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ARTICLE

Institutionalising global mining knowledge: the rise of engineering education in late Qing China, 1870–95

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Abstract

The history of mining education in late Qing China has received relatively little attention in scholarly literature. Through the lens of institutionalising global mining knowledge, this article addresses the following questions: How did the demand for expertise within the framework of mining bureaucracy evolve under the impact of Western imperialism? How did mining education enter scholarly discourse and become eventually institutionalised in the late Qing China? Drawing on evidence from the collections of Sheng Xuanhuai's archive series, it investigates two previously overlooked 'failures' of Sheng's mining-related enterprises, namely his earliest mining practices in Hubei in the 1870s and his proposal for establishing a mining school in Shandong in 1888–89. It then reconnects these efforts with the histories of Western learning, late Qing mining bureaucracy, the monetary crisis of that era, and the global recruitment of engineers despite a pronounced distrust of foreign expertise. It argues that these seemingly discrete efforts or 'failures' in fact paved the way for initiating China's first engineering university as well as other mining colleges in around 1895 and eventually led to the rise of engineering education before the entire educational system was transformed in China.

Keywords: engineering education; institutionalisation; mining engineers; Qing China; Sheng Xuanhuai

Introduction

Technical experts, and in particular engineers, played an increasingly significant role in constructing railways, canals, and machinery when the global expansion of the great powers was accelerated by high industrialisation after 1870. Specialised expert training, as Max Weber (1864–1920) pointed out, was one distinctive factor behind the organisation of capitalistic enterprise.[1] When China turned to pursue modern technology—in terms of mechanisation and industrialisation via borrowing and imitating Western methods—it was starting from a base that had seen neither an indigenous 'scientific' nor an 'industrial' revolution. And, although China was the homeland of numerous ancient inventions, the country's prevailing knowledge systems had evolved on their own terms—even after the arrival of Western learning in the late sixteenth century.[2]

[1] M. Weber, *The Religion of China: Confucianism and Taoism*, (trans.) H. H. Gerth (Glencoe, IL, 1951), pp. 119–21.

[2] See e.g. A. A. Bennett, *John Fryer: The Introduction of Western Science and Technology into Nineteenth-Century China* (Cambridge, MA, 1967); M. Lackner, I. Amelung, and J. Kurtz (eds.), *New Terms for New Ideas: Western Knowledge and Lexical Change in Late Imperial China* (Leiden, 2001); and B. A. Elman, *On Their Own Terms: Science in China, 1550–1900* (Cambridge, MA, 2005).

Late imperial Chinese literati-scholars, who engaged in subjects such as pharmacy, astronomy, medicine, and agriculture, had transformed selective practical knowledge into elite written culture. They produced a large array of technological texts and graphics that were sometimes used for administrative purposes.[3] Technical experts played a particularly significant role in the Qing bureaucracy; they were assigned to supervise technical processes of agriculture, handicraft, and hydraulic engineering projects.[4] But the confluence of scholarly learning and technology, the emerging technical experts, and the statecraft (*jingshi* 經世) approach to governance did not shake the supremacy of Confucian tradition that envisioned classical learning as superior to hands-on practice. On the other hand, Chinese artisans had oral traditions that transmitted applied, practical knowledge, but formal schools for technical education did not exist in pre-1860 China.[5] It was the training of technical experts in the Self-Strengthening Movement (1860–95), especially supervisors in military-related manufacturing industries, that triggered the beginning of educating modern Chinese engineers.

Institutionalising modern science and technology education in China was closely interrelated with the West–East and East–East transfer of knowledge and materialised in educational institutions such as traditional Confucian academies, missionary schools, and military training schools.[6] Previous scholarship has given particular attention to the case studies of Fuzhou Navy Yard and Jiangnan Arsenal, as well as the Tongwen College —all of which were specialised schools established in the 1860s for training shipbuilding experts, naval and military engineers, and diplomats.[7] Nevertheless, late Qing technical education reforms have often been mentioned in passing in the historical narratives. Scholars largely have focused on prominent figures of China's first-generation engineers and scientists educated overseas (in Europe, the USA, and Japan) and examined

[3] F. Bray, V. Dorofeeva-Lichtmann, and G. Métailié (eds.), *Graphics and Text in the Production of Technical Knowledge in China: The Warp and the Weft* (Leiden, 2007); and D. Schäfer (ed.), *Cultures of Knowledge: Technology in Chinese History* (Leiden, 2012).

[4] See e.g. P.-E. Will, *Bureaucracy and Famine in Eighteenth-Century China*, (trans.) E. Forster (Stanford, 1990); R. A. Dodgen, *Controlling the Dragon: Confucian Engineers and the Yellow River in the Late Imperial China* (Honolulu, 2001); J. K. Leonard, *Stretching the Qing Bureaucracy in the 1826 Sea-Transport Experiment* (Leiden, 2019); C. Moll-Murata, J. Song, and V. H. Ulrich (eds.), *Chinese Handicraft Regulations of the Qing Dynasty: Theory and Application* (München, 2005); C. Moll-Murata, *State and Crafts in the Qing Dynasty* (Amsterdam, 2018); and M. Siebert, K. Jun Chen, and D. Ko (eds.), *Making the Palace Machine Work: Mobilizing People, Objects, and Nature in the Qing Empire* (Amsterdam, 2021).

[5] For a comparative perspective on the history of vocational and technical education between China and Europe before 1850, see K. Davids, *Religion, Technology, and the Great and Little Divergences: China and Europe Compared, c. 700–1800* (Leiden, 2012), pp. 91–98. The term 'technical education' became common after 1880 in English literature. An equivalent Chinese term for 'technical education' could hardly be found—if it existed at all—in the late Qing documents. A transitional term *shiye jiaoju* 實業教育 for specialised education in industries, agriculture, and commerce was commonly used after 1895. See H. Chen, 'Technology for re-engineering the Qing empire: the concept of "arts" and the emergence of modern technical education in China, 1840–1895', *ICON: Journal of the International Committee for the History of Technology* 26.1 (2021), p. 13. This article uses 'engineering education' to refer to the higher technical education, i.e. educational institutions specialised for training engineers.

[6] For studies on the history of classical academies and Confucian education, see e.g. B. A. Elman, *From Philosophy to Philology: Intellectual and Social Aspects of Change in Late Imperial China* (Cambridge, MA, 1984); and S. B. Miles, *The Sea of Learning: Mobility and Identity in Nineteenth-Century Guangzhou* (Cambridge, MA, 2006). On missionary and military schools, see e.g. J. G. Lutz, *China and the Christian Colleges, 1850–1950* (Ithaca, NY, 1971); R. J. Smith, 'The reform of military education in late Ch'ing China, 1842–1895', *Journal of the Hong Kong Branch of the Royal Asiatic Society*, 18 (1978), pp. 15–40.

[7] See K. Biggerstaff, *The Earliest Modern Government Schools in China* (Ithaca, NY, 1961); D. Wright, 'John Fryer and the Shanghai Polytechnic: making space for science in nineteenth-century China', *British Journal for the History of Science* 29.1 (1996), pp. 1–16; Y. Meng, 'Hybrid science versus modernity: the practice of the Jiangnan Arsenal, 1864–1897', *East Asian Science, Technology, and Medicine*, 16 (1999), pp. 13–52.

transnational networks, professional mobility, and engineering practices.[8] Because the major structure of the Chinese traditional education system, despite the self-strengthening reforms, remained unchanged until 1902, a large body of existing literature concentrates on the history of China's post-1902 new-style school system, which was modelled on Japan's education system.[9] When focusing on the history of higher education, present-day scholars tend to establish connections between the late Qing scholarly or intellectual learning with the later modern higher-education disciplines.[10]

This article examines the rarely told history of mining education in late Qing China and reveals previously unknown connections between mining practices and the founding of China's first engineering university and another mining college in around 1895.[11] Although historians of the Qing in recent decades have attempted to shift away from the paradigm of 'Western impact and Chinese response' to re-examining the late nineteenth-century transformation in China, the Western impact in the context of mining practices cannot be ignored or overlooked. This article investigates the institutionalisation of global mining knowledge in China and addresses the following questions: How did the demand for expertise within the framework of mining bureaucracy evolve under the impact of Western imperialism? How did mining education enter scholarly discourse and was finally institutionalised after a period of debates and trials that spanned nearly two decades?

My investigation centres on one key historical actor: Sheng Xuanhuai (1844–1916), who was an official–industrialist and acted as a field manager of several modernisation projects initiated (or officially supervised) by Li Hongzhang (1823–1901), the chief architect of the Self-Strengthening Movement. Along with the opening of more treaty ports in China after 1860, several newly founded arsenals, shipyards, and other coal-consuming industries

[8] See e.g. P. Harrell, *Sowing the Seeds of Change: Chinese Students, Japanese Teachers, 1895–1905* (Stanford, CA, 1992); W. Ye, *Seeking Modernity in China's Name: Chinese Students in the United States, 1900–1927* (Stanford, 2001); X. Xu, *Chinese Professionals and the Republican State: The Rise of Professional Associations in Shanghai, 1912–1937* (Cambridge, 2001); E. J. M. Rhoads, *Stepping Forth into the World: The Chinese Educational Mission to the United States, 1872–81* (Hong Kong, 2011); and R. Culp, E. U, and W. Yeh (eds.), *Knowledge Acts in Modern China: Ideas, Institutions, and Identities* (Berkeley, 2016).

