, based on his investigation of gold, silver, and copper mines, the success of mining was highly uncertain. Variability in rainfall could significantly increase the cost of water drainage, and newly discovered mineral deposits might be quickly depleted due to uncertainty about their size. Merchants were hesitant to invest: the taxation quota was based on historical precedent and did not account for these uncertainties, leaving them unwilling to bear a fixed tax burden when costs and output were unpredictable. Therefore, Lin suggested abandoning the fixed taxation quota and proposed allowing newly discovered deposits to be mined on a trial basis for a year, with taxes levied only if the deposits proved abundant. For abandoned mining sites, he rec-

commended encouraging their reopening and taxing merchants based on the actual situation.⁶⁹ Lin's memorial demonstrates his technocratic approach to mining administration. Even his taxation policy was grounded in empirical surveys, technological insights, and pragmatic reasoning.

The technocratic approach prepared Qing officials for the forthcoming Self-Strengthening Movement (1861–95), during which they employed the model of merchant operation under bureaucratic supervision (*guandu shangban*) to accelerate rapid industrialization. Lin Zexu was probably one of the earliest officials to formally bring up this policy. Although a similar structure had existed since the eighteenth century, it was only formally introduced in Lin's memorial in 1849. Based on a detailed description of drainage technology and its high cost, Lin Zexu pointed out that mining required significant capital investment. Given the uncertainties of deposit size and the demand for substantial capital, Lin Zexu concluded that to establish a mining enterprise, "the capital required was immense, far beyond the capacity of a single individual."⁷⁰ Therefore, private investment alone was not sufficient. However, direct state management was not suitable either. According to Lin, the tenure of officials was often short and inconsistent, which could lead to administrative entanglements and deficits. Furthermore, it was impossible for local officials to personally manage the mines. Inevitably, they would have to delegate tasks to local clerks, thus increasing the risk of corruption. Therefore, Lin Zexu proposed to let local officials take the lead in recruiting merchants to form partnerships. According to Lin, the advantage of this model was that "the government retains supervisory authority without the burden of financial liability."⁷¹

Lin Zexu's institutionalization of merchant operation under bureaucratic supervision laid the foundation for the Qing government's approach to industrialization. In 1887, Tang Jiong (1829–1909), the governor of Yunnan, reported to Beijing that the management of mining was extremely strained, and progress was slow. Local merchants lacked sufficient capital. Previously, large-scale mining operations had been financed by wealthy merchants from Sichuan, Hubei, Jiangxi, and Guangdong. However, after the Sino-French War (1884–85), many of these external merchants left, leaving local merchants, who were short on capital, to take over. The absence of investors led to a shortage of skilled miners, previously brought in by investors. Tang Jiong emphasized that skilled miners were crucial for locating ore deposits and ensuring successful smelting operations, but many of them had perished or

left during the war. In addition, there were insufficient manual workers. After a long period of inactivity and poor profits, recruitment efforts were yielding few results.⁷²

To address the problems of capital, technology, and labor, Tang Jiong followed Lin Zexu's model and proposed to raise funds by sending government envoys to Sichuan, Guangdong, Hankou, Ningbo, and Shanghai to attract potential investors. Regarding technology, he suggested adopting Western machines to increase productivity. He planned to hire Japanese mining engineers to evaluate mining conditions in Yunnan and recommend appropriate machinery, thereby avoiding unnecessary expense.⁷³

Tang Jiong's solution was a common approach to industrialization in the late nineteenth century. Interestingly, although by Tang Jiong's era, Chinese bureaucrats were already influenced by Western ideology and adopted Western engineering technology, Tang Jiong's approach still followed the model of merchant operation under bureaucratic supervision, which originated in the eighteenth century. His focus remained on the social technology that Wu Qijun had emphasized—namely, how to raise funds, how to recruit labor, and in particular, how to recruit skilled miners and smelters. The only difference was that Wu Qijun's earlier advice about finding skilled and experienced timbering headmen and smelter headmen had evolved into the need to find Japanese engineers who were knowledgeable in purchasing, installing, and operating machinery. In the same manner, the capital-intensive tools of mining and smelting that Wu Qijun had described were replaced by Western machines. Due to the high cost of imported machinery, the Qing government's role gradually shifted from merely organizing merchant investment to direct state involvement by the turn of the century. The approaches of Wu Qijun and his contemporaries had long prepared the way for the industrialization of China.

* * *

Wu Qijun's mining treatise collected, codified, and reorganized the practical knowledge Yunnan bureaucrats had accumulated since the eighteenth century, providing Qing scholar-officials with detailed technological references for mining administration. Wu's approach to statecraft was deeply rooted in a technocratic culture that had been gradually developing among Qing bureaucrats. In this culture, technological knowledge and expertise became essen-

tial sources of power and promotion for both Han and Manchu officials. In the nineteenth century, as the empire faced increasing internal and external pressures, this technocratic culture became more pronounced. A pragmatic approach to statecraft, grounded in technological expertise, emerged as the key strategy to save the empire.

Wu Qijun and his contemporaries represent the culmination of the pragmatic approach of the previous century, while also marking the beginning of a new era. These scholar-officials selectively compiled earlier writings on practical technologies of governance into anthologies such as *Collected Essays About Statecraft of the Qing*, which became the foundational text for the reformist movement known as *jingshi*. As the Imperial Household Department's operations gradually disintegrated, civil officials increasingly replaced bannermen in managing the empire's material, financial, and technological resources. Drawing on their understanding of mining technology—particularly the capital- and labor-intensive nature of mining—these bureaucrats adopted the method of merchant management under bureaucratic supervision to boost mining productivity. This approach involved using state initiatives to attract investors, pool capital, and introduce technology and skilled labor. It laid the groundwork for the introduction of Western machinery and engineers, ultimately setting the stage for China's industrialization in the late nineteenth century.

The technocratic approach to statecraft represented by these officials coincided with a changing relationship between the state and natural resources, both ontologically and conceptually. Officials like Wu Qijun did not necessarily understand natural resources as we do in modern times. For Qing officials, natural resources such as minerals were expressed through the term “the beneficence of heaven, earth, and nature.” In eighteenth-century discourse, minerals were gifts from heaven and earth that allowed the poor to sustain themselves; they were not objects from which the state should seek profit or compete with the people for benefit. In practice, the Qing state did not directly extract these resources for their industrial value. Instead, the state sourced minerals through either taxation or procurement based on trade networks, and the main purpose was to issue currency rather than accumulate wealth for the state treasury.

By Wu's era, however, the Daoguang emperor and his officials no longer hesitated to discuss using mineral resources for the state's benefit. State officials began to use policy measures and direct investment to intensify

extraction. Simultaneously, at the conceptual level, in political discourse, the beneficence of heaven, earth, and nature—which was supposed to benefit the people—became reconceptualized as resources that could be further exploited for the power and wealth of the state. The state's extraction of mineral resources was no longer just for the sake of coinage, but for increasing state revenues and replenishing the depleted treasury.

This transition was not limited to mineral resources, but encompassed all natural resources, including salt, mining, and agriculture. In 1848, the Daoguang emperor explicitly ordered all high officials in the court to discuss reforms in five areas: salt administration, the land tax, grain transportation, river management, and mining, with the goal of raising funds for the Ministry of Revenue.⁷⁴ Here, the Daoguang emperor no longer concealed his intentions behind secret edicts or rhetoric about the people's livelihood. Instead, he made clear that the extraction of resources was essential for the wealth and strength of the state. Qing intellectuals in the nineteenth century also shared this opinion. Historian William Rowe points out that nineteenth-century scholars like Bao Shichen (1775–1855) explicitly advocated for the pursuit of material profit not only in the interest of the rural populace but also for the Chinese state and nation.⁷⁵ During the crises of the nineteenth century, when the Qing state could no longer comfortably rely on trade and procurement to address environmental and economic challenges, the beneficence of nature had transformed into what historian Peter Lavelle has termed “the profits of nature.”⁷⁶ As a result, technocrats' expertise in the effective extraction and management of natural resources became the essential skill for saving the empire.

Conclusion

In 1905, the governor-general of Yunnan and Guizhou, Ding Zhenduo (1842–1914), reported to Beijing on the tin mining industry in the Gejiu, applying for approval to raise more capital to establish a modern tin mining and manufacturing company:

The Gejiu tin mines are vital to the livelihoods of the people in Yunnan. . . . However, most of the [local] mine owners are poor, lacking sufficient capital, and seeking quick profits without understanding long-term strategies. . . . Moreover, the mining sites are close to the Vietnamese border, and foreign interests are eyeing them covetously. Since the founding of the Mengzi customs house, this area has become more accessible, but local financial resources are limited, making the tin mining industry vulnerable to foreign manipulation. It is urgent to take timely measures to maintain control and prevent mining rights and profits from flowing abroad. Therefore, I propose a collaboration between the government and merchants to raise capital and establish a company.¹

Ding's proposal was driven by the urgent need to compete with France for mining sovereignty. After the Sino-French War (1884–85), the French incorporated northern Vietnam under its influence and made Mengzi County, to which Gejiu tin mines belonged, a port of trade between the Qing empire and French Indochina. Afterward, tin from Gejiu became a highly profitable global commodity. It was transported by railroad across the Qing-Vietnam border, then shipped from Vietnam to Hong Kong, where it entered the international metal market. The high profitability of tin attracted French imperial interests to intervene in the tin mining industry in Gejiu, which was met with resistance from Chinese merchants. However, although the Qing established the Gejiu Mining and Commerce Bureau in 1883, the mining industry was entirely funded and managed by merchants.² Therefore, tin mining in Gejiu suffered

from a lack of capital and insufficient funds. Moreover, successive wars damaged mining and smelting equipment in Gejiu, making it impossible to resume large-scale production, let alone ward off French encroachment. Thus, Ding called for establishing a state-merchant joint venture in order to “control and prevent mining rights and profits from flowing abroad.”³

This company, jointly owned by the Qing government and merchants, laid the foundation for mechanized industrial tin mining in China. By issuing shares, each priced at 1,000 yuan in silver coins, the company successfully raised 485,000 yuan from the Qing government and 181,000 yuan from merchants.⁴ These shares formed the start-up funds for the Yunnan Tin Company. Four years later, after sending representatives to tin mines in Southeast Asia for further investigation, the Yunnan government decided to purchase machinery from Germany. To fund these purchases, the provincial government initiated another round of fundraising, with government shares reaching one million yuan and an additional 769,500 yuan raised from private investors.⁵ These machines laid the material foundation for China’s modern tin mining industry. The Yunnan Tin Company evolved into the manufacturing giant Yunnan Tin Group Holding Company, the largest tin producer and exporter in China and the world today.

The transformations of the twentieth century were immense, yet amid these sweeping changes, we can still trace the legacy of the technocrats of the eighteenth and nineteenth centuries. By the time Ding Zhenduo composed his memorial, the discourse around mining had shifted to, as historian Shellen Wu points out, the concept of state sovereignty and competition between states. The tools of production had also evolved, moving from manually operated water pumps and smelting furnaces to machines imported from Germany. However, when we set aside intellectual discourse and examine actual practices, we can still observe similarities between Ding Zhenduo in 1905 and the technocratic-minded bureaucrats of the eighteenth and nineteenth centuries. Officials continued to visit mining sites to learn about mining technology so as to guide their policy-making process, and the government continued to rely on close collaboration with merchants to extract natural resources. Thus, these dramatic changes, including the modernization and industrialization projects in the late Qing, while undoubtedly a response to European influence, also represented a continuation of the creative and innovative strategies employed by Qing bureaucrats starting in the eighteenth century.

Different Responses to Global Trade and Capitalism

We witnessed the start of the tin centuries at the beginning of the eighteenth century, when global trade and the expansion of capitalism put unprecedented pressure on the demand for tin in China. This demand manifested in multiple ways: economic development increased the use of pewter as an everyday material, expanding commercial activities heightened the need for coinage, and the massive export trade in tea created enormous demand for tin-lined containers. The Qing state, its bureaucrats, and the broader population responded to these pressures in different ways.

Landless peasants and adventurous entrepreneurs responded to the market demand, ecological pressure, and government restrictions on mining by migrating to mining frontiers in Yunnan and Bangka, fundamentally altering local landscapes, economies, and societies. In these frontier regions, Chinese miners and merchants employed the social technology of mining to efficiently organize capital and labor, pushing local residents (such as those in Bangka and Gejiu) to the less profitable margins of the mining industry. Their production methods and social organization, coupled with a culture of fraternity, naturally aligned with the profit-driven nature of capitalism and the capital- and labor-intensive demands of the mining industry, making them natural allies in the global expansion of capitalism. However, in this pursuit of wealth accumulation, only a small number of Chinese merchants and miners emerged as winners. Most, through exploitation of their bodies and labor, unwittingly became the labor force in the colonies that fueled the so-called European miracle.