[9] See e.g. X. Cong, *Teachers' Schools and the Making of the Modern Chinese Nation-State, 1897–1937* (Toronto, 2007); P. G. Zarrow, *Educating China: Knowledge, Society and Textbooks in a Modernizing World, 1902–1937* (Cambridge, 2015).

[10] See e.g. R. Hayhoe, *China's Universities 1895–1995: A Century of Cultural Conflict* (New York, 1996); Y. Lu and R. Hayhoe, 'Chinese higher learning: the transition process from classical knowledge patterns to modern disciplines, 1860–1910', in *Transnational Intellectual Networks: Forms of Academic Knowledge and the Search for Cultural Identities*, (eds.) C. Charle, J. Schriewer, and P. Wagner (Frankfurt and New York, 2004), pp. 269–306.

[11] For my earlier studies on the late Qing mining textbooks and the establishment of China's first engineering university in Tianjin, see Hailian Chen, 'Creating intellectual space for West-East and East-East knowledge transfer: global mining literacy and the evolution of textbooks on mining in late Qing China, 1860–1911', in *Accessing Technical Education in Modern Japan*, (eds.) E. Pauer and R. Mathias (Folkestone and Amsterdam, 2022), pp. 37–69; and H. Chen, 'Daxuetang für die Institutionalisierung der Ingenieurwissenschaft: von der Bowen Akademie zur Beiyang Universität', in *Wissensort in China. Jahrbuch der Deutschen Vereinigung für Chinastudien 16*, (eds.) H. Martin and K. Joachim (Wiesbaden, 2023), pp. 87–114. Several Chinese-language articles provide a sketchy chronological overview of mining education policy and training programmes of the overseas students, but focus mainly on university mining departments after 1895. See e.g. Y. Wu 吴玉伦, 'Jindai kuangye gongcheng jiaoyu zhi yuanqi 近代矿业工程教育之缘起 [The origin of modern mining engineering education]', *Shanxi shida xuebao (shehui kexue ban)* 山西师大学报（社会科学版） *[Journal of Shanxi Normal University (Social Science Edition)]*, 33.2 (2006), pp. 89–93; Z. Xiong 熊宗武, 'Shehui biange yu jindai gaodeng gongcheng jiaoyu de xingqi: yi gaodeng kuangye jiaoyu wei duixiang de kaocha 社会变革与近代高等工程教育的兴起——以高等矿业教育为对象的考察 [Social changes and the rise of higher engineering education: case study of mining education]', *Gaodeng gongcheng jiaoyu yanjiu* 高等工程教育研究 *[Journal of Higher Engineering Education]*, 6 (2013), pp. 128–32; G. Zhou 周谷平 and Z. Xiong 熊宗武, 'Liuxuesheng yu jindai Zhongguo gaodeng kuangye jiaoyu 留学生与近代中国高等矿业教育 [Oversea students and higher mining education in modern China]', *Gaodeng jiaoyu yanjiu* 高等教育研究 *[Journal of Higher Education]*, 34.1 (2013), pp. 81–89.

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established by foreigners resulted in an increasing demand for coal.[12] To supply steam ships of the China Merchants Steamship Navigation Company (established in 1872) with coal,[13] Li Hongzhang and other Chinese officials became enthusiastic about the search for coal, especially in North China. In 1875, at the beginning of his industrial practices and political career, Sheng was appointed by Li to prospect for coal in Hubei Province and was put in charge of two short-lived mining agencies: *Hubei kaicai meitie zongju* 湖北開採煤鐵總局 (Hubei General Bureau of Coal and Iron Mining), 1876–79, and *Jingmen kuangwu zongju* 荊門礦務總局 (Jingmen Mining Bureau), 1879–81.[14] However, these enterprises failed because of high costs and limited access to capital, low productivity, and other administrative problems.

These early 'failed' attempts in China's modernisation project have been largely neglected by previous scholarship. Only a few Chinese articles analyse the reasons for Sheng's failure in organising the mining enterprise.[15] Instead, scholars have focused on examining famous mining companies such as the Kaiping coal mines in Zhili (present-day Hebei) Province and the Hanyeping Company in Hubei Province in the late Qing period.[16] A more recent trend pays close attention to the identification of foreign mining experts or geologists, focusing either on global mobility of mining engineers and technology transfer from the West to China, or on Western and Japanese imperialism in China.[17] But, the history of mining education within China—including Sheng Xuanhuai's proposal for a mining school at Yantai in Shandong Province—remains largely overlooked and unaddressed.

[12] S. R. Brown and T. Wright, 'Technology, economics, and politics in the modernization of China's coal-mining industry, 1850–1895', *Explorations in Economic History* 18 (1981), pp. 62–65.

[13] A. Reinhardt, *Navigating Semi-Colonialism: Shipping, Sovereignty, and Nation-Building in China, 1860–1937* (Cambridge, MA, 2018), pp. 75–79.

[14] Y. Xu 徐元基, Pingzi Ji 季平子, and Xi Wu 武曦 (eds.), *Sheng Xuanhuai dang'an ziliao, di wu juan: Hubei kaicai meitie zongju, Jingmen kuangwu zongju* 盛宣怀档案资料, 第五卷: 湖北开采煤铁总局, 荆门矿务总局 *[Collected Materials of Sheng Xuanhuai, vol. 5: Hubei General Bureau of Coal and Iron Mining and Jingmen Mining Bureau]* (Shanghai, 2016), pp. I–II.

[15] See e.g. H. Liang 梁华平, 'Lun Sheng Xuanhuai zaoqi chuangban Hubei meitie kuangwu yaozhe de zhuguan yuanyin 论盛宣怀早期创办湖北煤铁矿务夭折的主观原因 [On the subjective reason for Sheng Xuanhuai's failure in the early coal and iron mining practices in Hubei]', *Jianghan luntan* 江汉论坛 *[Jianghan Forum]* 4 (1981), pp. 55–60; J. Zou 邹俊杰 and Yingchun Jiang 姜迎春, 'Jindai yangwupai dui Hubei meitie kaicai de tansuo yu shijian: yi Li Hongzhang, Sheng Xuanhuai de huodong wei zhongxin 近代洋务派对湖北煤铁开采的探索与实践—以李鸿章、盛宣怀的活动为中心 [Modern practices in coal and iron mining in Hubei during the Foreign Affair Movement: centring around the activities of Li Hongzhang and Sheng Xuanhuai]', *Zhongguo kuangye daxue xuebao (Shehui kexueban)* 中国矿业大学学报 (社会科学版) *[Journal of China University of Mining and Technology (Social Sciences)]* 3 (2017), pp. 90–95.

[16] E. C. Carlson, *The Kaiping Mines (1877–1912)* (Cambridge, MA, 1957); Hansheng Quan 全漢昇, *Hanyeping gongsi shilue* 漢冶萍公司史略 *[A Brief History of the Hanyeping Company]* (Hongkong, 1972); T. Wright, *Coal Mining in China's Economy and Society, 1895–1937* (Cambridge, 1984); Y. Fang 方一兵, *Hanyeping gongsi yu Zhongguo jindai gangtie jishu yizhi* 汉冶萍公司与中国近代钢铁技术移植 *[Hanyeping Company and Transfer of Modern Iron and Steel Technology to China]* (Beijing, 2010); and J. Hornibrook, *A Great Undertaking: Mechanization and Social Change in a Late Imperial Chinese Coalmining Community* (Albany, 2015).

[17] See e.g. G. Y. Shen, *Unearthing the Nation: Modern Geology and Nationalism in Republican China* (Chicago, 2014); S. X. Wu, *Empires of Coal: Fueling China's Entry into the Modern World Order, 1860–1920* (Stanford, CA, 2015); V. Seow, *Carbon Technocracy: Energy Regimes in Modern East Asia* (Chicago, 2022). For Chinese literature, see the major works by Fang Yibing and her collaborators: Y. Fang 方一兵 and W. Qian 潜伟, 'Zhongguo jindai gangtie gongyehua jinchengzhong de shoupi bentu gongchengshi (1894–1925 nian) 中国近代钢铁工业化进程中的首批本土工程师 (1894–1925 年) [The earliest Western trained engineers in China's industrialisation of iron and steel production, 1894–1925]', *Zhongguo kejishi zazhi* 中国科技史杂志 *[The Chinese Journal for the History of Science and Technology]* 29.2 (2008), pp. 117–33; and L. Lei 雷丽芳, Wei Qian 潜伟, and Yibing Fang 方一兵, 'Jindai Zhongguo kuangye gongchengshi qunti de xingcheng 中国近代矿业工程师群体的形成 (1875–1929) [The formation of the community of mining and metallurgy engineers in modern China, 1875–1929]', *Ziran kexueshi yanjiu* 自然科学史研究 *[Studies in the History of Natural Sciences]* 37.1 (2018), pp. 55–70.

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Rather, Sheng is better known as the founder of China's first engineering university and the manager of the Hanyeping Company in the post-1895 period.

Drawing on evidence found in numerous private correspondence letters in the unique collections of Sheng Xuanhuai's archive series and other primary documents from the late Qing period, this article investigates two previously overlooked 'failures' of Sheng's mining-related enterprises, namely his earliest mining practices in Hubei in the 1870s and his proposal for establishing a mining school in Shandong in 1888–89. It then reconnects these efforts with the histories of Western learning, late Qing mining bureaucracy, the monetary crisis of that era, the global recruitment of engineers despite a pronounced distrust of foreign expertise, and finally the establishment of China's first engineering university in 1895. This larger framework enables us to redraw the contour of institutionalising global mining knowledge in China and shed new light on the history of engineering education in late Qing China.

Mining bureaucracy and new text-based knowledge for scholarly learning

Blending scholarly learning and artisanal practices was a challenge for classical educational systems in both China and the West. Although the text-and-visual-based culture of technology-related knowledge provided essential communication vehicles for higher technical education, the formalisation of modern technical education was neither a linear evolution of the traditional system of apprenticeship nor an innovation that originated from the classical learning at universities. Instead, it was a complex synthesis of school and workshop cultures that spanned more than two centuries (from the seventeenth to the late nineteenth centuries) in the West. It encountered particular cultural prejudices and university-based resistance to changing old orders and obtaining equal recognition and status in higher education.[18]

Mining as an important thread in the European educational history is worth our attention. Treatises on mining and metallurgy written by experienced experts in Europe emerged and flourished after 1500.[19] The mining education in the German states (such as Saxony) in the early modern period led the way toward formalisation of technical schools in Europe. By the mid-eighteenth century, training mining officers or bureaucrats was of growing significance when the German states aimed to centralise the control of the mining industry. They established mining academies (i.e. *Bergakademie* as well as *Bergschule*) as public institutions to train mining officials and employed them in the state-owned industries.[20] The German mining-school pattern was further transferred to other regions in Europe and became a prototype for technical schools, especially those later famous *Polytechniques* and *Technische Hochschulen*.[21] The earlier training programmes

[18] See e.g. P. Lundgreen, 'Engineering education in Europe and the U.S.A., 1750–1930: the rise to dominance of school culture and the engineering professions', *Annals of Science*, 47.1 (1990), pp. 33–75; R. Fox and A. Guagnini, 'Introduction', in *Education, Technology and Industrial Performance in Europe, 1850-1939*, (eds.) R. Fox and A. Guagnini (Cambridge and Paris, 1993), pp. 1–9; A. Guagnini, 'Technology', in *A History of the University in Europe, Volume III: Universities in the Nineteenth and Early Twentieth Centuries (1800-1945)*, (ed.) Walter Rüegg (Cambridge, 2004), pp. 593–635.

[19] See e.g. P. O. Long, *Openness, Secrecy, Authorship: Technical Arts and the Culture of Knowledge from Antiquity to the Renaissance* (Baltimore, 2001), pp. 175–91.

[20] D. Brianta, 'Education and training in the mining industry, 1750–1860: European models and the Italian case', *Annals of Science* 57 (2000), pp. 271–74, 278–79. For a detailed examination of the teaching process by incorporating mathematics into mining education, see T. Morel, *Underground Mathematics: Craft Culture and Knowledge Production in Early Modern Europe* (Cambridge, New York, Port Melbourne, New Delhi, and Singapore, 2023), pp. 183–212.

[21] Brianta, 'Education and training', pp. 271–74, 278–79; Guagnini, 'Technology', pp. 597–600.

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of mining schools, designed for bureaucrats rather than artisans or craftsmen, conform to the core value of German cameralism—the science of state administration, which was particularly developed by Johann Beckmann (1739–1811) as the concept of *Technologie* in the late eighteenth century.[22]

Similar to the German cameralism, mining administration (*kuangzheng* 礦政), also mentioned as *kuangwu* 礦務 (mining affairs), was one of the well-established fields in the Qing bureaucracy of managing mint metals and monetary policies long before the arrival of Western imperialism. The Qing state launched and sustained the development of mining industries with its own institutional framework (including policies and laws),[23] although no specific physical institutions like the later mining bureaus (such as those established in Hubei and elsewhere after 1870) were established. Local officials (such as the mining officials) were agents of the central government and their assistants, such as clerks, runners, servants, and secretaries, had a good command of local conditions and extended technical expertise and skills to assist administrative operations.[24]

One distinct feature of the Qing's mining bureaucracy was that mining was foremost concerned with political and social order. Under Qing law, mining could not harm farmland or *fengshui* 風水 (geomancy).[25] Therefore, mining officials and their assistants had developed their own way of managing matters related to mines,[26] including compiling administrative handbooks such as *Diannan kuangchang tulüe* 滇南礦廠圖略 (*Illustrated Account of the Mines and Smelters in Yunnan*) (published in 1844).[27] These procedures did not impact the classical educational system. Through their compilation by literati, they could be said to have emerged in conversation with the classical educational system.

After 1860, many Qing reformers desired a quick 'fix' in order to revitalise the empire. Under these circumstances, the mining industry called for urgent reforms by introducing new (i.e. Western) technology and knowledge. 'The study of mining' (*kuangxue* 礦學) subsequently emerged as a new field for scholarly learning and text-based Western mining knowledge was circulated among Chinese intellectuals.[28] The Jiangnan Arsenal series provided contemporary Chinese readers (officials, literati-scholars, merchants, and students) with the most direct approach to 'the study of mining' and for practical mining knowledge as related to administrative, commercial, or purely scholarly learning purposes.[29] John Fryer (1839–1928) was the most productive translator at the Jiangnan Arsenal in Shanghai and contributed significantly to the translation of mining treatises.[30] The

[22] E. Schatzberg, *Technology: Critical History of a Concept* (Chicago, 2018), pp. 79–90. As I have argued elsewhere, technology was not a static concept in nineteenth-century China either; see Chen, 'Technology for re-engineering', pp. 10–43.

[23] H. Chen, *Zinc for Coin and Brass: Bureaucrats, Merchants, Artisans, and Mining Laborers in Qing China, ca. 1680s–1830s* (Leiden, 2019), pp. 167–207, 238–40.

[24] T. Ch'ü, *Local Government in China under the Ch'ing*, 4th print edn (Cambridge, MA, 1988).

[25] Chen, *Zinc for Coin and Brass*, pp. 133–43. For a comprehensive examination of *fengshui* in relation to mining industries in the nineteenth century, especially during the early 1870s, see T. G. Brown, *Laws of the Land: Fengshui and the State in Qing Dynasty China* (Princeton and Oxford, 2023), pp. 158–92.

[26] Chen, *Zinc for Coin and Brass*, pp. 238–40.

[27] *Ibid.*, pp. 395–406. For a comparative analysis of traditional mining literature between China and Europe, see H. U. Vogel, 'The mining industry in traditional China: intra- and intercultural comparisons', in *Cultures of Technology and the Quest for Innovation*, (ed.) H. Nowotny (New York, 2006), pp. 173–74.

[28] Some Western mining knowledge was already introduced to China through missionaries in the early seventeenth century, especially through translating Georgius Agricola's renowned *De Re Metallica* (1556) into Chinese *Kunyu gezhi* 坤輿格致. However, the Chinese edition of this text was not widely circulated. See H. U. Vogel, '"Das wird gewiss die Staatskasse füllen!" Johann Adam Schall von Bells chinesische Übertragung von Agricolas De re metallica libri XII im Jahre 1640', *27. Rundbrief: Agricola-Forschungszentrum Chemnitz* (2019), pp. 55–82.

[29] Chen, 'Creating intellectual space', pp. 37–69.

[30] See Bennett, *John Fryer*, p. 42.

earliest translations included a monograph on coal mining, *Kaimei yaofa* 開煤要法 (lit. *Essentials to Opening Coal Mines*, published in 1871). In 1876, Fryer founded China's first scientific journal, *Gezhi huibian* 格致彙編 (*The Chinese Scientific and Industrial Magazine*, 1876–92).[31] He also opened a question-and-answer session in that journal to interact with readers. Remarkably, the topic of coal mining had aroused much reader interest in 1876. Several readers wanted to know about the methods or tools for mining coal or the principle of safety lamps in mines,[32] or even what mine shafts and working-faces looked like.[33] To answer them, Fryer provided illustrations, such as the sectional view of underground coal mines (Figure 1) and the water-lifting machine commonly used in coal mines in England and India (Figure 2).[34]

Was the text-based Western mining knowledge influential? It was. Consider, for instance, Sheng Xuanhuai's mining practices in Hubei. Local officials, such as Zhang Fuhuang, had studied the book *Kaimei yaofa* carefully and thus knew the advantage of using Western tools and machinery for drilling and drainage. At that time, an English merchant called James Henderson was commissioned by the Qing government to purchase mining machines in England. Nevertheless, his final bid price, estimated at more than £45,000, was too high to make the plan of opening coal mines in Zhili Province profitable.[35] After reading the news about Henderson in *Shenbao* on 6 April 1875, Zhang Fuhuang and other local officials in Hubei knew that Western machinery cost too much. Instead of using labour-saving devices for drilling, they still planned to hire miners so that the local poor could make a livelihood through mining.[36] According to a report by another local official, Ye Sizhong, it was decided to use Western-style pipes made of copper alloy, instead of the traditional bamboo pipes, for lifting water in coal mines.[37] In general, the influence of foreign machinery on the Chinese mining industry in the early industrialisation phase should not be overestimated. Although large numbers of enterprises in China at the turn of the twentieth century used foreign machinery, their operations were on a very small scale.[38] As translated works on mining became timely textbooks for Chinese intellectuals who had received no mining education, mining field managers were increasingly recognising the necessity for educating mining experts. China's education of its own mining engineers was not intended to be a simple replacement of traditional *fengshui* experts, but was driven by distrust of foreign expertise, as shall be examined in the following section.

Expertise in demand: from the *fengshui* expert to the distrust of foreign mining engineers

The tension between government goals and local interest is manifested fully in the case of coal mining in Hubei in the 1870s. Sheng Xuanhuai was interested in finding coal in

[31] *Gezhi huibian* 格致彙編 *[The Chinese Scientific and Industrial Magazine]*, located in Shanghai, was a continuation of the former *Zhongxi wenjian lu* 中西聞見錄 *[Peking Magazine]*, 1872–76.