Simultaneously, the Qing state developed a system of mining taxation and management, creating a political economy that diverged from Ming precedents. At the end of the Qing bureaucratic administration, county-level officials in Yunnan were particularly attuned to the growing significance of mining due to their close interactions with miners and merchants. Through constant engagement with mining production and administration, these bureaucrats developed a keen awareness of the critical roles that capital, organization, and skilled labor played in the mining industry. The bureaucrats' involvement in mining administration also motivated knowledge production. From the eighteenth century onward, Qing bureaucrats produced mining treatises and texts, primarily contributed by county-level officials. Figures like Wu Qijun later systematized this information, enabling mining

knowledge to undergo a twofold transformation during the nineteenth century: first, from being a subsidiary branch of monetary law to becoming an autonomous field of expertise; and second, from highly localized Yunnan knowledge to a shared body of information circulated among state officials.

To bolster the mining industry, Qing bureaucrats creatively initiated government efforts to recruit investors and skilled labor. Over time, they innovatively created the model of merchant management under bureaucratic supervision, which emerged from informal practices in the eighteenth century. This model laid the groundwork for industrialization projects in the late Qing. Remarkably, the solutions devised by Qing bureaucrats bore similarities to those of colonial officials employed by the Dutch and British. This suggests that Qing officials did not lag in their awareness of and response to global changes. However, unlike European colonial officials, whose primary goal was resource extraction and profit maximization, Qing officials, until the mid-nineteenth century, remained conditioned by the Confucian ideal of a benevolent, providential, small state. In contrast to the more aggressive European approach, Qing direct investment in mining came surprisingly late. In the case of tin, it was only in 1905 that the provincial government of Yunnan began to fund tin mining.

Another difference between the eighteenth-century Qing state and European powers lay in their methods of sourcing materials. Rather than engaging in direct extraction through costly and cumbersome administrative systems, the Qing state flexibly harnessed both global and domestic trade networks, effectively utilizing merchant expertise to procure materials for the state. Whether it was silver from the Americas, copper from Japan, tin from Bangka, hardwood from India, jade from Xinjiang, or timber from Guizhou, the Qing court relied on cooperation between bureaucrats and merchants to source these materials. The Imperial Household Department and licensed traders formed close ties to fulfill this goal.⁶ This close collaboration significantly enhanced Qing officials' expertise in trade and procurement, making bureaucrats act like seasoned merchants. This flexible approach to resource management began to falter, however, in the nineteenth century, as China lost its dominant position in the global export market. Consequently, the Qing shifted from procurement to directly supporting and investing in mining, thereby engaging in the global competition to assert sovereignty over mining rights.

The Spread of Technocratic Statecraft Among Confucian Elites

From the eighteenth century onward, scholar-officials trained in Confucian classics began to cultivate a technocratic culture. Through close interactions with miners and merchants, they developed technological expertise, which they applied to their administrative duties and policy-making processes. While this technocratic culture began to be subtly integrated into practice during the eighteenth century, it became more explicit in the nineteenth century. Bureaucrats' understanding of technology gradually came to coexist with, and at times even supersede, traditional moral discourse as the basis for arguments in court memorials.

This shift among Confucian elites can be attributed to multiple factors. First, we must not overlook the influence of the Manchu court. As historians Dorothy Ko and Kai Jun Chen point out, a technocratic culture was established at the central court from the founding of the Qing dynasty. Manchu rulers valued and respected knowledge about material production. Bannermen experts mastered production management and craft skills, leveraging this technological knowledge to advance their political status.⁷ At the same time, the increasingly intense competition in the civil service examinations, together with the commercial revolution, blurred the boundaries between artisan-scholars and scholar-artisans, challenging the traditional hierarchy of "mind over hand."⁸

Although the Han Chinese bureaucrats discussed in this book continued to begin careers through their mastery of Confucian classics, they increasingly relied on technological expertise as the key to accessing power since the eighteenth century. Among them were county magistrates in Yunnan who were specialized in mining, provincial governors who conducted experiments to create new alloys to solve the monetary crisis, and officials who learned accounting and auditing for the sake of procurement. The technocratic culture that originated in the Manchu court gradually permeated all levels of the imperial bureaucratic system, reaching even the remote frontiers of Yunnan.

In contrast to the relatively subtle changes in the eighteenth century, the transformations of the nineteenth century were pronounced and dramatic. Under the pressure of financial, economic, and ecological crises, elites of the Qing empire urgently sought ways to save the empire by drawing on examples from an earlier pragmatic approach to governance. In the realm of mining, this urgency manifested in Wu Qijun's efforts to codify and systematize

knowledge about mining technology. Wu Qijun, a top candidate in the civil service examination, advanced his career through his botanical knowledge and expertise in mining and salt administration. The technological approach to statecraft was not confined to mining; it was widely applied across various domains, including agriculture, hydraulic engineering, salt administration, and military logistics. Influenced by the publication of *Collected Essays About Statecraft of the Qing*, reformist intellectuals used previously accumulated technological knowledge as inspiration to guide the industrialization projects in the late Qing. In these reformist projects, civil officials gradually replaced the Imperial Household Department and bannermen technocrats in managing material production in the empire, emerging as the driving force behind the industrialization of China.

Expanding the Range of Natural Resources Under State Management

The technocratic turn in statecraft among Qing bureaucrats was accompanied by an increasing variety of natural resources coming under direct state management. Qing elites referred to natural resources as “the beneficence of heaven, earth, and nature.” In the eighteenth century, discourses about these natural resources typically centered around the proper utilization of agricultural land, forest, rivers, and a few precious minerals, such as gold, silver, copper, and jade.⁹ In eighteenth-century discourse, these natural resources were primarily viewed as serving the well-being of the people, with state taxation regarded as a secondary bonus. These resources belonged to the traditional statecraft domains that Confucian elites had a long history of managing: agronomy, hydraulic engineering, taxation, and monetary law.

In the nineteenth century, two significant shifts occurred in the management of natural resources. First, there was a shift in the discourse on *li*, the concept of benevolence or profit derived from these resources. The focus gradually moved from people’s welfare to profits in the service of state wealth and power. Simultaneously, an increasing number of materials and commodities previously sourced through merchant networks were brought under direct state control as part of the “profits of nature.” As a result, the scope of knowledge concerning the management of these natural resources expanded among Confucian-educated elites.

Compared to agronomy and hydraulic engineering, mining technology and management were relatively new fields for Confucian scholars. Before

Wu Qijun's mining treatise, scholarly attention to mining was largely confined to taxation and monetary law. It was not until the publication of the *Sequel to Collected Essays About Statecraft of the Qing* (Huangchao jingshi wen xubian; 1897) that mining was recognized as a distinct category of statecraft knowledge.¹⁰ In this 1898 sequel, the chapter on mining included court memorials on coal mines and other mineral resources written by prominent late Qing statesmen such as Li Hongzhang (1823–1901), Lin Zexu, and Zhang Zhidong (1837–1909). This compilation marked the independence of mining management from monetary law, establishing mining as a distinct category of statecraft. It also indicated that the state's management of minerals had gradually expanded beyond precious metals associated with mintage to encompass all mineral resources, including the cornerstones of modern industry: coal and iron.

Among minerals, tin did not receive direct state investment until the early twentieth century. Although tin had long played an important role in both daily life and the state's monetary system, its mining had always been operated by the private sector. For a long time, the Qing state sourced tin primarily through global trade networks. The incorporation of tin into the domain of natural resources that required direct state management mirrored the experience of coal described by Shellen Wu. It was only when tin became highly profitable in the global market, and its mining rights were coveted by foreign powers, that the Qing state began to actively promote tin mining and safeguard its sovereignty over the industry.

From the perspective of resource management, the technocratic culture of the Qing dynasty may not have been a uniquely Chinese phenomenon but rather part of a global trend driven by capitalism and industrialization. As capitalist industrial production started to consume a wider range of natural resources, the fate of the state became increasingly tied to its ability to exploit and control these resources. The scarcity and profitability of these resources made them a subject of bureaucratic management. Consequently, pragmatic and technological knowledge related to the utilization, extraction, and processing of these resources naturally emerged as a crucial source of power.

Have the Tin Centuries Ended?

Today, because tin is primarily used in industrial processes and intermediate manufacturing, most ordinary people have become unfamiliar with this

metal. This stands in stark contrast to the eighteenth and nineteenth centuries, when tin was an integral part of daily life through pewter vessels, coins, and household items. The tin centuries have never entirely ended, but they underwent a profound structural transformation in the late nineteenth and early twentieth centuries. The invention and widespread adoption of tin cans in the food industry, along with tin's critical applications in steam engines and internal combustion engines, transformed tin from an ordinary global commodity into a strategic metal essential for both welfare and warfare. Within this emerging global capitalist economy, Europe and America became the largest consumers of tin. Due to their control of smelting facilities, Western powers also captured the most profitable segments of the value chain, while the Global South was relegated to the most vulnerable position as raw material suppliers. The tin industry became increasingly cartelized.¹¹

China's position in this global system underwent a dramatic reversal: by the end of the nineteenth century, it changed from a major tin consumer to a raw material exporter. Large quantities of tin from Gejiu were transported to Vietnam via the Yunnan-Vietnam Railway, then shipped to Hong Kong and onward to European refineries. This shift reflected broader changes in global economic geography and China's integration into the capitalist world system. In Southeast Asia, the mid-nineteenth century witnessed increased Chinese migration, but these migrants no longer participated as shareholders. Instead, they became coolie laborers whose exploitation sustained European hegemony. Meanwhile, the role of the state also changed. Particularly in Yunnan, competition with French imperialists for mining rights intensified state involvement in the mining sector, leading to the founding of the Yunnan Tin Company.

The tin centuries, characterized by both continuity and transformation, extend to the present day, though this book focuses on its initial stage. In the twentieth century, the tin industry underwent a structural change: global value chains were reconstituted, the state's role was transformed, and tin evolved from a regional commodity into a strategic resource. In the context of these drastic changes, some continuities persisted from the eighteenth century. Tin remained a crucial commodity, the technocratic tradition continued to evolve, and migration patterns endured. Although we can no longer easily find adventurous entrepreneurs like Fan Yasi, the role of technocrats in Chinese governance has persisted and become increasingly important.

GLOSSARY

Place names commonly found in standard references are omitted; original characters for authors and book titles cited in the notes are provided in the bibliography.

- | | |
|--------------------------------------|--|
| Akdun 阿克墩 | chonggou / chungkow 沖溝 |
| ancha shi 按察使 | chongshui gou / choonchweekoo 沖水溝 |
| | chou 稠 |
| baigang xi 白剛錫 | <i>Chou Dian shi shu</i> 籌滇十疏 |
| balitou / paritheeuw 巴力頭 | Chu Bangli 褚邦禮 |
| Ban-di 班第 | ciam / jian (PY) 尖 |
| banshanke 半山客 | Cunfen 存棻 |
| Bao Shichen 包世臣 | cuobianjiang 剗邊匠 |
| Baochang Ju 寶昌局 | |
| baojia 保甲 | dage 大哥 |
| Baoquan Ju 寶泉局 | danfen zhi 石分制 |
| Baoyuan Ju 寶源局 | <i>Daxue</i> 大學 |
| beihuang 背荒 | <i>Dianhai yuheng zhi</i> 滇海虞衡志 |
| beitou / peetow 陂頭 | <i>Diannan kuangchang tulüe</i> 滇南礦廠圖略 |
| Belin 伯麟 | <i>Diannan kuangchang yucheng tulüe</i> 滇
南礦廠輿程圖略 |
| Boohing 寶興 | diantong 點銅 |
| bufenzhi 不分汁 | <i>Dianxi</i> 滇繫 |
| Cai Yurong 蔡毓榮 | Ding Wenjiang 丁文江 |
| caiban 採辦 | Ding Zhenduo 丁振鐸 |
| " <i>Caitong liantong ji</i> " 采銅煉銅記 | Dingziku 丁字庫 |
| Cao Yin 曹寅 | dixiong 弟兄 |
| caopi jian 草皮尖 | dong 洞 (character used in Wu Qijun's
mining treatise) |
| caoping yin 漕平銀 | dong 洞 (character used in Ban-di's
memorial) |
| chang 廠 | dong laoda 董老大 |
| changmin 廠民 | Dongshu 東墅 |
| changwu 廠務 | dongtou 硐頭 |
| cheekow / chegou (PY) 車溝 | dongzhang 硐長 |
| Chen Hongmou 陳宏謀 | |
| Chen Shilie 陳世烈 | |

Fan Yasi 范亞四
fanshajiang 翻砂匠
Fei Xin 費信
fenggui 風櫃
fenjin lu 分金爐

Gan Guobi 甘國壁
“Gejiu gongyi changgui bei ji” 個舊公議
廠規碑記
gewu 格物
gong 公
gongsi / kongsì 公司
gongyi 公議
guan 官
guancheng 官秤
guandu 官牒
guandu shangban 官督商辦
Guansheng Gong 關聖宮
Guanzi 管子
Guiliyang 桂良
gunbianjiang 滾邊匠
guoji 國計
guotou 鍋頭

Haiwang 海望
He Changling 賀長齡
Hengshan 恒善
Heßen 和珅
Hong Mai 洪邁
Huang Wenbing 黃文斌
Huang Zhao 黃肇
Huangchao jingshiwen bian 皇朝經世
文編
Huangchao jingshiwen xubian 皇朝經世
文續編
huangqian 黃錢
huangtong 黃銅
huiguan 會館
hun / fen 分
huwei biao 互為表裡