[32] See question No. 31 in *Gezhi huibian* (May 1876).

[33] See question No. 62 in *Gezhi huibian* (September 1876).

[34] See e.g. J. Fryer, 'Xiguo kaimei lüefa 西國開煤畧法 [Simplified methods of mining coal in Western countries]', *Gezhi huibian* (October 1876); and J. Fryer, 'Qishui jiqi 起水機器 [Water-lifting machine]', *Gezhi huibian* (June 1876).

[35] See the news in *Shenbao* 申報 *[Shanghai News]*, 6 April 1875.

[36] Xu, Ji, and Wu (eds.), *Sheng Xuanhuai dang'an ziliao, di wu juan*, pp. 14–15, 29.

[37] *Ibid.*, pp. 15–17.

[38] A. Feuerwerker, *China's Early Industrialization: Sheng Hsuan-huai (1844-1916) and Mandarin Enterprise* (Cambridge, MA, 1958), pp. 2–5. For an in-depth examination of mechanisation of coalmines in Pingxiang County, Jiangxi Province at the turn of the twentieth century, see Hornibrook, *Great Undertaking*, pp. 125–62.

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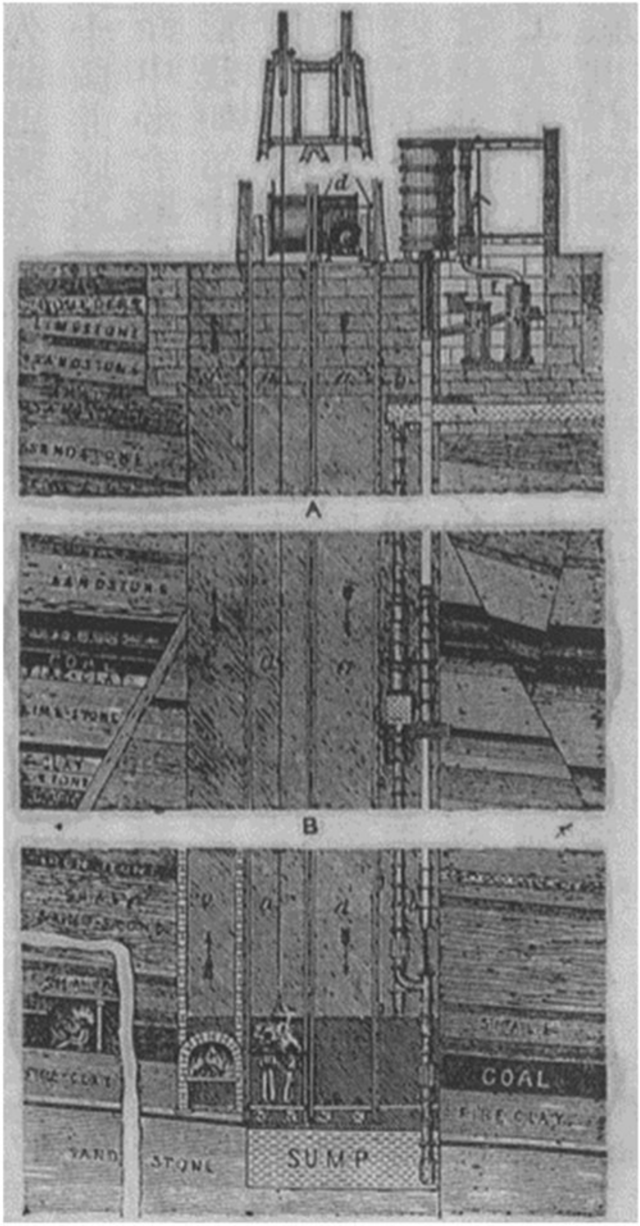

Figure 1. Sectional view of underground coal mines.
Source: J. Fryer, 'Xiguo kaimei lüefa 西國開煤畧法 [Simplified methods of mining coal in Western countries]', *Gezhi huibian* 格致彙編 (October 1876).

Guangji County, Hubei, where he had constantly seen the abandoned pits near the riverside. He then commissioned local officials to make field surveys and send him regular reports. The survey reports revealed that private and illegal coal mines were common in the area, and that anthracite of good quality and suitable for the needs of arsenals and steam ships was mined in that region. However, coal mining was not favoured by the local populace, due mainly to *fengshui* disputes.[39] In the following months, while

[39] Xu, Ji, and Wu (eds.), *Sheng Xuanhuai dang'an ziliao, di wu juan*, p. 4. The Qing emperors and their governors were well aware of one fact: some kind of 'harm' to the *fengshui* was, at times, a pretence, because local

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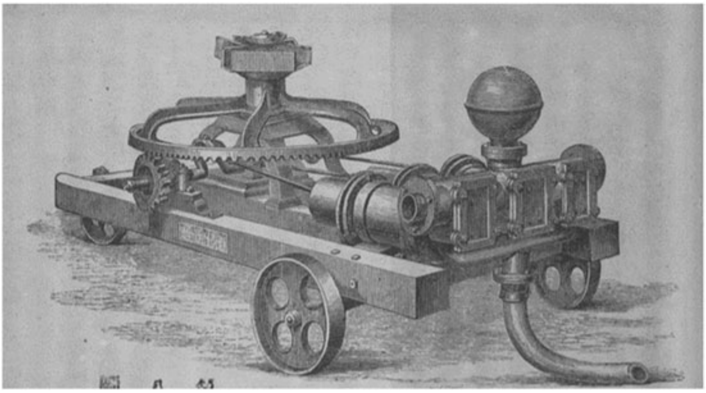

Figure 2. Water-lifting machine used in coal mines. Source: J. Fryer, 'Qishui jiqi 起水機器 [Water-lifting machine]', *Gezhi huibian* (June 1876).

trial mining went on, the mining officials had to cooperate with the local gentry and, above all, they had to follow the advice of the 'dragon head' (*longtou* 龍頭), the local *feng-shui* expert, when excavating at sites surrounded by graves.[40]

When trial mining with native methods (including the instructions of the 'dragon head') did not prove profitable, Sheng Xuanhuai and his advisers turned their attention to Western mining methods, particularly the deep drilling tools, which could enable prediction of the depth and range of a coal seam. To that end, a British mining engineer named Samuel John Morris (Chinese name: Ma Lishi 馬立師, or 馬利師; *circa* 1840–96[41]) was hired at a monthly salary of 300 taels,[42] firstly for a period of six months. Morris held an engineering degree awarded in 1855 and had worked in India from 1863 to 1867. Before coming to China, he worked at coal mines in Takashima and Imari in Japan. Morris's major activities were documented as drilling and prospecting in Hubei.[43]

Nevertheless, Morris failed to discover a rich or large deposit in the former coalfield after expiration of his contract period in around mid-1876. As Morris complained in several letters, the local manager of coal mines did not cooperate with him and replaced his assistants without giving advance notice. Moreover, the assistants did not follow his instructions and even destroyed the excavation site by throwing rocks because they disliked foreigners.[44] Sheng Xuanhuai reported Morris's inability in prospecting to Li Hongzhang. Afterwards, he requested Robert Hart (1835–1911), a Qing government appointee as inspector general of the Chinese Maritime Customs Service, to look for a proper mining engineer from England.[45] It is necessary to add some clarification as to

strongmen often controlled the mineral ores for illegal mining. See Chen, *Zinc for Coin and Brass*, pp. 199–200; and Brown, *Laws of the Land*, pp. 152–96.

[40] Xu, Ji, and Wu (eds.), *Sheng Xuanhuai dang'an ziliao, di wu juan*, p. 29.

[41] According to his Chinese working contract signed in February 1876, Samuel J. Morris was then aged 36. See *ibid.*, p. 56. Morris died on 9 February 1896 in Yokohama. See his obituary published in 'Latest intelligence', *The North-China Herald and Supreme Court & Consular Gazette* 56.1489 (Shanghai, 12 February 1896), p. 235.

[42] Morris's salary could be categorised as above the average salaries of foreign experts. For example, in the Fuzhou Navy Shipyard, the monthly salaries for foreign instructors varied between 200 and 250 taels, and was about 100 taels for foreign artisans in the 1870s. See Q. Lin 林慶元, *Fujian chuanzhengju shigao (zengding ben)* 福建船政局史稿 (增訂本) *[History of Fuzhou Navy Shipyard, enlarged and revised edn]* (Fuzhou, 1999), pp. 297–98.

[43] Xu, Ji, and Wu (eds.), *Sheng Xuanhuai dang'an ziliao, di wu juan*, pp. 34–35, 55–57.

[44] *Ibid.*, pp. 86–87.

[45] *Ibid.*, p. 160. As a consequence, Andrew White Crookston (Guo Shidun) and two other assistants were employed. They did not find profitable coal deposits at Guangji County either. Rather, they found iron in Daye, which became the important iron-producing centre for supplying the later famous Hanyeping Company.