“Ji Tongzheng quanshu yougan” 輯銅政
全書有感

jian 尖 (ciam)
jingshi zhiyong 經世致用
jinshi 進士
juren 舉人

Kaihaku goshi shinrei 海舶互市新例
Kang Ling 康鋌
kanhuo jiang 看火匠
kezhang 課長 (tax chief)
kezhang 客長 (guest chief)
Kingfu 慶復
Kodō zuroku 鼓銅凶錄
kongsì / gongsì 公司
kuangchang 礦廠
“Kuangchang cailian pian” 礦廠采煉篇
kuangdao 礦盜
kuangtu 礦徒
kuangxue 礦學
Kuangxue xinyao xinbian 礦學心要新編
kuangyin 礦銀
kuping liang 庫平兩
kuping yin 庫平銀

Lanfang Gongsì/Kongsì 蘭芳公司
li 利
Li He Hao 麗和號
Li Hongzhang 李鴻章
Li Hu 李湖
Li Mao 李茂
Li Shiping 李世屏
Li Xuan 李鋤
Lin Daoqian 林道乾
Lin Zexu 林則徐
Liu Shiyan 劉世衍
long 竜
Lu Xue 魯學
Luo Fangbo 羅芳伯
lutou 爐頭

Ma Huan 馬歡
Mansuo 慢梭
Maolong 茂隆
Martai 馬爾泰

menliang 悶亮
 mifen zhi 米分制
 min 民
 minzu shibie 民族識別
 moqianjiang 磨錢匠
 muqian 母錢

Nan Shufang 南書房
 Nasutu 那蘇圖
 Neige Zhongshu 內閣中書
 Ni Shenshu 倪慎樞
 Ni Tui 倪蛻
 niu chi shui 牛吃水

Omida 鄂弥达

pingtui 平推

Qi Zhengchang 祁正昌
 qianfa 錢法
 qiangui 錢貴
 qianhuang 錢荒
 qinfu 親赴
 Qing shilu 清實錄
 qingqian 青錢
 qingtong 青銅
 qinshen 親身
 qinwang chayan 親往查驗
 qizhang 七長
 Qu Dajun 屈大均
 Qun fang pu 群芳譜

rouhuang 揉垹
 ruhuo 入伙

Sazai 薩載
 shading 砂丁
 shangqianren 上前人
 Shi Fan 師範
 shiping yin 市平銀
 shuagou / swakow 刷溝
 shuahuijiang 刷灰匠
 shu'an tongjiang 熟諳銅匠

Shuowen jiezi 說文解字
 shuji 書記
 si 私
 sizhu jiesuan 四柱結算
 Song Gengping 宋賡平
 Song Yingxing 宋應星
 Sun Liangcai 孫良才
 Sungyūn 松筠

Tan Cui 檀萃
 Tang Jiong 唐炯
 Tang Lian 湯璉
 Tang Ying 唐英
 tanzhang 碳長
 tiandi ziran zhi li 天地自然之利
 Tian gong kai wu 天工開物
 Tong Hua 童華
 tonghuang 銅荒
 tongzheng 銅政
 Tongzheng bianlan 銅政便覽
 Tongzheng kao 銅政考
 Tongzheng quanshu 銅政全書
 “Tongzheng tiao yi” 銅政條議
 tugong 土貢
 tulüe 圖略
 Tusde 圖思德

waiyi yangshang 外夷洋商
 Wang Anguo 王安國
 Wang Chang 王昶
 Wang Song 王崧
 Wang Taiyue 王太岳
 Wanli kuaiji lu 萬曆會計錄
 Wanshou Gong 萬壽宮
 Wei Yuan 魏源
 weiyuan 委員
 Wu Qijun 吳其濬
 Wu Qiyān 吳其彥
 Wu Tan 吳壇
 Wu Xuan 吳烜

xi 錫 (tin, the metal)
 xi 稀 (thin, as in fluidity)

xiangtou 鑲頭
xiaoqian 小錢
Xinxiu bencao 新修本草
xiyanjiang 洗眼匠
Xizhao tulüe 西招圖略
Xu Hongzu 徐宏祖
Xu Jinsheng 徐金生
Xu Xun 許遜

yang 樣
yangxi 洋錫
yaopai 腰牌
Yi 彝
yingzao chi 營造尺
Yu Qingchang 余慶長
yuehuo 月活
yuehuotou 月活頭
yulou nong 雩婁農
Yun Miao 雲廟
Yunnan kuangchang gongqi tulüe 雲南礦
廠工器圖略
Yunnan tongzhi 雲南銅志

Yunnan tongzhi gao 雲南通志稿
Yunsheng Huiguan 雲省會館

zazuo 雜作
Zhang Ruozhen 張若震
Zhang Yingzong 張應宗
Zhang Zhidong 張之洞
zhaoshang kaicai 招商開採
Zheng He 鄭和
zheng jian duo di 爭尖奪底
Zhi Huai shangyou lun 治淮上遊論
Zhihe Fanglüe Guan 治河方略館
Zhihe tulüe 治河圖略
Zhiwu mingshi tukao 植物名實圖考
Zhong Guangyu 鐘光豫
Zhou Enmin 周恩民
Zhou Zhiqi 周之琦
Zixun gechang dui 咨詢各廠對
zouchang zhe 走廠者
zouxiao 奏銷
zuqian 祖錢

NOTES

INTRODUCTION

1. "Dr. Gillan's Observations on the State of Medicine, Surgery, and Chemistry in China," in Macartney and Cranmer-Byng, *An Embassy to China*, 296.
2. Yu Minzhong et al., *Qinding hubu guzhu zeli*, 2:25–26.
3. Liu, *Tea War*.
4. Economic historians have written extensively on silver and the Chinese economy. See Von Glahn, *Fountain of Fortune*; Lin, *China Upside Down*; Dean, *China and the End of Global Silver*. For important Chinese language works, see Peng Xinwei, *Zhongguo huobishi*; Dai Jianbing, *Zhongguo jindai yinliang shi*. For export silver in luxury production, see Eberhard, "Metamorphic Medium"; Eberhard, "Extractive Romances"; Chan and Wan, *The Silver Age*.
5. For the study of Qing monetary policy, see Dunstan, "Safely Supping with the Devil"; Hall, "Notes on the Early Ch'ing Copper Trade"; Vogel, "Chinese Central Monetary Policy." For state management of copper mining, including the state loan for mining, see Chang Ling, "Qingdai Yunnan de 'fangben shoutong' zhengce." Yang Yuda, Nanny Kim, and Chiu Peng-Sheng have produced a number of works on copper shipping and the copper market. See Kim, *Mountain Rivers, Mountain Roads*; Yang Yuda, "Diantong, Hantong, yu Qingdai zhongqi de Hankou tong shichang"; Chiu Peng-Sheng, "Shiba shiji dientong shichang."
6. Hailian Chen, *Zinc for Coin and Brass*.
7. Peter Golas has conducted comprehensive research on mining technology in general, with a small portion on tin mining in Yunnan, China. See Golas, *Science and Civilisation in China*, vol. 5, pt. 13. On iron technology, see Wagner, *Science and Civilisation in China*, vol. 5, pt. 11. On zinc technology, see Hailian Chen, *Zinc for Coin and Brass*. On silver mining in late imperial China, see Kim, "Silver Mines and Mobile Miners."
8. Archaeo-metallurgists have done a lot of research on tin mining and smelting in early China. See Yingchen Wang et al., "Imported or Indigenous?" In his erudite work on Chinese mining technology, Peter Golas devotes a small section of his book to tin mining technology in Gejiu, primarily based on late Qing mining manuals and twentieth-century social surveys. However, due to the scope of his book and the limits of his sources, he barely covers changes in the seventeenth and nineteenth centuries, when major mining activities moved

- from China proper to frontier areas like Yunnan and Southeast Asia. Golas, *Science and Civilisation in China*, vol. 5, pt. 13, 90–105.
9. For example, see Raj, *Relocating Modern Science*; Cook, *Matters of Exchange*.
 10. Smith, *Entangled Itineraries*.
 11. Pagani, *Eastern Magnificence and European Ingenuity*; Andrade, *The Gunpowder Age*; Hostetler, *Qing Colonial Enterprise*.
 12. Schäfer, “Silken Strands”; Kai Jun Chen, *Porcelain for the Emperor*.
 13. Reid, “An ‘Age of Commerce’ in Southeast Asian History”; Kuhn, *Chinese Among Others*, 9–10.
 14. Blussé, “Chinese Century”; Blussé, *Strange Company*; Cushman, *Fields from the Sea*; Trocki, *Prince of Pirates*; Ng, *Trade and Society*; Reid, “Chinese on the Mining Frontier in Southeast Asia”; Yuan, *Chinese Democracies*.
 15. Heidhues, *Bangka Tin and Mentok Pepper*.
 16. Heidhues, “Chinese Organizations in West Borneo and Bangka.”
 17. Yang Yuda, “Silver Mines in Frontier Zones”; Kim, “Silver Mines and Mobile Miners.”
 18. Shapin and Schaffer, *Leviathan and the Air-Pump*, 18–19, 25, 69–76, 78.
 19. Bray, “Science, Technique, Technology.”
 20. Eyferth, *Eating Rice from Bamboo Roots*.
 21. Macauley, *Distant Shores*.
 22. Pomeranz, *Great Divergence*.
 23. Mitchell, *Rule of Experts*.
 24. Fischer, *Technocracy and the Politics of Expertise*; Olson, *Scientism and Technocracy*.
 25. Seow, *Carbon Technocracy*, 16.
 26. Ko, *The Social Life of Inkstones*, 11. Here I follow Dorothy Ko in using Aristotle’s definition of *technē*, which refers to practical knowledge by which people produce and use valuable goods.
 27. The Imperial Household Department served as the primary institution for material production and management for the Qing court. For a general introduction to the Imperial Household system, see Rawski, *The Last Emperors*. For ethnography and cartography, see Hostetler, *Qing Colonial Enterprise*. For the salt monopoly, see Yulian Wu, *Luxurious Networks*. For the management of natural resources, see Schlesinger, *A World Trimmed with Fur*.
 28. Ko, *The Social Life of Inkstones*.
 29. Kai Jun Chen, *Porcelain for the Emperor*.
 30. Hartman, *Structures of Governance*.
 31. For English scholarship on salt administration, see Yulian Wu, *Luxurious Networks*. For scholarship in Chinese, see Chen Ran et al., *Zhongguo yanyeshi luncong*. For developments in the Ming and Qing dynasties, see Ni Yuping, *Boyi yu junheng*; Fan Jinmin, “Mingdai Huizhou yanshang”; Li Keyi, “Qingdai de yanguan yu yanzheng.”
 32. For the history of water management and its relationship to the Chinese state,

see Mostern and Horne, *The Yellow River*; Gao, *Yangzi Waters*; Ling Zhang, *The River, the Plain, and the State*; Dodgen, *Controlling the Dragon*. For hydraulic engineering technology, see Needham, “Hydraulic Engineering (II): Control, Construction and Maintenance of Waterways,” in *Science and Civilisation in China*, vol. 4, pt. 3, 211–365.

33. Rowe, *Saving the World*.
34. Leonard, *Controlling from Afar*.
35. Schäfer, *The Crafting of the 10,000 Things*.
36. Elman, *On Their Own Terms*.
37. Yulian Wu, *Luxurious Networks*.
38. He Bian, *Know Your Remedies*.
39. Shellen Xiao Wu, *Empires of Coal*; Seow, *Carbon Technocracy*.
40. Lavelle, *The Profits of Nature*.

CHAPTER 1. MIGRATING MINERS AND SHIFTING CENTERS

1. Xia Xiangrong et al., *Zhongguo gudai kuangye kaifa shi*, 20. For the discovery of pure tin decoration on bronze, see Wang et al., “Imported or Indigenous?” 177.
2. For early pewter vessels, see Li Yang et al., “Suizhou wenfengta M1, M2,” 92.
3. Wu Zimu, *Meng liang lu*, 13:4b.
4. Guojia wenwuju shuixia wenhua yichan baohu zhongxin et al., *Nanhai yihao chenchuan kaogu baogao zhi er*, vol. 2, 503–8.
5. *Erya*, 11.
6. Xu Shen, *Shuowen jiezi*, 293.
7. Li Shizhen, *Bencao gangmu*, 481.
8. Li Shizhen, *Bencao gangmu*, 482.
9. International Tin Association, “Global Resources and Reserves,” 2020.
10. Song Yingxing, *Tian gong kai wu*, vol. 3, *juan* 14, 10a.
11. Qu Dajun, *Guangdong xinyu*, 15:10a–b.
12. Song Yingxing, *Tian gong kai wu*, vol. 3, *juan* 14, 10a.
13. Xu Hongzu, *Xu Xiake youji*, 356.
14. Gu Yanwu, *Zhao yu zhi*, vol. 3, 1890.
15. Von Glahn, “Modalities of the Fiscal State.”
16. Wong, *China Transformed*; Wong, “Taxation and Good Governance.”
17. Huan Kuan, *Yan tie lun*, sec. 1, 1:1a–5b, translation from William de Bary et al., *Sources of Chinese Tradition*, vol. 1, 360–61.
18. Fang Xing, “Kuangshui yinliang,” 206.
19. Fang Xing, “Kuangshui yinliang”; Lin Feng, “Wanli kuangjian shuishi yuanyin zaitan.” I thank Siyen Fei for the reference.
20. Wan et al., *Mingdai wanli kuaijilu zhengli yu yanjiu*, vol. 2, 1253–5. I thank Richard von Glahn for referring me to this source.
21. Wan et al., *Mingdai wanli kuaijilu zhengli yu yanjiu*, vol. 1, 662–64.

22. Gu Yingtai, *Ming shi ji shi ben mo*, vol. 3, 1023.
23. Tang Lizong, *Keng ye jing li*.
24. Crawford, "Eunuch Power in the Ming Dynasty."
25. Ray Huang, *Taxation and Governmental Finance*, 241.
26. Xu Hongzu, *Xu Xiake youji*, 357.
27. Tang Lizong, *Keng ye jing li*, 122.
28. Gu Yanwu, *Zhao yu zhi*, vol. 3, 1890.
29. Tang Lizong, *Keng ye jing li*, 122.
30. Qu, *Guangdong xinyu*, 15:10a-b; Tang Lizong, *Keng ye jing li*, 500.
31. Ray Huang, *Taxation and Governmental Finance*, 241.
32. James Tong, *Disorder Under Heaven*, 58-64.
33. Tang Lizong, *Keng ye jing li*, 504-5.
34. Zhang Tingyu et al., *Ming shi*, 81:3330.
35. Zhao Erxun et al., *Qing shi gao*, 124:3664.
36. Wei and Lu, "Qingdai qianqi kuangye zhengce de yanbian (shang)"; Wei and Lu, "Qingdai qianqi kuangye zhengce de yanbian (xia)."
37. Ortai et al., *Zhu pi yu zhi*, case 1, vol. 4, "Kong Yuxun shang," 47a.
38. Ortai et al., *Zhu pi yu zhi*, case 1, vol. 4, "Kong Yuxun shang," 47b.
39. Taisu Zhang, *The Ideological Foundations of Qing Taxation*.
40. Guoli gugong bowuyuan, *Gongzhongdang Kangxi chao zouzhe*, vol. 3, 842-45.
41. Guoli gugong bowuyuan, *Gongzhongdang Kangxi chao zouzhe*, vol. 3, 899-902.
42. Omida, palace memorial, QL 3/1/24 (1738), FHA, no. 04-01-36-0083-008; Omida, QL 3/2/25 (1738), FHA, no. 04-01-01-0032-029.
43. Omida, QL 3/2/25 (1738), FHA, no. 04-01-01-0032-029.
44. See Omida, palace memorial, QL 3/1/24 (1738), FHA, no. 04-01-36-0083-008; Omida, QL 3/2/25 (1738), FHA, no. 04-01-01-0032-029.
45. Omida, QL 3/2/25 (1738), FHA, no. 04-01-01-0032-029.
46. Omida, QL 3/2/25 (1738), FHA, no. 04-01-01-0032-029.
47. Omida, QL 3/2/25 (1738), FHA, no. 04-01-01-0032-029.
48. Ownby and Heidhues, "Secret Societies" Reconsidered; Ownby, *Brotherhoods and Secret Societies*; Murray and Qin, *The Origins of the Tiandihui*.
49. Heidhues, "Chinese Organizations in West Borneo and Bangka."
50. On the trade in Japanese copper, see Hall, "Notes on the Early Ch'ing Copper Trade"; Dunstan, "Safely Supping with the Devil." For Qing monetary policy, see Vogel, "Chinese Central Monetary Policy."
51. Omida, routine memorial, QL 3/2/26 (1738), FHA, no. 02-01-04-013108-020.
52. Omida, routine memorial, QL 3/2/26 (1738), FHA, no. 02-01-04-013108-020.
53. Martai, routine memorial, QL 4/5/6 (1739), FHA, no. 02-01-04-13202-017.
54. Martai, routine memorial, QL 4/5/6 (1739), FHA, no. 02-01-04-13202-017.
55. Martai, routine memorial, QL 4/5/6 (1739), FHA, no. 02-01-04-13202-017.
56. Yang Xifu, palace memorial, QL 13/2/5 (1748), FHA, no. 04-01-36-0086-020.
57. Omida, routine memorial, QL 3/2/16 (1738), FHA, no. 02-01-04-13108-020.

58. Omida, routine memorial, QL 3/2/16 (1738), FHA, no. 02-01-04-13108-020.
59. In 1738 and 1740, Omida was attacked by officials Chen Gaoxiang and Shen Shifeng. They accused Omida of colluding with salt merchants by inviting them to invest in mining operations and lending them money at interest. In his defense, Omida explained that he loaned the money to merchants and used the interest to build dikes and dams. The Qianlong emperor dismissed the accusations, suggesting tacit approval of such arrangements. See Chen Gaoxiang, QL 3/5 (1738), FHA, no. 03-0984-012; Ortai's defense of Omida, QL 3/6/14 (1738), FHA, no. 03-1096-007; Shen Shifeng, palace memorial, QL 5/7/22 (1740), FHA, no. 04-01-01-0052-035.
60. For the role of salt merchants in the material culture of the Qing court, see Yulian Wu, *Luxurious Networks*.
61. For every hundred *jin* of tin, the government procurement price was nine taels of silver, while the market price was twenty-two taels of silver. Xu Ben, routine memorial of the Ministry of Revenue, QL 8/6/22 (1743), cited from Zhongguo renmin daxue Qing shi yanjiusuo, *Qingdai de kuangye*, vol. 2, 610.
62. Xu Ben, routine memorial of the Ministry of Revenue, QL 8/6/22 (1743), cited from Zhongguo renmin daxue Qing shi yanjiusuo, *Qingdai de kuangye*, vol. 2, 616.
63. Yu Minzhong, routine memorial, QL 40/12/14 (1775), FHA, no. 02-01-04-16736-008.
64. Lin Rongqin, *Qing dai Hunan de kuangye*, 120. Kang Shaoyong, routine memorial, DG 8/05/01 (1828), FHA, no. 02-01-04-20345-018.
65. Chen Xin and Wang Zhitai, "Distribution of Tin Deposits in China."
66. Schwartz et al., "The Southeast Asian Tin Belt."
67. Nanny Kim and Yang Yuda are the few who have discussed the mobility of miners in Yunnan. See Kim, "Silver Mines and Mobile Miners"; Yang Yuda, "Qingdai zhongqi Dian bian yinkuang." See also Yang Yuda, "Silver Mines in Frontier Zones."
68. Zhang Yingzong, palace memorial, YZ 9/11/01 (1731), National Palace Museum Digital Library of Qing Archives, Taipei, no. 005477/402002458.
69. Chen Wenwei, Pan Qingjian, and Fan Chun'gui, *Qinding Yue shi tongjian gang-mu*, 35:21a, 43:1b.
70. Kim, "Silver Mines and Mobile Miners"; Yang Yuda, "Qingdai zhongqi Dian bian yinkuang." See also Yang Yuda, "Silver Mines in Frontier Zones."
71. Cai, "Chou Dian shi shu," 689–707.
72. Cai, "Chou Dian shi shu," 689–707.
73. Cai, "Chou Dian shi shu," 695.
74. Chang, "Qingdai Yunnan de 'fangben shoutong' zhengce."
75. Kim, *Mountain Rivers, Mountain Roads*, 391–94.
76. Lan, "Qingdai diantong jingyun dui yantu de yingxiang yanjiu." See also Kim, "Copper Transports Out of Yunnan."
77. Lan, "Qingdai diantong jingyun luxian kaoshi."
78. Hirzel, "Mint Metal Procurement for Jiangsu and Zhejiang"; Kim, *Mountain*

Rivers, Mountain Roads; Ma Qi, “Qingdai gesheng caimai diantong de yunshu wenti.”

79. Fei Huang, *Reshaping the Frontier Landscape*.
80. For instance, in Ruan Yuan’s *Yunnan tongzhi gao*, mining regulations were listed under “kuangchang,” and in Li Kun’s *Mengzi xian zhi*, mining was listed under “changwu.” See Ruan et al., *Yunnan tongzhi gao*, 1:3a; Li Kun, *Mengzi xian zhi*, 8.
81. For *changmin*, see Ortai et al., *Yunnan tongzhi*, 11:52a; Li Kun, *Mengzi xian zhi*, 44. For *zouchang zhe*, see Tu Shulian et al., *Tengyue zhou zhi*, 10:50a; Xu Mengzi *xian zhi*, 12:27b.
82. Yang Yuda, “Diantong, Hantong, yu Qingdai zhongqi de Hankou tong shichang.” Yang’s research points out that even though copper was under government monopoly, a large amount of copper was traded in private markets.
83. Wang Mo, palace memorial, QL 5/7/2 (1740), FHA, no. 04-01-35-1231-015.
84. Shimada, “18 seiki ni okeru Oranda Higashi Indo Gaisha no suzu bōeki.”
85. See Smith, “The Codification of Vernacular Theories of Metallic Generation”; Smith, *The Body of the Artisan*.
86. Schäfer, *The Crafting of the 10,000 Things*, 97.
87. Bian, *Know Your Remedies*, 47.
88. Tang Lizong, *Keng ye jing li*, 34.
89. Fang Xing, “Kuangshui yinliang”; Lin Feng, “Wanli kuangjian shuishi yuanyin zaitan.”
90. Pan, “The Spread of Georgius Agricola’s *De Re Metallica*.”
91. Tang Lizong, *Keng ye jing li*, 282–83.
92. For instance, in Guangdong an official named Tuoyong used his knowledge in accounting to explain the increasing cost of mining. See Xu Ben, routine memorial of the Ministry of Revenue, QL 8/6/22, cited from *Zhongguo renmin daxue Qing shi yanjiusuo*, *Qingdai de kuangye*, vol. 2, 615.
93. Cai, “Chou Dian shi shu,” 696.
94. Preface to Ni Tui, *Dian yun li nian zhuan*, 6.
95. Ni Tui, “Fu dangshi lun changwu shu,” 122–23.
96. Ni Tui, “Fu dangshi lun changwu shu,” 123.
97. Ni Tui, “Fu dangshi lun changwu shu,” 123.
98. From 1830 to 1832, Ni Shenshu served as the magistrate for Hejin County, and then as magistrate for Xiangyuan County from 1839 to 1842. See Mao Pixi, *Hejin xian zhi*, 5:7a; Li Tingfang et al., *Xiangyuan xian zhi*, 9:13b.
99. Ni Shenshu, “Caitong liantong ji,” in Ruan Yuan et al., *Yunnan tongzhi gao*, 74:24a–26a.
100. Ni Shenshu, “Caitong liantong ji,” 74:26a.
101. Yu Qingchang, *Jinchang xingji*, 39a.
102. Yu Qingchang, *Jinchang xingji*, 39a.
103. Fang Guoyu, *Yunnan shiliao mulu gaishuo*, 654, 728–30.

1. Han, *Mengzi xian zhi*, 149.
2. Yin, “Gejiu gaikuang,” 13.
3. The classification of Yi as a state-recognized ethnic group, or *minzu*, occurred during the *minzu shibie* in the 1950s, which was undertaken according to the principles of classification outlined by Stalin. Harrell, *Perspectives on the Yi of Southwest China*, 7. For a detailed history of *minzu shibie*, see Harrell, *Cultural Encounters on China's Ethnic Frontiers*.
4. Harrell, *Perspectives on the Yi of Southwest China*, 7–8.
5. Long Luogui, “Honghe Yizu zhixi ji qi lishi yuanliu lüekao,” 69–71.
6. Archaeological evidence shows that traces of bronze smelting date to the Eastern Han (25–220) period. Wang Dadao, Sun Shuyun, and Li Yanxiang, “Yunnan Gejiu Chongzipipo yelian yizhi diaocha ji luzha fenxi.”
7. Ortai et al., *Yunnan tongzhi*, vol. 11, 48b, 52b.
8. Han, *Mengzi xian zhi*, 151.
9. For instance, the number of silver furnaces in Longshu decreased from thirty to one over the course of the eighteenth century. Li Kun, *Mengzi xian zhi*, 64–65.
10. *Gaozong chunhuangdi shilu*, 121:23a. The Qing court changed the alloy content of its currency as a response to the currency shortage in the early eighteenth century.
11. Macartney and Cranmer-Byng, *An Embassy to China*, 296.
12. Han, *Mengzi xian zhi*, 151–52.
13. Data in Ruan et al., *Yunnan tongzhi gao*, 74:7a. Routine memorial of the Ministry of Revenue, QL 1/10/25 (1735), cited from Zhongguo renmin daxue Qing shi yanjiusuo, *Qingdai de kuangye*, 602; routine memorial of the Ministry of Revenue, XF 1/11/02 (1851), FHA, no. 02-01-04-21489-033; Yang Juan, “Jindai guoji jingji yitihua Beijing xia Gejiu xikuang kaifa yanjiu.” This data only includes the calculated minimum output based on the tax quota. The actual mining output should be higher.
14. Studnicki-Gizbert, *The Three Deaths of Cerro de San Pedro*.
15. Smith, *From Lived Experience to the Written Word*, 91–116.
16. Li Kun, *Mengzi xian zhi*, 64.
17. I am grateful to Nanny Kim for the discussions that helped shape this idea.
18. For the case of Liu Shiyan, see the palace memorials sent by the governor-general of Yunnan and Guizhou in 1767 and 1781: National Palace Museum (Taipei), documents 403040444 and 403022770. See also the memorial by the governor-general of Yunnan and Guizhou Tusde (1716–79), QL 41/12/12 (1776), FHA, no. 04-01-12-0177-57.
19. Fei Xiaotong, *From the Soil*, 30–31; Watson, “Chinese Kinship Reconsidered.”
20. Zhang Yunsui (1693–1751), “Zhang Yunsui zougao,” 683.
21. Yao Zili, “Jiushidai Gejiu kuangqu de yixie xisu,” 150–51.