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judging whether Morris was a qualified coal-mining engineer. In fact, Morris specialised in civil engineering[46] and had experience in developing mining excavation using machines, such as in his former work at the Takashima coal mine in 1868.[47] But his former experience in Japan did not demonstrate his ability as a *successful* mining engineer.[48]

Morris continued with his engineering and commercial activities in China. From *circa* 1883 to 1893, he was hired by Sheng Xuanhuai to prospect for coal as well as iron for the *Jinzhou kuangwu ju* 金州礦務局 (Mining Bureau of Jinzhou) and also worked for the China Merchants Steamship Navigation Company.[49] He changed his Chinese name to Ma Kuangshi 馬礦師 (lit. 'Mining Master Ma' or 'Mining Engineer Ma'), although he was also mentioned as Ma Lisheng 馬利生 in some Chinese translations of his letters, probably because there was already another merchant named John Morris registered as Ma Lishi in Shanghai.[50] In the popular Shanghai daily newspaper *Shenbao* from February to May in 1886, Samuel J. Morris (i.e. Ma Kuangshi) advertised himself as an experienced civil and mining engineer who had worked in China and Japan for 18 years. He stressed that he was able to distinguish different types of ores and was ready to provide advice to anyone wishing to invest in mining industries.[51] A subtle change of his professional description in the English directories was from 'civil and mining engineer' registered in 1889 into 'civil engineer and architect' in 1892.[52] When the hiring of *competent* Western engineers was stressed by Chinese reformers, it invariably heightened the pressure on those *incompetent* individuals such as Morris, which turned him away from his mining business; he even requested Sheng Xuanhuai to provide him with a recommendation letter to confirm his almost 20 years of work experience and competence in China.[53]

Indeed, the early experience with Samuel J. Morris changed late Qing officials' attitudes towards expertise as well as foreign experts. Despite his later employment by Sheng Xuanhuai, Morris's 'failure' in Hubei was widely considered by the Qing officials

[46] See 'Latest intelligence', p. 235.

[47] For Morris's activities in Japan, see A. Cobbing, 'Irei no O-Yatoi Gaikokujin: kōzan gishi Morisu no sokuseki o Tadoru 異例のお雇い外国人——鉱山技師モリスの足跡を辿る [An exceptional Oyatoi: tracing the footsteps of mining engineer Samuel John Morris]', *Nishi Nihon Bunka* 西日本文化 *[Culture of Western Japan]* 339 (1998), pp. 24–27. See also A. Cobbing, *The Japanese Discovery of Victorian Britain: Early Travel Encounters in the Far West* (London and New York, 1998), p. 167. The author would like to acknowledge great thanks to Prof. Andrew Cobbing from the University of Nottingham for kindly sharing the Japanese article.

[48] See J. Himeno 姫野順一, 'Shoki Takashima tankō no nichi ei gōben kaisha to o yatoi gaikokujin no yakuwari sairon: Sekai isan "Meiji Nippon no sangyō kakumei" no bunseki shikaku 初期高島炭坑の日英合弁会社とお雇い外国人の役割再論——世界遺産「明治日本の産業革命」の分析視角 [Reconsidering the role of "employed foreigners" in the joint venture between Japan and Britain in Early Takashima Colliery: an analytical view into the world heritage of "Japan's Meiji industrial revolution"]', *Nagasaki gaidai ronsō* 長崎外大論叢 *[The Journal of Nagasaki University of Foreign Studies]* 21 (2017), pp. 1–17. The author would like to thank Prof. Naofumi Nakamura from Tokyo University for drawing my attention to this reference.

[49] There were a number of letters written and signed by Morris in English and attached with Chinese translations that are kept in the collections of *Sheng Dang* 盛檔 (Sheng Xuanhuai Archive) in Shanghai tushuguan 上海圖書館 (Shanghai Library). For example, he signed a working contract with the *Jinzhou kuangwu ju*; see *Sheng Dang*, file number: STSD002622, date of 25 October 1883 (GX9/9/25). He was hired by the China Merchants Steamship Navigation Company during 1892–93; see *Sheng Dang*, file number: STSD043175, date of 29 September 1893 (GX19/8/20).

[50] See e.g. *The Chronicle & Directory for China, Corea, Japan, The Philippines, Cochin-China, Annam, Tonguin, Siam, Borneo, Straits Settlements, Malay States, &c.* (Hongkong, 1889), p. 448.

[51] The advertisement 'Ma Kuangshi gaobai 馬礦師告白 [Advertisement of Ma Kuangshi]', first appeared in *Shenbao [Shanghai News]* no. 4609 (16 February 1886), p. 11; and was repeated in *Shenbao* no. 4658 (6 April 1886), p. 5; no. 4686 (4 May 1886), p. 5; no. 4693 (11 May 1886), p. 8; and no. 4707 (25 May 1886), p. 6.

[52] See *The Chronicle & Directory for China*, p. 448; *The Chronicle & Directory for China, Corea, Japan, The Philippines, Indo-China, Straits Settlements, Siam, Borneo, Malay States, &c.* (Hongkong, 1892), p. 127.

[53] See *Sheng Dang*, file number: STSD043173, date of 28 September 1893 (GX19/8/19).

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as well as other literati-scholars as indicative of the inferior quality of overseas Western mining engineers, because they believed that the first-class engineers could make a living in mining industries easily and would not be willing to leave their own countries. Otherwise, their salaries would be extremely high.[54] Since the Western experts were not always reliable, Sheng Xuanhuai began to address the importance of educating China's own mining experts.

He had already emphasised the necessity for recruiting specialised experts in the mining regulations issued in early 1876. In that regard, he specified the need to hire truly capable persons, instead of those assistants or advisers recommended by local officials. In particular, in one letter *Lun kuangshi shu* 論礦事書 (On mining affairs) addressed to Li Hongzhang in September 1876, Sheng Xuanhuai emphasised the importance of mining engineers in opening up a mine. In his view, the major impediment to developing mining industries was the difficulty not in raising funds, but in finding a proper expert to run the mines. Prospecting was the very first and key step. Such expertise or talent (*rencai* 人才) for prospecting should be domestically cultivated.[55]

For the first time, Sheng Xuanhuai proposed that some 10 to 20 Chinese students who were studying at the Tongwen College (in Beijing), or at arsenals in Fujian or Shanghai, should be selected to learn from the Western engineers. In addition, Sheng proposed that some 10 to 20 Chinese students should be sent abroad to study mining engineering. The last point, in Sheng's view, was directly relevant to maintaining China's sovereignty.[56] It also echoes one of Li Hongzhang's statements in early 1876 that Chinese mining industries could employ foreigners but should not be taken advantage by foreigners.[57]

Sheng's proposal was soon put into action. In 1877, Li wrote to the China Education Mission commissioner Yung Wing (1828–1912) that he should encourage Chinese students to take up the major of mining engineering, which the country desperately needed.[58] Similarly, when sending the students from Fuzhou Navy Yard to Europe, Li also told the throne that some students should take up subjects like mining. As a consequence, five students, namely Lin Qingsheng, Chi Zhenquan, Zhang Jinsheng, Luo Zhenlu, and Lin Rizhang, ended up in the *École nationale supérieure des mines* in Paris and returned to China in around 1881.[59] They were actively engaged in prospecting for coal, lead, iron, and copper in Fujian, Zhili, Shandong, and Hubei Provinces in the 1880s and early 1890s.[60] Moreover, when the Chinese Education Mission project was aborted in 1881, about ten of the students who had returned from the USA had become involved in the mining industries (primarily in the Kaiping coal mines).[61]

Sheng Xuanhuai's proposal for a mining school at Yantai

The failure of the Hubei mining enterprise in 1881 shifted Sheng Xuanhuai away from mining to other industries, including building railway lines and establishing telegraph

[54] See G. Song 宋賡平, *Kuangxue xinyao xinbian* 礦學心要新編 *[New Edition of the Core Essentials on Mining Studies]*, *juanxia* 卷下, vol. 3 (1902), pp. 10, 29–30.

[55] Xu, Ji, and Wu (eds.), *Sheng Xuanhuai dang'an ziliao, di wu juan*, pp. 107–8.

[56] *Ibid.*, pp. 107–8.

[57] *Ibid.*, pp. 66–67.

[58] See Li Hongzhang's letter addressed to Yung Wing on 24 February 1877 (GX3/1/22), G3–01–011, in T. Gu 顾廷龙 and Y. Dai 戴逸 (eds.), *Li Hongzhang quanji* 李鸿章全集 *[Complete Works of Li Hongzhang]*, vol. 32 (Hefei, 2008), pp. 8–9.

[59] J. Yang 楊家駱 (ed.), *Yangwu yundong wenxian huibian* 洋務運動文獻彙編 *[Collection of Materials on the Foreign Affair Movement]*, vol. 5 (Taibei, 1963), p. 253. See also Lin, *Fujian chuanzhengju shigao*, pp. 193–94.

[60] Lei, Qian, and Fang, 'Jindai Zhongguo kuangye', pp. 61–62.

[61] Rhoads, *Stepping Forth*, pp. 190–94, 199–200; Lei, Qian, and Fang, 'Jindai Zhongguo kuangye', pp. 59–60.