22. Moore, "Law and Social Change," 720.
23. Han, *Mengzi xian zhi*, 152–55.
24. Tan Cui, *Dian hai yu heng zhi*, 20.
25. This term and a similar social structure were mentioned by Wang Song in Ruan et al., *Yunnan tongzhi gao*; and by Wu Qijun in *Yunnan kuangchang gongqi tulüe*.
26. "Zhao Tianjue jiyi bei" (1712, 1736), reprinted in Yunnan sheng Gejiu shi zhengxie, *Gejiu wenwu gailan*, 57.
27. In 1935, there were 4,180 mining enterprises operating in Gejiu. Su, *Yunnan Gejiu xiye diaocha*, 21.
28. Wu Qijun, *Yunnan kuangchang gongqi tulüe*, 16b.
29. "Zhao Tianjue jiyi bei," 57.
30. Mann, *Local Merchants and the Chinese Bureaucracy*, 24.
31. Li Kun, *Mengzi xian zhi*, 163.
32. Li Kun, *Mengzi xian zhi*, 164.
33. The stele commemorating the founding of the Yunnan Native Place Association in 1765 identified it as the Temple of Lord Guan. The bronze bell cast in 1784 bore the inscription "Yunnan Native Place Association" (Yunsheng Huiguan). Nineteenth-century renovation inscriptions refer to it as the Yunnan Temple. This evidence indicates that the building complex had three names: Temple of Lord Guan, Yunnan Native Place Association, and Yunnan Temple. See Yunnan sheng Gejiu shi zhengxie, *Gejiu wenwu gailan*, 19, 59, 68, 70, 72.
34. Chen Shilie, "Guansheng gong bei ji," 59.
35. Chen Shilie, "Guansheng gong bei ji," 59.
36. "Gejiu Yunmiao gai xiang zhongceng tianjing gongde bei ji," 72.
37. Yunnan sheng Gejiu shi zhengxie, *Gejiu wenwu gailan*, 17–19, 72.
38. Chen Shilie, "Guansheng gong bei ji," 59–60.
39. In 1898, the Qing government established the Ministry of Railway and Mines, along with a preliminary set of regulations to respond to escalating demands for mining concessions from the European imperial powers. Later in 1902, the first set of mining regulations went into effect to foil foreign intervention. See Shellen Xiao Wu, *Empires of Coal*, 139–40.
40. "Gejiu gongyi changgui bei ji," 60.
41. "Gejiu gongyi changgui bei ji," 60.
42. Rankin, *Elite Activism and Political Transformation in China*; Rowe, *Hankow*.
43. "Gejiu gongyi changgui bei ji," 60.
44. Han, *Mengzi xian zhi*, 153–55.
45. Wu Qijun, *Yunnan kuangchang gongqi tulüe*, 20a.
46. "Gejiu gongyi changgui bei ji," 60–61.
47. "Gejiu gongyi changgui bei ji," 60–61.
48. Han, *Mengzi xian zhi*, 153–55.
49. Zelin, *The Merchants of Zigong*.

50. "Chongyi Gejiu chang tiaogui xu" (1887) and "Gejiu ban kuang tiaogui" (1890), in Yunnan sheng Gejiu shi zhengxie, *Gejiu wenwu gailan*, 61–64.
51. Ding, "Yunnan Gejiu fujin dizhi kuangwu baogao," in *Ding Wenjiang xuanji*, 233.
52. Dong Huasheng and Su Jiceng, "Gejiu xiye de tufa shengchan guocheng," 33–36.
53. Han, *Mengzi xian zhi*, 153–55.
54. "Gejiu gongyi changgui bei ji," 61; "Gejiu ban chang tiaogui," 64.
55. Su, *Yunnan Gejiu xiye diaocha*, 30.
56. Dong Huasheng and Su Jiceng, "Gejiu xiye de tufa shengchan guocheng," 39; Su, *Yunnan Gejiu xiye diaocha*, 30.
57. Ding, "Yunnan Gejiu fujin dizhi kuangwu baogao," 217.
58. Han, *Mengzi xian zhi*, 156.
59. Dayeshi Tonglüshan tongkuang yizhi baohu weiyuanhui, *Tonglüshan gu tongkuang yizhi kaogu faxian yu yanjiu*, 498–502.
60. Wu Qijun, *Yunnan kuangchang gongqi tulüe*, 3–4, 14.
61. Dong and Su, "Gejiu xiye de tufa shengchan guocheng," 38; Ding, "Yunnan Gejiu fujin dizhi kuangwu baogao," 218.
62. Han, *Mengzi xian zhi*, 154.
63. Wu Qijun, *Yunnan kuangchang gongqi tulüe*, 14a–b.
64. Han, *Mengzi xian zhi*, 156; Wu Qijun, *Yunnan kuangchang gongqi tulüe*, 3b; Su, *Yunnan Gejiu xiye diaocha*, 23.
65. The subcontracting of mining costs among different investors can be traced back to the early eighteenth century. See Ni Tui, "Fu dangshi lun changwu shu," 122–23; Wu Qijun, *Yunnan kuangchang gongqi tulüe*, 3b.
66. Wu Qijun, *Yunnan kuangchang gongqi tulüe*, 15a; Su, *Yunnan Gejiu xiye diaocha*, 23.
67. "Gejiu gongyi changgui bei ji," 61; Wu Qijun, *Yunnan kuangchang gongqi tulüe*, 17a.
68. Wu Qijun, *Yunnan kuangchang gongqi tulüe*, 15a.
69. "Gejiu gongyi changgui bei ji," 61.
70. Giersch, *Corporate Conquests*, 42–49.
71. Han, *Mengzi xian zhi*, 157.
72. Ding, "Yunnan Gejiu fujin dizhi kuangwu baogao," 220; Su, *Yunnan Gejiu xiye diaocha*, 31–34; Dong and Su, "Gejiu xiye de tufa shengchan guocheng," 40–46.
73. Su, *Yunnan Gejiu xiye diaocha*, 31–34; Dong and Su, "Gejiu xiye de tufa shengchan guocheng," 42.
74. Ding, "Yunnan Gejiu fujin dizhi kuangwu baogao," 220; Dong and Su, "Gejiu xiye de tufa shengchan guocheng," 42.
75. Han, *Mengzi xian zhi*, 158; Liang Dingheng, "Gejiu siying yelianye bianqian jilüe," 53–54.
76. The account was written by Liang Dingheng, the manager of Meixing Tin Mining Corporation (founded in 1937) and Changfachang Tin Mining Corporation (founded in 1911). Liang Dingheng, "Gejiu siying yelianye bianqian jilüe," 51–55.

- For the history of Meixing and Changfachang, see Yunnan sheng Gejiu shi zhengxie, *Gejiu wenwu gailan*, 40–41.
77. Su, *Yunnan Gejiu xiye diaocha*, 38.
 78. Ding, “Yunnan Gejiu fujin dizhi kuangwu baogao,” 222.
 79. See the discussion regarding ore properties in “Zixun gechang dui,” an appendix to Wang Chang’s *Tongzheng quanshu*, published at the end of the eighteenth century, quoted from Wu Qijun, *Yunnan kuangchang gongqi tulüe*, 40a–41b. Ni Shenshu (“Caitong liantong ji,” 26a) also used the same binary to define ore properties.
 80. Smith, *From Lived Experience to the Written Word*, 14, 246–48.
 81. Wu Qijun, *Yunnan kuangchang gongqi tulüe*, 21a.
 82. Su, *Yunnan Gejiu xiye diaocha*, 37.
 83. Wu Qijun, *Yunnan kuangchang gongqi tulüe*, 46–47; Su, *Yunnan Gejiu xiye diaocha*, 37; Zhou Zhengwu, *Tian gong shen ye*, 72, 224.
 84. Wu Qijun, *Yunnan kuangchang gongqi tulüe*, 15a.
 85. Su, *Yunnan Gejiu xiye diaocha*, 38.
 86. Su, *Yunnan Gejiu xiye diaocha*, 36.
 87. Liang Dingheng, “Gejiu siying yelianye bianqian jilüe,” 54.
 88. Su, *Yunnan Gejiu xiye diaocha*, 37–38; Wu Qijun, *Yunnan kuangchang gongqi tulüe*, 8–9; Dong and Su, “Gejiu xiye de tufa shengchan guocheng,” 48; Liang Dingheng, “Gejiu siying yelianye bianqian jilüe,” 54.
 89. Wu Qijun, *Yunnan kuangchang gongqi tulüe*, 15a.
 90. Han, *Mengzi xian zhi*, 154.
 91. Wu Qijun, *Yunnan kuangchang gongqi tulüe*, 5a.
 92. Han, *Mengzi xian zhi*, 154–55.
 93. Wu Qijun, *Yunnan kuangchang gongqi tulüe*, 4a–b.
 94. Su, *Yunnan Gejiu xiye diaocha*, 29–30.
 95. Wu Qijun, *Yunnan kuangchang gongqi tulüe*, 4b–5a.
 96. Masuda Kō, *Kodō zuroku*, 3a. *Kodō zuroku* is an illustrated book showing how to extract copper from copper mines. It was privately printed for the Sumimoto family, which owned and managed copper mines and refineries.
 97. Wu Qijun, *Yunnan kuangchang gongqi tulüe*, 21b.
 98. Su, *Yunnan Gejiu xiye diaocha*, 38–39; Liang Dingheng, “Gejiu siying yelianye bianqian jilüe,” 54.
 99. Yang Yuda, “Qingdai zhongqi (1726–1855) Dian dongbei de tongye kaifa yu huanjing bianqian,” 172. Also see Hans Ulrich Vogel, “Copper Smelting and Fuel Consumption in Yunnan,” 147–48; Nanny Kim, “Fuel for the Smelters.”
 100. Wu Qijun, *Yunnan kuangchang gongqi tulüe*, 46–47.
 101. Wang Zhī’an, “Tufa lianxi de zhuyao ranliao.”
 102. For hazardous production environment and financial uncertainty in smelting, see Yijun Wang, “The Goddesses of Metal and Fire.”
 103. Tang Jiong, “Chou yi kuangwu ni zhaoji shanggu yanpin dongyang kuangshi shu,” 100.

104. Zhang Yunsui, "Zhang Yunsui zougao," 683.
105. Wang Zhi'an, "Tufa lianxi de zhuyao ranliao," 63–64.
106. Giersch, *Corporate Conquests*.
107. *Dan* is a Chinese unit of volume, often used in the measurement of grains. See Guo Songyi, "Qingdai de liangqi he liangfa," 6.
108. Zelin, *The Merchants of Zigong*. See also Zelin, "Eastern Sichuan Coal Mines in the Late Qing."
109. Wu Qijun, *Yunnan kuangchang gongqi tulüe*, 12a.
110. Wu Qijun, *Yunnan kuangchang gongqi tulüe*, 18a.
111. Han, *Mengzi xian zhi*, 155–6.
112. Wu Qijun, *Yunnan kuangchang gongqi tulüe*, 18b.
113. Sociologist Su Rujiang (*Yunnan Gejiu xiye diaocha*, 64–66) provides an informative survey of the miners and their family backgrounds in the early twentieth century.
114. Wu Qijun, *Yunnan kuangchang gongqi tulüe*, 13; "Gejiu gongyi changgui bei ji," 61; Yao Zili, "Jiushidai Gejiu kuangqu de yixie xisu," 152.
115. Han, *Mengzi xian zhi*, 154; Wu Qijun, *Yunnan kuangchang gongqi tulüe*, 13.
116. Wu Qijun, *Yunnan kuangchang gongqi tulüe*, 13.
117. Han, *Mengzi xian zhi*, 156; Wu Qijun, *Yunnan kuangchang gongqi tulüe*, 13.
118. Ownby and Heidhues, "Secret Societies" Reconsidered, 68–87.
119. Han, *Mengzi xian zhi*, 155–56.
120. Han, *Mengzi xian zhi*, 155.
121. See the routine memorial by the Minister of Punishment Akdun QL 12/11/3. FHA, no. 02-01-07-04837-003.
122. Liang Yong, "Qingdai Sichuan kezhang yanjiu"; Liang Yong, "Chongqing jiaoan yu basheng kezhang."
123. Liao, "Qingdai gongshang qunti zhong de kezhang," 16.

CHAPTER 3. MINING ORGANIZATIONS IN THE FORMATION OF GLOBAL CAPITALISM

1. Letters and papers received from China to the Lords XVII, the Amsterdam Chamber and the China Commission, 1761, 976–77, National Archives of the Netherlands, NL1.04.02.4384.
2. Abu-Lughod, *Before European Hegemony*; Hamashita, *China, East Asia and the Global Economy*, 12–26.
3. Shimada, "Hinterlands and Port Cities," 201; Jacobs, *Merchant in Asia*, 368–69.
4. Yu Minzhong et al., *Qinding hubu guzhu zeli*, 2:57.
5. Wang Mo, palace memorial, QL 5/8/23, FHA, no. 04-01-35-0123-15.
6. Ideally, the Guangdong government would tax tin mines in Guangdong 30 percent of tin output (20 percent as mining tax and 10 percent as fees) and ship the taxed amount to Beijing. However, Wang Anguo pointed out that even though the court had issued orders to establish new mining sites, the tax could

- not meet the demand of the metropolitan mint, so the Guangdong provincial government had to purchase the rest from the market. Wang Anguo, routine memorial to the Ministry of Revenue, cited from *Zhongguo renmin daxue Qing shi yanjiusuo, Qingdai de kuangye*, vol. 2, 616.
7. Yu Minzhong et al., *Qinding hubu guzhu zeli*, 2:57.
 8. Liu, *Tea War*, 31.
 9. Liu, *Tea War*, 31.
 10. Fei Xin, *Xing cha sheng lan*, 2:1a–2b; Ma Huan, *Yizhengtang dingzheng ying ya sheng lan*, 10a–16b.
 11. Heidhues, *Bangka Tin and Mentok Pepper*, 3.
 12. Jacobs, *Merchant in Asia*, 215.
 13. According to Liu Yong, from 1735 to 1756, the High Government in Batavia sent ships from Batavia to Canton. From 1757, the China Committee, controlled by the Gentlemen Seventeen, took over the trade. The ships sailed directly from the Dutch Republic, made a stop at Batavia, loaded up with “Batavia Goods,” and sold them to Canton. See Liu Yong, *The Dutch East India Company’s Tea Trade*, 1–50; Liu Yong, “Lun 1757–1794 nian Helan duihuamaoyi zhong Badaweiya de jue,” 56.
 14. In 1752, Jacob Mossel, the governor-general of the Dutch East Indies, pointed out explicitly that the East Indies goods, including tin, enabled the VOC to enjoy an advantageous position compared to other European nations, who could trade with the Chinese only using gold and silver. See Jacob Mossel, “Bedenkingen over den intrinsiquen staat van de goetroyeerde Nederlandsche O.I.C.,” National Archives of the Netherlands, Den Haag, no. 1.04.02:4747, cited from Liu Yong, *The Dutch East India Company’s Tea Trade*, 3.
 15. Liu Yong, *The Dutch East India Company’s Tea Trade*, 50.
 16. Shimada, “Hinterlands and Port Cities,” 202.
 17. The list of tributary gifts from Ryukyu, QL 47/2 (1782), FHA, no. 03-0189-2917-030.
 18. Vos, *Gentle Janus, Merchant Prince*, 30–31.
 19. Thomas Raffles, “Letter to Lord Minto,” Malacca, 18 February 1811, Mss Eur C35: 1810–1911, 102, London, British Library; Thomas Raffles, “Notes on Trade,” Rx. Calcutta, 1810, Mss Eur F148/3, 68, 73, London, British Library.
 20. For the source of tin, see Fei Xin, *Xing cha sheng lan*, 2:1a, 2b; Ma Huan, *Yizhengtang dingzheng ying ya sheng lan*, 10a–16a. For the Chinese emigrant community in Palembang, see Ma Huan, *Yizhengtang dingzheng ying ya sheng lan*, 8b–9a.
 21. Blussé, “Chinese Century.”
 22. Macauley, *Distant Shores*, 48.
 23. The report was delivered in 1814, but it was not published until 1848. Horsfield, “Report on the Island of Bangka,” 299–301.
 24. Horsfield, “Report on the Island of Bangka,” 302.
 25. According to J. A. Schuurman, there are three possible dates (1709, 1710, and 1711) offered for the discovery of tin on Bangka. Schuurman, *Historische schets van de tinwinning op Banka*, 4. Franz Epp, the medical officer of the Dutch East-

- Indies in Bangka in 1836–38, believed that tin was discovered in 1710. The American naturalist Dr. Thomas Horsfield concluded that tin mining started in 1711 after an extensive survey in Bangka in 1812 and 1813. In general, most European scholars and traders in the nineteenth century were convinced that there was no tin excavation in Bangka before the eighteenth century. See Horsfield, “Report on the Island of Bangka,” 819; Court, *An Exposition of the Relations of the British Government*, 150; Epp, *Schilderungen aus Ostindiens Archipel*, 183.
26. Epp, *Schilderungen aus Ostindiens Archipel*, 183.
 27. Jackson, “Mining in 18th century Bangka,” 29.
 28. Heidhues, *Bangka Tin and Mentok Pepper*, 4–7; Horsfield, “Report on the Island of Bangka,” 305–9.
 29. Heidhues, *Bangka Tin and Mentok Pepper*, 25.
 30. Cushman, *Family and State*.
 31. Heidhues, *Bangka Tin and Mentok Pepper*, 7; Heidhues, *Chinese Presence in Malay-Indonesian Narratives*, 38–41.
 32. Bougas, “Patani in the Beginning of the XVII Century.”
 33. Wieringa, *Carita Bangka*, 89, cited from Heidhues, *Bangka Tin and Mentok Pepper*, 25.
 34. Horsfield (“Report on the Island of Bangka,” 310) refers to the Chinese man who established the Belo settlement as Assing. The full name, Oen Assing, was mentioned in the Dutch translation of a Malay narrative. See Clercq, “Bijdrage tot de Geschiedenis van het Eiland Bangka,” 144.
 35. Macauley, *Distant Shores*, 45–74.
 36. Clercq, “Bijdrage tot de Geschiedenis van het Eiland Bangka,” 144–47.
 37. Horsfield, “Report on the Island of Bangka,” 310.
 38. Heidhues, *Golddiggers, Farmers, and Traders*, 31.
 39. Zhou Xin, “Bangjia manbi xilie (1)”; Heidhues, *Golddiggers, Farmers, and Traders*, 36.
 40. Based on my fieldwork in Jieyang, the difference between Hakka and local Chaozhou identity is minimal. Most people identified with the Chaozhou region rather than their subethnicity.
 41. Although the two collision belts shared a similar formation process, they did not have the same tectonic settings. The southeast China–north Vietnam tin province was formed through several episodes of continuing rifting from the Paleozoic to the Cenozoic, while the Southeast Asian tin belt was formed through a succession of collisions. See Charles S. Hutchison, “The Tin Metallogenic Provinces of S. E. Asia and China: A Gondwanaland Inheritance,” in Hutchison, *Geology of Tin Deposits in Asia and the Pacific*, 232–33.
 42. Alluvial placer tin deposits play important roles in Guangdong, Hunan, and some parts of Guangxi. See Li Xiji, “Geological Characteristics of the Tin Deposits,” 310; Xu Ben, QL 8/8/22, FHA, no. 02-01-04-13643-005. In Bangka, although primary tin deposits exist, the most studied and mined are placer deposits. See Schwartz and Surjono, “The Pemali Tin Deposit,” 18–19.

43. Fraenkel, "Beschrijving tot de kennis der tinmijnen van het Eiland Banka," 393.
44. Jackson, "Mining in 18th Century Bangka," 42.
45. Heidhues, *Bangka Tin and Mentok Pepper*, 15.
46. Fraenkel ("Beschrijving tot de kennis der tinmijnen van het Eiland Banka," 393–94) calls *kulit* and *kolong* mining the Chinese method. Heidhues (*Bangka Tin and Mentok Pepper*, 11) points out that a few Bangkanese also worked in *kulit* mines.
47. Fraenkel, "Beschrijving tot de kennis der tinmijnen van het Eiland Banka," 394; Heidhues, *Bangka Tin and Mentok Pepper*, 11.
48. Court, *An Exposition of the Relations of the British Government*, 222.
49. Court, *An Exposition of the Relations of the British Government*, 222.
50. Horsfield, "Report on the Island of Bangka," 811; Court, *An Exposition of the Relations of the British Government*, 222–23.
51. Court, *An Exposition of the Relations of the British Government*, 230.
52. Court, *An Exposition of the Relations of the British Government*, 227. See also Thomas Horsfield, "Report on the Island of Bangka," 813. Historian James Jackson ("Mining in 18th Century Bangka") provides a comprehensive explanation of the Chinese water management method.
53. Routine memorial by the provincial governor of Hunan Li Hu, QL 44/9/24, FHA, no. 02-01-04-17118-006.
54. Needham, *Science and Civilisation in China*, vol. 4, pt. 2, 339–44.
55. Epp, *Schilderungen aus Ostindiens Archipel*, 186.
56. Needham, *Science and Civilisation in China*, vol. 4, pt. 2, 135–37; Court, *An Exposition of the Relations of the British Government*, 234.
57. Epp, *Schilderungen aus Ostindiens Archipel*, 186.
58. Jackson, "Mining in 18th century Bangka," 46.
59. Epp, *Schilderungen aus Ostindiens Archipel*, 186–67; Horsfield, "Report on the Island of Bangka," 813–15.
60. Horsfield, "Report on the Island of Bangka," 814.
61. Court, *An Exposition of the Relations of the British Government*, 234.
62. Horsfield, "Report on the Island of Bangka," 813.
63. Court, *An Exposition of the Relations of the British Government*, 234–35.
64. Heidhues, *Bangka Tin and Mentok Pepper*, 11.
65. Epp, *Schilderungen aus Ostindiens Archipel*, 176.
66. Horsfield, "Report on the Island of Bangka," 811.
67. Horsfield, "Report on the Island of Bangka," 813.
68. For the payment for carpenters, see Fraenkel, "Beschrijving tot de kennis der tinmijnen van het Eiland Banka," 397. Each person operating the bellows was paid two gulden per night. See Epp, *Schilderungen aus Ostindiens Archipel*, 186.
69. Horsfield, "Report on the Island of Bangka," 797.
70. Scott, *The Art of Not Being Governed*.
71. Epp, *Schilderungen aus Ostindiens Archipel*, 176.
72. Ownby and Heidhues, "Secret Societies" Reconsidered, 18.

73. Lanfang Republic or Lanfang Gongsi/Kongsi was a Chinese state and federation founded by Luo Fangbo (1738–95) in West Borneo. It developed from the Chinese gold miners' community in West Borneo. The earliest study on Lanfang Republic was done by de Groot (*Het kongsiwezen van Borneo*), who believed the Chinese *kongsi* federation originated from the Chinese village organization. Chinese scholar Luo Xianglin (*Xi Poluo Zhou Luo Fangbo deng suo jian gongheguo kao*) has written a history of the Lanfang Republic and its founder Luo Fangbo.
74. Mary Heidhues (*Bangka Tin and Mentok Pepper*) and Carl Trocki (*Opium and Empire*) have studied the Chinese mining *kongsi* in Bangka and Singapore, showing how the egalitarian culture contributed to economic activities. Tai Peng Wang (*The Origins of Chinese Kongsi*) has studied the Chinese *kongsi* as a political entity. His study emphasizes the democratic nature of *kongsi*, using the *kongsi* as an example of genuine Chinese “democracy without western influence.” Wang’s argument was influenced by a political agenda related to the autocracy of Singapore. As Heidhue’s study has shown, the democratic or egalitarian nature of the *kongsi* was conditional and limited.
75. Fraenkel, “Beschrijving tot de kennis der tinmijnen van het Eiland Banka,” 397.
76. Fraenkel, “Bijdrage tot de kennis van het eiland Banka,” 58.
77. Fraenkel, “Beschrijving tot de kennis der tinmijnen van het Eiland Banka,” 397.
78. Horsfield, “Report on the Island of Bangka,” 813.
79. Jackson, “Mining in 18th Century Bangka,” 51.
80. Fraenkel, “Beschrijving tot de kennis der tinmijnen van het Eiland Banka,” 397.
81. Mary Heidhues (“Chinese Organizations in West Borneo and Bangka”) and Carl Trocki (“The Rise and Fall of the Ngee Heng Kongsi”) point out that colonialism and capitalism eventually changed the democratic and egalitarian nature of *kongsi*.
82. Horsfield’s report shows there were five *tikos* ruling six mining districts at the beginning of 1800s, while Court’s report indicates that there were seven *tikos* in Bangka ten years later. See Heidhues, *Bangka Tin and Mentok Pepper*, 38; Court, *An Exposition of the Relations of the British Government*, 150.
83. Horsfield, “Report on the Island of Bangka,” 819.
84. Court, *An Exposition of the Relations of the British Government*, 152.
85. The usual monthly advances to the miners included thirteen gantangs of rice for a single man, and twenty gantangs of rice for a married man (1 gantang = 4.5 catties = 6 pounds), plus some oil and salt. Each miner also received a small cash advance, which was paid using tin coins. Horsfield, “Report on the Island of Bangka,” 821; Heidhues, *Bangka Tin and Mentok Pepper*, 15–16.
86. Court, *An Exposition of the Relations of the British Government*, 152.
87. Court, *An Exposition of the Relations of the British Government*, 151.
88. Here I follow Heidhues’s practice of using *congsee* to refer to the person, the agent of the *tikos*, and *kongsi* to refer to the mining enterprise. Heidhues, *Bangka Tin and Mentok Pepper*, 18.