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companies as well as telegraph schools. He served as the Superintendent of East Customs (*Donghaiguan jiandu*) at Yantai/Chefoo from 1886 to 1892. His close connection with mining industries in Shandong even dated back to 1882. As mentioned above, Chi Zhenquan and Lin Rizhang, two of the first generation of returned students who studied mining in Europe, were appointed by Li Hongzhang to survey lead deposits in Shandong and Sheng was appointed by Li to supervise the mining enterprise in order to supply lead to local arsenals.[62] In later reports to Li, Sheng made a formal acknowledgement of the ability of the returned Chinese students. In his view, the 'students' (*kuang xuesheng* 礦學生), namely Chi and Lin, were capable of lead prospecting and smelting, and therefore they could replace foreign engineers (*kuangshi* 礦師).[63]

The principal stimulus to the plan of initiating a mining school at Yantai, according to the currently limited available evidence, was the urgent 1887–88 coinage reforms caused by the late Qing monetary crisis. Adopting foreign machinery for minting coins began to be practised in Zhili and Jiangsu Provinces in 1887. Purchasing machinery from the West and training Chinese artisans or workers were challenging. But a larger problem was that of solving the insufficient supply of mint metals, and therefore revitalising non-ferrous mining industries beyond coal and iron.[64] Traditional mining industries in the Southwest, which supplied Chinese central and provincial mints with mint metals (primarily copper and zinc), had been largely destroyed by the social unrest during the 1870s. One new proposal approved in the 1887–88 coinage reforms was to open up zinc and lead mines in Zichuan, Shandong Province, which could alleviate the problems caused by transporting zinc and lead out of Guizhou and Hunan Provinces over mountains and long distances.[65] This brought Shandong a new opportunity to develop non-ferrous mining. But the increased cost of hiring foreign engineers for prospecting in that province and elsewhere in China surely would not have escaped the attention of an astute official-merchant such as Sheng.

Moreover, the major source of copper for Chinese central mints had primarily been Yunnan copper and imported Japanese copper. Tang Jiong (1829–1909), the Yunnan provincial governor in charge of mining affairs from 1887 onwards, investigated the Yunnan mining industries and stressed the importance of introducing Western mining machinery to copper mines. He made reference to the innovation of Japanese mining industries and proposed hiring Japanese engineers. He also pointed out that, in Japanese copper mines, their native engineers had replaced the foreign ones.[66] Such a rapid change from China's neighbouring country, as a successful example of promoting technical education, began to arouse the attention of late Qing reformers.[67]

This impression was further strengthened and swiftly delivered by Li Shuchang (1837–98), then the Chinese ambassador to Japan. After the new minting policy was issued in 1887, Sheng Xuanhuai, possibly being commissioned by Li Hongzhang, asked Li Shuchang to help him purchase copper in Japan and also consulted him on Japanese minting

[62] D. Xia 夏東元, *Sheng Xuanhuai nianpu changbian* 盛宣懷年譜長編 *[A Detailed Chronological Biography of Sheng Xuanhuai]*, vol. 1 (Shanghai, 2004), p. 156.

[63] *Ibid.*, pp. 161–62.

[64] F. H. H. King, *Money and Monetary Policy in China, 1845–1895* (Cambridge, MA, 1965), pp. 213–20; W. Burger, *Ch'ing Cash*, vol. 1 (Hong Kong, 2016), pp. 163–81.

[65] See the palace memorial G13–04–015, in Gu and Dai (eds.), *Li Hongzhang quanji*, vol. 12, pp. 90–91.

[66] Yang (ed.), *Yangwu yundong wenxian huibian*, vol. 7, pp. 31–33. For Tang Jiong's report on Guizhou zinc industries, see Chen, *Zinc for Coin and Brass*, pp. 184–85.

[67] The most influential work introducing Japan to Chinese readers in the post-1895 period was *Riben guozhi* 日本國志 *[Monograph on Japan]*, completed by Huang Zunxian 黃遵憲 (1848–1905) in 1887, but published in 1895. For Huang's impression of Japanese technical education, see Chen, 'Technology for re-engineering', p. 26.

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technology. In a letter dated 19 February 1888 (GX14/1/8[68]), Li Shuchang gave Sheng the following advice on establishing a mining school: China has an urgent demand for foreign experts in numerous branches and the key step in revitalising mining administration would be to establish schools and study geology and chemistry as well as metallurgy.[69]

Apparently, Sheng Xuanhuai considered this advice immediately and urgently. Evidence on the early development of this plan is found in several telegrams. According to a reply message telegraphed to Sheng on 14 April 1888 (GX14/3/4), Zhang Zhidong (1837–1909), then general governor of Guangdong and Guangxi Provinces, fully supported this plan. About ten days later, Sheng received another telegram reply dated 25 April 1888 (GX14/3/15) from the Shandong provincial governor, Zhang Yao (1832–91). The latter Zhang asked him whether he had talked with Li Hongzhang.[70] Consequently, another week later, in the evening of 3 May 1888 (GX14/3/23), Sheng telegraphed Li, making the following points:

(1) Both British and American mining engineers are trained at schools. Their students at mining schools should spend several months with their teachers in the field, to investigate mines and to assay mineral ores. A mining school like this is planned at Yantai, so that Chinese mining students could survey the mines nearby;
(2) Provincial governors from Guangdong and Shandong support this proposal, but the budget plan has to be reported to the government. Besides, funds can also be raised from merchants; and
(3) First-class mining engineers specialised in non-ferrous metals, coal, and iron, respectively, are in demand. These engineers should be both able to teach Chinese students and survey the fields. They will begin by receiving a three-year contract.

Instantly, in the early morning of the next day, Li Hongzhang telegraphed Liu Ruifen (1827–92), the ambassador in London, to seek proper foreign engineers.[71] Three months later on around 6 August 1888 (GX14/6/29), Sheng went to Tianjin and discussed this plan with Li. A few days after their meeting, the news of establishing a mining school was announced in the Shanghai newspaper, *Shenbao*. According to the newspaper, Max Goebel (Gu Beier), then the consul-general for Belgium at Shanghai, was willing to help seek competent and experienced foreign engineers as teaching staff.[72]

As shown in Sheng's archive series, a proposal for the entire plan of a mining school was drafted on 13 November 1888 (GX14/10/10), but the final proposal, with substantial changes and revisions, was submitted by Sheng to Li Hongzhang three days later. The submitted proposal consists of ten items that address the following subjects: (1) sources of funding for maintenance fees; (2) hiring foreign mining engineers for teaching; (3)

[68] For the date recorded in the Chinese lunar calendar, this article uses a three-number sequence that indicates the reign year, lunar month, and day, and the abbreviation GX stands for the Guangxu reign period. For example, the date 'GX14/1/8' means the fourteenth year of the Guangxu reign, first month, and eighth day.

[69] See *Sheng Xuanhuai Dang'an* 盛宣懷檔案 *[Sheng Xuanhuai Archive]*, date of 19 February 1888 (GX14/1/8), file number: 76-070B-2-071B-1 (https://repository.lib.cuhk.edu.hk/en/item/cuhk-1760813).

[70] Shanghai tushuguan 上海圖書館 (ed.), *Sheng Xuanhuai wenhua jiaoyu dang'an xuanbian* 盛宣懷文化教育檔案選編 *[Selected Materials on Culture and Education from Sheng Xuanhuai Archive]*, vol. 7 (Shanghai, 2019), pp. 466–67.

[71] See the two telegrams G14–03–033 and G14–03–034, in Gu and Dai (eds.), *Li Hongzhang quanji*, vol. 22, p. 329. About three months later, Liu Ruifen found an English engineer in London, but he was afraid that this person would be too young to be capable in practice. See *Sheng Xuanhuai Dang'an*, date of 19 August 1888 ([GX14]/7/12), file number: 72-028B-1-029A-2 (https://repository.lib.cuhk.edu.hk/ en/item/cuhk-1758532).

[72] See 'Lun Zhongguo xingban kuangwu xuetang shi 論中國興辦礦務學堂事 [On promoting mining schools in China]', *Shenbao*, no. 5506 (18 August 1888), p. 1.

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reasons for choosing Yantai as the location; (4) buildings and infrastructure for the school; (5) purchasing relevant books, ore species, and mining tools or devices; (6) recruiting students; (7) arrangement of three-year courses; (8) qualifications of students; (9) tasks of the superintendent and administrative assistants; and (10) promotion for foreign teachers and Chinese students awarded by the Qing government.[73]

Sheng's financial plan reveals how a mining school could be institutionalised in the late Qing administration through joint state–merchant investment and management. Through raising funds from four provinces, namely Zhili, Jiangnan, Guangdong, and Shandong,[74] with an amount of 5,000 taels per year from each province, the maintenance fees for the school would be covered. In addition, the China Merchants Steamship Navigation Company would donate the one-time amount of 15,000 taels for building the school infrastructure. By adding the merchant company (of which Sheng was also the director) into the sponsorship, Sheng placed himself in a more powerful position to supervise the school. Governors of the four provinces would have priority to hire the first-class graduates from the mining school, and any other mining enterprises from other provinces—being invested in either by the officials or by private merchants—could employ the rest of the graduates.

Qualifications of graduates from this mining school, however, stirred up some controversy. As previously mentioned, the first generation of students who returned from Europe was often recorded as (mining) students (*kuang xuesheng*), instead of mining engineers (*kuangshi*), because these returned students were not treated equally to foreign engineers in terms of salaries. Sheng proposed to confer the certificate of 'first-class mining engineer' (*toudeng kuangshi*) to excellent graduates and to award official titles or positions to such graduates. But, as explained by Li Hongzhang in one letter, mining graduates could not be conferred with official ranking titles such as those from navy or military schools because the latter schools were built for military defences. Despite this, Sheng still proposed to award them honourable official status with a corresponding hat button (*xuxian dingdai*).[75] As Confucian scholars' debate over the concept of art or technology in around 1885 suggests, non-classical learning could not be simply legitimised in the imperial examination system.[76] In practice, this meant that a Western-style non-military school could not be built in haste.