89. Horsfield, "Report on the Island of Bangka," 820–21.
90. Horsfield, "Report on the Island of Bangka," 821.
91. Horsfield, "Report on the Island of Bangka," 821.
92. Court, *An Exposition of the Relations of the British Government*, 219.
93. Heidhues, *Bangka Tin and Mentok Pepper*, 40.
94. Fraenkel, "Bijdrage tot de kennis van het eiland Banka," 57–58.
95. Horsfield, "Report on the Island of Bangka," 325.
96. The leader of a *kongsi* corporation in mining was called the *kepala parit*. See Epp, *Schilderingen aus Ostindiens Archipel*, 188. *Kepala parit* is a Malay word; *parit* means "mine," and *kepala* means "head." Local Chinese called it *parith-eeuw* (PY: *balitou*), which means "the headman of a mine." See Heidhues, *Bangka Tin and Mentok Pepper*, 38.
97. Tai Peng Wang, *The Origins of Chinese Kongsi*.
98. Horsfield, "Report on the Island of Bangka," 822.
99. Heidhues, *Bangka Tin and Mentok Pepper*, 71–77.
100. Routine memorial by the minister of revenue Su-er-ne, QL 37/12/6, FHA, no. 02-01-04-16407-006. Similar advice of attracting more investment from merchants could be found in most court memorials in Hunan. See the memorial by the provincial governor of Hunan, Jiang Pu, QL 10/2/4, FHA, no. 03-0770-044.
101. For the history of the steam engine in tin mines in England, see Burton, *Mines and Miners of Cornwall and Devon*, 23–24, 37–52.
102. Heidhues, *Bangka Tin and Mentok Pepper*, 48.
103. Raffles Letter, IOR G/21/60, 269–77; Court, *An Exposition of the Relations of the British Government*, 219–21.
104. Heidhues, *Bangka Tin and Mentok Pepper*, 28.
105. Court, *An Exposition of the Relations of the British Government*, 160–67. See also Raffles Letter, IOR G/21/61 (2), 148–49.
106. Heidhues, *Bangka Tin and Mentok Pepper*, 66–68.
107. Pomeranz, *Great Divergence*, 275–77, 283, 313–15; Macauley, *Distant Shores*, 6–7, 18.

CHAPTER 4. THINKING LIKE ARTISANS, SEEING LIKE MERCHANTS

1. In previous scholarship, copper coins and coinage were called *copper money* or *copper cash*. Here I use *coins* and *coinage* to emphasize their materiality.
2. Nasutu, palace memorial, QL 3/7/6, FHA, no. 04-01-35-1228-013.
3. Davis, *Copper and Copper Alloys*, 8.
4. For example, Von Glahn (*Fountain of Fortune*) studies the understanding of monetary theory in late imperial China and uses the late Ming attempt to reimpose the dominance of copper coin to demonstrate the limits of the Ming state and the power of the market to influence state policy. Man-houng Lin's *China Upside Down* uses the nineteenth-century monetary crisis to discuss the economic philosophy among different schools of statecraft reformers. Vogel ("Chinese Central Monetary Policy") discusses the fluctuation before the nine-

teenth century and the monetary policies the Qing state used to increase the circulation of copper coins. Zheng Yongchang (“Qingdai qianlong chao qiangui shiqi zhi siqian wenti ji qi duice”) studies the policies of the Qing state to eliminate counterfeiting from 1736 to 1775. Zheng argues that at the beginning of Qianlong’s rule, the Qing state had to rely on the “small money” or counterfeits to supplement the shortage of cash. Zheng Yongchang, “Qingdai qianlong chao qiangui shiqi zhi siqian wenti ji qi duice (1736–1775).”

5. Kai Jun Chen, *Porcelain for the Emperor*; Ko, *The Social Life of Inkstones*.
6. Dean, *China and the End of Global Silver*, 9.
7. Vogel, “Chinese Central Monetary Policy,” 4.
8. Man-houng Lin, *China Upside Down*, 2.
9. Vogel, “Chinese Central Monetary Policy,” 5.
10. Vogel, “Chinese Central Monetary Policy,” 18.
11. Von Glahn, *Fountain of Fortune*.
12. Vogel, “Chinese Central Monetary Policy,” 7.
13. Vogel, “Chinese Central Monetary Policy,” 6.
14. On the trade in Japanese copper, see Hall, “Notes on the Early Ch’ing Copper Trade”; Dunstan, “Safely Supping with the Devil”; Vogel, “Chinese Central Monetary Policy,” 6.
15. According to *Kaihaku goshi shinrei*, promulgated in 1715, Japan implemented an annual ceiling of three million *jin* on copper exports to China. Dunstan, “Safely Supping with the Devil,” 52; Sun Xiaoying, “Qing Yongzheng shidai riben tong jinkou zhuangkuang,” 70.
16. Man-houng Lin, *China Upside Down*, 33.
17. Du Jiaji, “Qing zhongqi yiqian de zhuqian liang wenti,” 27–31.
18. The monopoly over copper mining and trade was a state policy of the Qing; however, scholars have shown that in reality, much copper was traded by merchants in private markets. For example, Hankou was a trading center of Yunnan copper, tin, zinc, and lead. See Yang Yuda, “Diantong, Hantong, yu Qingdai zhongqi de Hankou tong shichang.”
19. Sun Chengze, *Chun ming meng yu lu*, 38:5a–b.
20. Zheng, “Qingdai qianlong chao qiangui shiqi zhi siqian wenti ji qi duice,” 40–41.
21. Sun Chengze, *Chun ming meng yu lu*, 38:6a–b.
22. “Gresham’s Law,” in *Encyclopedia Britannica*, <https://www.britannica.com/topic/Greshams-law>. Last access June 20, 2024.
23. Sun Chengze, *Chun ming meng yu lu*, 38:6 a–b.
24. Zheng, “Qingdai qianlong chao qiangui shiqi zhi siqian wenti ji qi duice,” 45–49.
25. *Shengzu ren huangdi shilu*, 85:5b–6a.
26. *Shizong xian huangdi shilu*, 61:2b, 40:29b–30a.
27. *Shizong xian huangdi shilu*, 52:4a–b.
28. *Shizong xian huangdi shilu*, 61:2b.

29. Pratt, *Imperial Eyes*, 8.
30. Man-houng Lin, *China Upside Down*, 6.
31. Burger, *Ch'ing Cash*, 66.
32. Man-houng Lin, *China Upside Down*, 5, 31.
33. In the Yongzheng era, mints in the eastern provinces and in the capital relied on Japanese copper. After the large-scale development of Yunnan's mining industry under the Qianlong emperor, Yunnan copper supplied mints across the empire. However, mints in Beijing and the eastern provinces continued to use imported tin, while those in Yunnan and Sichuan sourced tin from Gejiu.
34. Burger, *Ch'ing Cash*, 18.
35. Song Yingxing, *Tian gong kai wu*, vol. 2, 8:5–6.
36. Zheng, "Qingdai qianlong chao qiangui shiqi zhi siqian wenti ji qi duice," 121–30.
37. Zhang Tingyu et al., *Qinding huangchao wenxian tongkao*, 16:26a–b.
38. Palace Museum and Max Planck Society for the History of Science, *Gongting yu difang*; Schäfer, "Silken Strands."
39. Burger, *Ch'ing Cash*, 20.
40. Zhang Tingyu et al., *Qinding huangchao wenxian tongkao*, 16:27a.
41. Kai Jun Chen, *Porcelain for the Emperor*, 14, 99–126.
42. Here we see that the Qing government used the title of special commissioner to describe both mine supervisors and procurers of copper. Both appointments required technical and managerial knowledge to complete the job. Haiwang (?–1755), minister of revenue and supervisor-in-chief of the Imperial Household Department, palace memorial, QL 1/2/7, FHA, no. 04-01-35-1226-029.
43. Tan Xingyi, palace memorial, QL 3/10/18, FHA, no. 04-01-35-1229-002.
44. Nasutu, palace memorial, QL 3/7/6, FHA, no. 04-01-35-1228-013.
45. Nasutu, QL 3/7/6, FHA, no. 04-01-35-1228-013.
46. Nasutu, QL 3/7/6, FHA, no. 04-01-35-1228-013.
47. The provincial mint of Jiangxi, Baochang Ju, was located in Nanchang.
48. Nasutu, palace memorial, QL 3/7/6, FHA, no. 04-01-35-1228-013.
49. Sun Chengze, *Chun ming meng yu lu*, 38:1a–b.
50. For example, see Palace Museum and Max Planck Society for the History of Science, *Gongting yu difang*. Also see Kai Jun Chen, *Porcelain for the Emperor*.
51. Zhao Erxun et al., *Qing shi gao*, juan 308, *liezhuan* 95, 1a.
52. Kai Jun Chen's (*Porcelain for the Emperor*) research on Tang Ying discusses the technocratic culture and the usage of material artifacts as mediums of knowledge transmission.
53. Zhang Ruozhen, palace memorial, QL 4/9/22, FHA, no. 04-01-35-1229-27.
54. Wang Xianguo, "Qianlong wunian gaizhu qingqian yuanyin chutan."
55. Zhang Ruozhen, palace memorial, QL 4/9/22, FHA, no. 04-01-35-1229-027.
56. Zhang Ruozhen, palace memorial, QL 4/9/22, FHA, no. 04-01-35-1229-027.
57. Zhang Ruozhen, palace memorial, QL 4/9/22, FHA, no. 04-01-35-1229-027.

58. Wang Xianguo, "Qianlong wunian gaizhu qingqian yuanyin chutan."
59. According to Wang Xianguo ("Qianlong wunian gaizhu qingqian yuanyin chutan," 13), copper from Yunnan was 9 taels 2 *qian* per picul, Japanese copper was 14 tael and 5 *qian* per picul, tin was 12–13 taels per picul, and zinc was only 4 taels 7 *qian* 5 *fen*. So Nasutu's formula cost 1.32 times that of the yellow money formula.
60. Zhang Ruozhen, palace memorial, QL 4/12/8 (1740), FHA, no. 04-01-35-1230-006.
61. Zhou Weirong, *Zhongguo gudai qianbi hejin chengfen yanjiu*, 98.
62. Zhou Weirong, *Zhongguo gudai qianbi hejin chengfen yanjiu*, 46.
63. For a pyrometallurgical method of separating copper from brass, see Hanxiang Shi, "Method for Extracting Pure Copper and Pure Zinc from Brass," CN Patent CN103131871A, filed June 5, 2013, and issued March 26, 2014.
64. *Gaozong chunhuangdi shilu*, 121:23b.
65. Zheng, "Qingdai qianlong chao qiangui shiqi zhi siqian wenti ji qi duice," 78–130.
66. For another example of managing skills through the management of artisans, see Anne Gerritsen's (*The City of Blue and White*) discussion of the porcelain industry.
67. Yu Minzhong et al., *Qinding hubu guzhu zeli*, 57.
68. Song Rulin et al., *Daoguang Suzhou fu zhi*, 17:34a–b.
69. Ma Qi, "Qingdai gesheng caimai diantong de yunshu wenti."
70. Tong Hua, "Tong zheng tiao yi," 802.
71. Tong Hua, "Tong zheng tiao yi," 804.
72. Guo Daoyang, *Zhongguo kuaiji shigao*, vol. 2, 67.
73. Chen Feng, "Qingdai qianqi zouxiao zhidu yu zhengce yanbian," 67–69.
74. Zhihong Shi, *Central Government Silver Treasury*, 14.
75. Yijun Wang and Kyoungjin Bae, "Kupiao and the Accounting System."
76. Zhijun Lin, "Chinese Double-Entry Bookkeeping."
77. Yijun Wang and Kyoungjin Bae, "Kupiao and the Accounting System."
78. Zhihong Shi, *Central Government Silver Treasury*, 14.
79. Shimada, "18 seiki ni okeru Oranda Higashi Indo Gaisha no suzu bōeki ni kansuru sūryōteki kōsatsu," 199–202.
80. Sazai, palace memorial, QL 35/09/27 (1770), FHA, no. 04-01-35-1277-011.
81. Sazai, palace memorial, QL 35/09/27 (1770), FHA, no. 04-01-35-1277-011.
82. Sazai, palace memorial, QL 35/09/27 (1770), FHA, no. 04-01-35-1277-011.
83. Sazai, palace memorial, QL 35/09/27 (1770), FHA, no. 04-01-35-1277-011.
84. Li Hu, palace memorial, QL 35/12/7 (1770), FHA, no. 04-01-14-0036-029.
85. Li Hu, palace memorial, QL 35/12/7 (1770), FHA, no. 04-01-14-0036-029. Ideally, according to *Lǚlǚ zhengyi*, promulgated by the Kangxi emperor, 1 catty = 16 taels. Wu Chengluo, *Zhongguo duliang heng shi*, 269. However, Guo Songyi ("Qingdai de liangqi he liangfa") shows that the measurements varied by region; even the measurements used by the Qing government varied when it came to taxation and storage.

86. Li Hu, palace memorial, QL 35/12/7, FHA, no. 04-01-14-0036-029.
87. Sazai, palace memorial, QL 35/09/27 (1770), FHA, no. 04-01-35-1277-011.
88. Kann, *The Currencies of China*, 62–64.
89. Sazai, palace memorial, QL 35/09/27 (1770), FHA, no. 04-01-35-1277-011.
90. Sazai, palace memorial, QL 35/09/27 (1770), FHA, no. 04-01-35-1277-011.
91. Li Hu, palace memorial, QL 35/12/7 (1770), FHA, no. 04-01-14-0036-029.
92. Li Hu, palace memorial, QL 35/12/7 (1770), FHA, no. 04-01-14-0036-029.
93. Raj, “From Merchants to Imperial Bureaucrats?,” 245. I thank Bu Yun Chen for this reference.
94. Stern, *The Company-State*.
95. Raj, “From Merchants to Imperial Bureaucrats?,” 244–68.
96. The earliest observation was made by Jonathan D. Spence (*Ts'ao Yin and the Kang-Hsi Emperor*). The latest monograph on this topic is Yulian Wu, *Luxurious Networks*.
97. Sun Xiaoying, “Kangxi chao nei wufu shangren yu ribentong”; Yang Yuda, “Diantong, Hantong, yu Qingdai zhongqi de Hankou tong shichang”; Chiu, “Shiba shiji dientong shichang.”

CHAPTER 5. TRANSCRIBING MINING TECHNOLOGY FOR THE EMPIRE

1. Diyi lishi dang'an guan, *Daoguangchao shangyu dang*, vol. 49, 114–15.
2. For instance, in the case of copper and tin, mining was mostly managed by private merchants. The Qing government had access to copper through a combination of taxation and procurement from the market. Rowe, *China's Last Empire*, 149–58.
3. Rowe, “Money, Economy, and Polity,” 69–96.
4. Rowe, “Introduction,” 75.
5. Rowe, *China's Last Empire*, 79, 155–57.
6. Yingcong Dai, *The White Lotus War*, 3–30, 447–48.
7. Rowe, “Introduction,” 75–85. Also see Mosca, “The Literati Rewriting of China.”
8. Diyi lishi dang'an guan, *Daoguangchao shangyu dang*, vol. 49, 114–15.
9. Wu Qijun's memorial on copper administration in Yunnan, DG 24/04/01 (1844), FHA, no. 03-3385-044.
10. Golas, *Science and Civilisation in China*, vol. 5, pt. 13, 35.
11. Golas, *Science and Civilisation in China*, vol. 5, pt. 13; Hailian Chen, *Zinc for Coin and Brass*.
12. Wang Chang, “Ji Tongzheng quanshu yougan,” in *Chunrong tang ji*, reprinted in *xxskqs*, vol. 1437, 547.
13. Wang Chang, “Xin zuan Yunnan tongzheng quanshu fanli,” in *Chunrong tang ji*, reprinted in *xxskqs*, vol. 1437, 324–26.
14. Fang Guoyu, *Yunnan shiliao mulu gaishuo*, 728–30.
15. Qian, *Qingchao beizhuan quanji*, vol. 2, 1073–79.
16. Fang Guoyu, *Yunnan mulu shiliao gaishuo*, 696.
17. Fang Guoyu, *Yunnan mulu shiliao gaishuo*, 685.

18. See Wu Qijun's reproduction of Wang Chang's mining manual in his *Yunnan kuangchang gongqi tulüe*, 37b–50b.
19. Ni Shenshu, “Caitong liantong ji,” in Ruan et al., *Yunnan tongzhi gao*, 74:24a–26a.
20. Wang Song, “Kuangchang cailian pian,” in Ruan et al., *Yunnan tongzhi gao*, 73:14b–17a.
21. Ban-di, palace memorial on coal mining in Shanxi, QL 11/11/16, FHA, no. 04-01-35-1237-028.
22. Wu Qijun, *Yunnan kuangchang gongqi tulüe*, 3a.
23. Dong Zhongshu, *Chun qiu fan lu*, 10:10b.
24. Wu Qijun, *Yunnan kuangchang gongqi tulüe*, 21b.
25. Wu Qijun, *Yunnan kuangchang gongqi tulüe*, 4b.
26. Bray, Dorofeeva-Lichtmann, and Métaillé, *Graphics and Text in the Production*, 3.
27. *Wu shi yi xian pu*, vol. 3, 3.
28. “The Biography of Officials: Wu Xuan, Wu Qiyan,” National Palace Museum Digital Library of Qing Archives, 故傳006123/701006102.
29. Guoshiguan, *Qingshi liezhuan*, book 38, vol. 38, 26–29.
30. Wu Qijun, “Shu Song Muzhong xiansheng xipi zayong shi hou,” in Wu Yuanbing ed., *Gushi wushi wencun*, 76.
31. Wu Qijun, *Zhiwu mingshi tukao*, 2.
32. Wu Qijun, *Zhiwu mingshi tukao*, 391.
33. “The Biography of Officials: Wu Xuan, Wu Qiyan,” National Palace Museum Digital Library of Qing Archives, 故傳006123/701006102.
34. “The Biography of Officials: Wu Xuan, Wu Qiyan,” National Palace Museum Digital Library of Qing Archives, 故傳006123/701006102.
35. Wu Qijun, “Zhi Huai shangyou lun,” in Wu Yuanbing ed., *Gushi wushi wencun*, 67.
36. Ko, *The Social Life of Inkstones*, 3–80; Kai Jun Chen, *Porcelain for the Emperor*.
37. Wu Qijun, palace memorial, DG 21/05/15 (1841), FHA, no. 04-01-12-0455-103.
38. Ministry of Personnel, DG 20/5/15 (1840), FHA, no. 05-13-002-000667-0039.
39. Wu Qijun, palace memorial, DG 21/05/15 (1841), FHA, no. 04-01-12-0455-103.
40. Imperial Household Department, DG 21/7 (1841), FHA, no. 05-08-030-000379-0005.
41. Wu Qijun, palace memorial, DG 21/05/15 (1841), FHA, no. 04-01-12-0455-103.
42. Jonathan Spence's *Ts'ao Yin and the Kang-Hsi Emperor* is the earliest study of Manchu bondservant Cao Yin. For a comprehensive study of how the workshops in the Imperial Household System operated, see Siebert, Chen, and Ko, *Making the Palace Machine Work*. For bannerment as salt administrators, see Yulian Wu, *Luxurious Networks*. For Tang Ying, the technocrat who managed porcelain production, see Kai Jun Chen, *Porcelain for the Emperor*.
43. Vedal, “Literati of the Garrisons”; Ma Zimu, “Fanyi ke yu Qingdai zhufang baqi de shijin.”
44. The Imperial Household Department, DG 11/9/21 (1831), FHA, no. 05-08-001-000035-0013.

45. The Imperial Household Department, DG 4/1/30 (1824), FHA, no. 05-13-002-000598-0028.
46. Wu Qijun, palace memorial, DG 21/05/15 (1841), FHA, no. 04-01-12-0455-103.
47. Diyi lishi dang'an guan, *Daoguangchao shangyu dang*, vol. 49, 114-15.
48. Wang Xi, *Zhihe tulüe*.
49. Sungyün, *Xizhao tulüe*.
50. Liu Zengqiang, "Diannan kuangchang tulüe yutu lai yuan kaobian."
51. Chuai Zhenyu, *Diansheng Yi ren tushuo*, 1-3.
52. Hostetler, *Qing Colonial Enterprise*.
53. Mosca, "Empire and the Circulation of Frontier Intelligence."
54. Wu Qijun, *Wu gongbaogong zouyi*, 3:62-64.
55. Guoshiguan, *Qingshi liezhuan*, book 38, vol. 38, 26-29; Wu Qijun, *Wu gongbaogong zouyi*, 5:2-3.
56. Wu Qijun, *Wu gongbaogong zouyi*, 5:6.
57. Wu Qijun, *Wu gongbaogong zouyi*, 6:11-13.
58. Rowe, *Saving the World*.
59. Yulian Wu, *Luxurious Networks*; Leonard, *Controlling from Afar*.
60. Rowe, *Saving the World*, 200-205, 446-51.
61. Will, *Handbooks and Anthologies for Officials*, 409-1092.
62. Wang Wenshao, *Xu Yunnan tongzhi gao*, 44:1-22.
63. Li Mingyang, "Zhongxi zhishi jiaohui xia de kuangxue," 638.
64. Song Gengping, *Kuangxue xinyao xinbian*, 1-2.
65. Long Yun, *Xinzuan Yunnan tong zhi*, 181:13a.
66. Rowe, *Saving the World*, 3.
67. Lin Zexu, palace memorial, DG 29/2/20 (1849), FHA, no. 04-01-36-0101-023.
68. Lin Zexu, palace memorial, DG 29/2/20 (1849), FHA, no. 04-01-36-0101-023.
69. Lin Zexu, palace memorial, DG 29/2/20 (1849), FHA, no. 04-01-36-0101-023.
70. Lin Zexu, palace memorial, DG 29/2/20 (1849), FHA, no. 04-01-36-0101-023.
71. Lin Zexu, palace memorial, DG 29/2/20 (1849), FHA, no. 04-01-36-0101-023.
72. Tang Jiong, "Chou yi Yunnan kuangwu shu," in Sheng, *Huangchao jingshiwen bian xubian*, vol. 12, 6589-93.
73. Tang Jiong, "Chou yi Yunnan kuangwu shu," in Sheng, *Huangchao jingshiwen bian xubian*, vol. 12, 6589-93.
74. *Xuanzong cheng huangdi shilu* (1856), DG 28/11/15 (1848), 461:9b, database of FHA.
75. Rowe, *Speaking of Profit*.
76. Lavelle, *The Profits of Nature*.

CONCLUSION

1. Ding Zhenduo, palace memorial, GX 31/6/20 (1905), FHA, no. 04-01-36-0113-032.
2. Su, *Yunnan Gejiu xiye diaocha*, 25.

3. Ding Zhenduo, palace memorial, GX 31/6/20 (1905), FHA, no. 04-01-36-0113-032.
4. The Qing government began to mint silver coins in 1887 as a part of the Self-Strengthening Movement. See Dean, *China and the End of Global Silver*, 44.
5. Su, *Yunnan Gejiu xiye diaocha*, 25.
6. For timber, see Meng Zhang, *Timber and Forestry in Qing China*. For jade, see Yulian Wu, "Transporting Jade." For Japanese copper, see Hall, "Notes on the Early Ch'ing Copper Trade." For hardwood, see Kyoungjin Bae, "Joints of Utility."
7. Ko, *The Social Life of Inkstones*; Kai Jun Chen, *Porcelain for the Emperor*.
8. Ko, *The Social Life of Inkstones*.
9. For the use of agricultural land and forest as a beneficence of nature, see *Gaozong chunhuangdi shilu* QL 7/6/27 (1742), 169:18a–b. For rivers, see *Gaozong chunhuangdi shilu*, QL 3/8/11 (1738), 74:25b. For jade, see *Qianlong chao shangyudang* (FHA database), QL 43/11/1 (1778), box no. 670, vol. 1, 383. For gold, see *Gaozong chunhuangdi shilu*, QL 37/12/28 (1773), 923:45b. For copper mines, see *Gaozong chunhuangdi shilu*, QL 46/6/22 (1781), 1135:14. For silver, see memorial on JQ 19/6/7 (1814), FHA, no. 03-2142-038.
10. Sheng, *Huangchao jingshiwen xubian*, vol. 12.
11. Ingulstad, Perchard, and Storli, *Tin and Global Capitalism*, 1–21.

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ABBREVIATIONS

FHA First Historical Archives of China, Beijing, China.

IOR India Office Records and Private Papers, British Library, London.

SKQS *Siku quanshu*. Unless otherwise noted, all books from SKQS were accessed through the Diaolong Full-Text Database of Chinese and Japanese Ancient Books. Page number cited in the notes refer to the original pagination as shown in the scanned images.

XXSKQS *Xuxiu siku quanshu*. Unless otherwise noted, all books from XXSKQS were accessed from the Diaolong Full-Text Database of Chinese and Japanese Ancient Books. Page number cited in the notes refer to the original pagination as shown in the scanned images.

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India Office Records and Private Papers, British Library, London.

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