Global recruitment of teachers for the mining school

Zhong Tianwei (1840–1900) played a managerial role in planning the mining school and in recruiting teachers globally. Zhong acted as one of Sheng's advisers (even if not officially or nominally) from the late 1880s until 1900.[77] He was one of John Fryer's close collaborators in the Jiangnan Arsenal's translation projects. Another joint connection between Fryer, Sheng, and Zhong was the Xu family: Fryer's earlier co-translators or Chinese writers on mining-related works involved the famous and productive scholars Xu Shou (1818–84) and his son, Xu Jianyin (1845–1901). The Xu family (also including Xu Huafeng and Xu Jiabao) contributed extensively to the translation of works on chemistry and industrial arts, including iron, steel, and general metal-working industries.[78] Zhong Tianwei travelled

[73] Shanghai tushuguan (ed.), *Sheng Xuanhuai wenhua jiaoyu dang'an xuanbian*, vol. 7, pp. 482–96. The selected archival document on Sheng's proposal ended on p. 497. But p. 497 is actually a duplicate of p. 489.

[74] In Sheng's draft proposal dated 13 November 1888 (GX14/10/10), he planned to raise funds from three provinces (namely Shandong, Guangdong, and Zhili). See *ibid.*, pp. 469, 473–74.

[75] *Ibid.*, pp. 525–26.

[76] Chen, 'Technology for re-engineering', pp. 10–43.

[77] See the chronicle of Zhong Tianwei, in Y. Xue 薛毓良 and H. Liu 刘晖桢 (eds.), *Zhong Tianwei ji* 钟天纬集 *[Collected Works of Zhong Tianwei]* (Shanghai, 2018), pp. 205–20.

[78] Chen, 'Creating intellectual space', pp. 51–52.

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with Xu Jianyin and the above-mentioned Li Shuchang to Europe during 1879–81 to investigate the military and manufacturing industries. Both Zhong and Xu were involved in initiating the coal, iron, and steel industries in Hubei before 1895 and Zhong had close contact with Li Shuchang when Li served as the Chinese ambassador in Japan.

The earliest available letter, in which Zhong Tianwei briefly mentioned the mining-school plan to Sheng, was dated 8 June 1888 (GX14/4/29). It is very clear that they had previously discussed this plan. Zhong's letter aimed to recommend a number of Chinese technical experts to Sheng for developing industries in Shandong. A mining school, for example, could give the above-mentioned Xu Huafeng an official position so that Xu would be motivated to work for the government.[79] Zhong Tianwei was the major coordinator to negotiate with Max Goebel as well as John Fryer in the search for teaching staff. The latter happened to travel to the USA in 1888 and helped Zhong/Sheng to recruit a US mining engineer. The plan did not work out. The mining engineers from the USA were too expensive to hire.[80] With the recommendation of Goebel, Sheng and Zhong hired a Belgian mining engineer, Emile Braive (Bai Naifu), at a monthly salary of about 500 taels. They planned to hire another Belgian mining engineer, who would arrive later, as an instructor at a monthly salary of 250 taels.[81]

Braive arrived in China on 1 April 1889 and thereafter submitted to Sheng Xuanhuai some general proposals for the mining school (in an English draft with a Chinese translation) along with the English curriculum, possibly on 18 May 1889 (GX15/4/19).[82] But he did not proceed any further with the school plan. Instead, while waiting for another foreign instructor to come to China, he made geological explorations in Shandong and other provinces in the North. Then, he was 'borrowed' by Zhang Zhidong, the general governor of Hubei and Hunan Provinces who had just being transferred from Guangzhou to Wuchang in 1889, to survey the iron and coal deposits of the Yangzi Valley downstream from Hankou, in order to investigate China's own raw-material supply for constructing a railway line from Beijing to Hankou.[83]

Yet, Braive's English curriculum and general regulations are still worth noting. The curriculum is almost an abridged copy, with some modifications, of those courses published in the College of Engineering (i.e. the former Kōbu Daigakkō) at the Imperial University of Japan (Teikoku Daigaku) for the year 1886–87. For example, it lists all the names of professors and assistant professors whose courses were related to mining and metallurgy, as shown in the English catalogue of that university (see Figure 3). Braive's list also includes a Japanese lecturer's name (i.e. S. Kawano 河野), which is not given in the catalogue.[84]

No separate Chinese translation of this curriculum has currently been found. The only exceptions include the Kanji characters given for the Japanese names and their degree

[79] Xue and Liu (eds.), *Zhong Tianwei ji*, pp. 386, 397.

[80] *Ibid.*, pp. 396, 399, 402, 406–8, 411, 428, 430–31.

[81] *Ibid.*, pp. 396, 399, 402, 405–6, 408, 410, 412–13, 418, 420, 425, 428, 431. See also a very brief telegram that Sheng Xuanhuai sent to Li Hongzhang, G14–12–030, in Gu and Dai (eds.), *Li Hongzhang quanji*, vol. 22, p. 429.

[82] Shanghai tushuguan (ed.), *Sheng Xuanhuai wenhua jiaoyu dang'an xuanbian*, vol. 7, pp. 567–87. The date of Braive's proposal is written as the nineteenth of the fourth month in the Chinese lunar calendar. Since Braive concentrated on mining surveys after the summer of 1889 and did not come back to the mining-school plan, that proposal must have been written in 1889 (GX15).

[83] M. Gorbel, 'Consulat général à Shanghai, rapport no 13', in *Royaume de Belgique. Recueil Consulaire, publié en exécution de l'arrêté royal, du 13 Novembre 1855*, vol. 72 (Bruxelles, 1891), pp. 200–4.

[84] *Imperial University of Japan (Teikoku Daigaku): The Calendar for the Year 1886–87* (Tokyo, 1886), pp. 42–43. For the history of mining education in Japan, see Erich Pauer, 'From student of Confucianism to hands-on engineer: the case of Ōhara Junnosuke, mining engineer', in *Accessing Technical Education in Modern Japan*, (eds.) Pauer and Mathias, pp. 114–60; and R. Mathias, 'The development of mining schools in Japan', in *Accessing Technical Education in Modern Japan*, (eds.) Pauer and Mathias, pp. 303–46.

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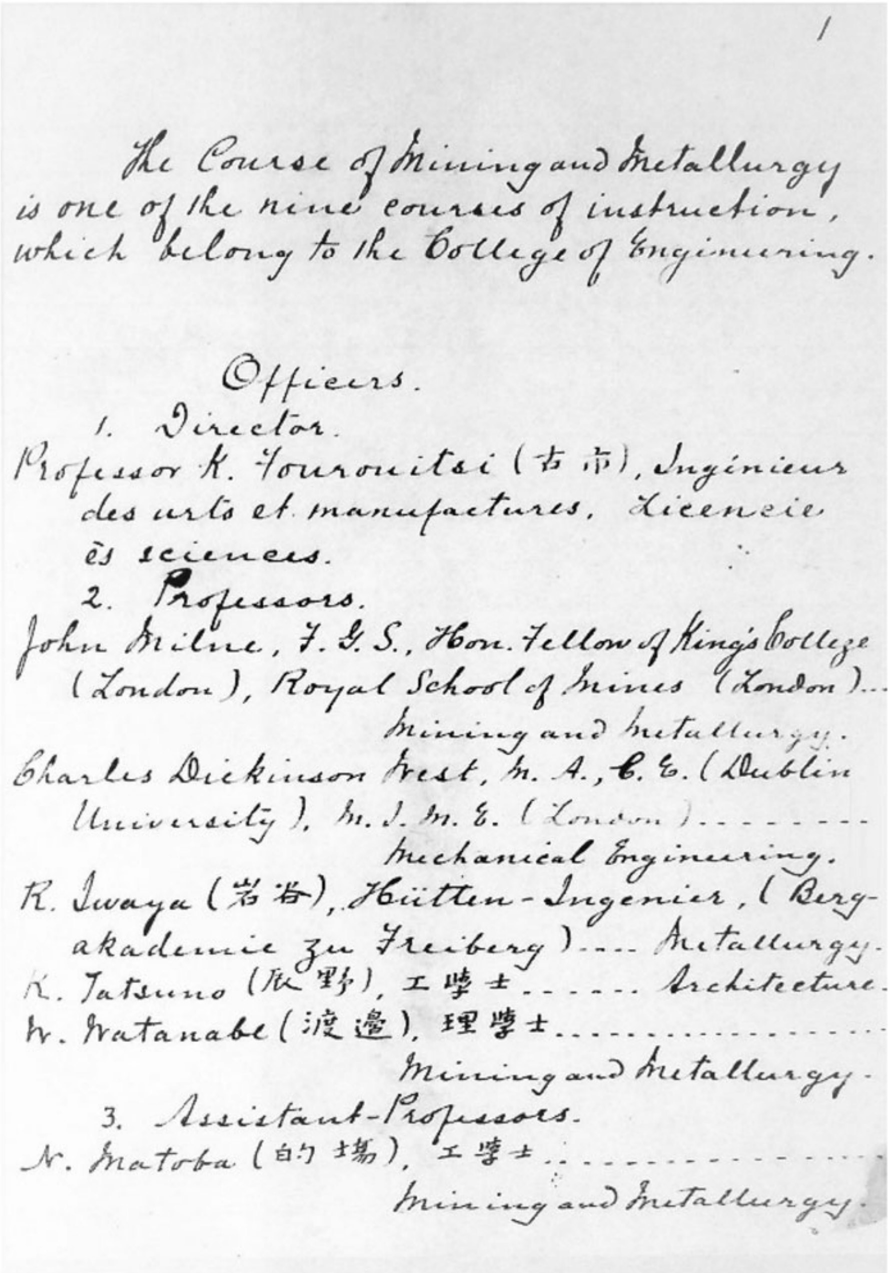

1

The Course of Mining and Metallurgy is one of the nine courses of instruction, which belong to the College of Engineering.

Officers.

1. Director.

Professor K. Fourouitsi (古市), Ingénieur des arts et manufactures, Licencié ès sciences.

2. Professors.

John Milne, F. G. S., Hon. Fellow of King's College (London), Royal School of Mines (London)... Mining and Metallurgy.

Charles Dickinson West, M. A., C. E. (Dublin University), M. I. M. E. (London)........ Mechanical Engineering.

R. Iwaya (岩谷), Hütten-Ingenier, (Bergakademie zu Freiberg).... Metallurgy.

K. Tatsuno (辰野), 工學士...... Architecture.

W. Watanabe (渡邊), 理學士........ Mining and Metallurgy.

3. Assistant-Professors.

N. Matoba (的場), 工學士........ Mining and Metallurgy.

Figure 3. Names of professors and assistant professors mentioned in E. Braive's 1889 mining-school proposal. Source: Shanghai tushuguan (ed.), *Sheng Xuanhuai wenhua jiaoyu dang'an xuanbian*, vol. 7 (Shanghai, 2019), p. 580.

titles, and some courses are translated into Chinese (see Figure 3 and Table 1). The three-year courses, compared with those of the Imperial University of Japan, are slightly modified, for example, by shifting one course to different study years, or splitting one course into two, or adding more hours to some courses (see Table 1).

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Table 1. Three-year courses listed in E. Braive's 1889 mining-school proposal in comparison with those of the Imperial University of Japan

Courses listed in Braive's proposal (Chinese translations for some courses are given in the original text)				Notes on the same courses in the Imperial University of Japan (1886–87)
		First year		
	Hours per week			
	1st term	2nd term	3rd term	
Mining (採鑛學)	4	4	4	
Mineralogy (金石學)	2	2	–	As one course
Geology (地質學)	2	2	–	
The Steam Engine	2	2	2	As one course: *Mechanical Engineering*
Mechanism	1	1	1	
Building Construction	2	2	–	Hours per week: 1.5/3
Surveying (陸地測量)	3	–	–	*Underground Survey*, hours per week 2/2/
Determination of Minerals (金石識別)	1	1	1	
Qualitative Analysis (撿質分析)	12	12	12	Hours per week 8/8/8
Drawing (様械図)	4	4	4	Hours per week 3/3/3
		Second year		
Underground Surveying (地中測量)	2	2	–	Not given in the second year
Metallurgy (冶金學)	4	4	4	
Dressing (淘汰法)	3	3	–	
Water Motors, Pumps, Cranes, et al.	–	–	2	*Mechanical and Metallurgical Technology*, 3 hours per week in the second term
Determination of Minerals	1	1	1	
Assaying (試金法)	5	5	5	
Blowpipe Analysis (吹管分析法)	4	4	4	
Quantitative Analysis (定量分析法)	12	12	12	Hours per week 10/10/10
		Third year		
Mining and Metallurgy	Excursion	–	Thesis	Diploma designs in the third term. All the courses are arranged in the second term

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Ore Deposits	–	3	–	
Mechanical and Metallurgical Technology	–	3	–	Given in the second year
Metallurgical Experiments	–	8	8	1 day per week
Mechanical Engineering Laboratory	–	4	4	3 hours per week
Mining Designing (採鑛法計畫)	–	4	4	4 hours per week
Metallurgical Designing (冶金法計畫)	–	4	4	

Sources: Shanghai tushuguan (ed.), *Sheng Xuanhuai wenhua jiaoyu dang'an xuanbian*, vol. 7 (Shanghai, 2019), pp. 582–84; *Imperial University of Japan (Teikoku Daigaku): The Calendar for the Year 1886–87* (Tokyo, 1886), pp. 50–51.

Despite its obvious duplication, Braive's curriculum does not indicate anything about the Japanese university, except for a statement that '[s]alaries of foreign professors are about $400 a month, and those Japanese professors are about $300 a month in average'.[85] Sheng Xuanhuai and Zhong Tianwei were, very likely, aware of the source of this curriculum and were well informed about the Japanese educational system, since Zhong was in charge of investigating minting technology and even visited Japan at the end of 1888.[86]

While Zhong was hoping to hire a mining engineer from the USA, he also planned to hire a Japanese engineer as assistant professor because of a lower salary for the Japanese.[87] Later on in 1888, Zhong changed his mind: since the Japanese instructors were not good at English, a Chinese expert would be better employed. At that time, Zhang Jinsheng, who was among the first generation of returned mining students from Europe and who had already undertaken several field surveys in Shandong with Xu Huafeng, was recommended by Xu and Zhong as a proper teaching assistant in the mining school.[88]

Apparently, Sheng Xuanhuai's plan of hiring only two (foreign) mining engineers for teaching 20 to 30 students all the subjects (e.g. mechanics, chemistry, physics, drawing, mineralogy, geology and prospecting, metallurgy, and surveying) was not realistic. In addition to Braive's proposal, Sheng also consulted another of the above-mentioned returned students, Luo Zhenlu, on the mining-school regulations. In a rough preliminary proposal, Luo pointed out that at least five foreign professors and five assistant professor or instructors should be hired.[89] Both Braive's and Luo's proposals opened the door for Sheng Xuanhuai and his advisers to reimagine the scale of this school and the placement of such as a school in the Qing bureaucracy and Chinese society.

Sheng Xuanhuai's detours to engineering education

Since the Yantai mining school did not materialise as planned, some scholars hold the view that Li Hongzhang did not approve it because of the inconvenient location. Instead

[85] Shanghai tushuguan (ed.), *Sheng Xuanhuai wenhua jiaoyu dang'an xuanbian*, vol. 7, p. 581.
[86] Zhong Tianwei was in charge of organising the visit to Japan. See Xue and Liu (eds.), *Zhong Tianwei ji*, pp. 390–93, 402, 410.
[87] *Ibid.*, p. 406.
[88] *Ibid.*, p. 414.
[89] Shanghai tushuguan (ed.), *Sheng Xuanhuai wenhua jiaoyu dang'an xuanbian*, vol. 7, pp. 532–66.

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of being at Yantai, a location at Tianjin would have been ideal for supervising the school, in case Sheng were promoted or transferred to another place.[90] Certainly, Li never submitted this plan to the throne, as hoped for by Sheng Xuanhuai from the beginning. With hindsight bias, Li hesitated in approving this plan, perhaps because he was anticipating Sheng's promotion in the future. In 1893, Sheng was, indeed, transferred to the position of Superintendent of Tianjin Customs and, in Tianjin in 1895, he established China's first engineering university—Beiyang University—with a department of mining engineering. Beiyang University was managed by a former US missionary, Dr. Charles Tenney (1857–1930), and therefore hired almost only American professors.[91]

One previously overlooked aspect in the entire story is that the original mining-school proposal was not refused entirely. Instead, Zhang Zhidong practised this idea in Hubei. As shown in several telegram exchanges with Li Hongzhang in late 1889, Zhang recognised the necessity and urgency in establishing technical schools for supporting railway construction. And a chemistry and mining school was considered by him as the foundation for producing iron and steel.[92] At that time, Sheng's ambition in mining industries was also fuelled by the railway plan. In his view, China should focus on developing one major mining enterprise, instead of opening several small mines.[93] This insight and his previous mining and surveying practices in Hubei were highly valued by Zhang and Li. Within one month, in late 1889, Zhang invited Sheng to meet in Shanghai and discuss further plans.[94] Zhong Tianwei, in particular, was hired by Zhang to organise the mining school.[95]

A laboratory was opened in Wuchang in 1890 for analysing coal and ores from Hubei and Hunan. The laboratory was developed into a mining 'college' (*Kuanghua xuetang*) in 1892 (with about 20 students in 1895).[96] That mining college, with yearly maintenance fees of 30,000 taels, was only a small part of the iron and steel works, with estimated total yearly fees of 2.468 million taels.[97] Even more dramatically, in around late 1896 and early 1897, when Sheng Xuanhuai took over the Hanyang iron works from Zhang Zhidong, he established a 'Hanyang steel and iron works college' (*Hanyang gangtiechang xuetang*), specialising in chemical analysis, iron and steel metallurgy, and machinery.[98] Strictly speaking, the Hanyang college was still not a 'mining' school, but a 'metallurgy' school. In both Tianjin and Wuchang, Sheng had realised the plan of initiating mining education.

[90] Xue and Liu (eds.), *Zhong Tianwei ji*, p. 435.

[91] The founding of China's first engineering university by Sheng Xuanhuai in Tianjin in 1895 was not a singular event or an after effect of the Sino-Japanese War, but was part of broader efforts initiated by reform-minded officials in late Qing China to develop technical education; see Chen, 'Daxuetang für die Institutionalisierung der Ingenieurwissenschaft', pp. 87–114.

[92] See the telegrams G15–10–037 and G15–10–042, in Gu and Dai (eds.), *Li Hongzhang quanji*, vol. 22, pp. 548–50.

[93] See the telegram G15–10–050, in *ibid.*, p. 553.

[94] See the telegrams G15–10–053, G15–11–009, G15–11–039, and G15–12–016 in *ibid.*, pp. 554, 557, 564, 569.

[95] Xue and Liu (eds.), *Zhong Tianwei ji*, pp. 452, 454.

[96] Biggerstaff, *Earliest Modern Government Schools*, pp. 69–70.

[97] D. Zhao 趙德馨 et al. (eds.), *Zhang Zhidong quanji* 張之洞全集 *[Complete Works of Zhang Zhidong]*, vol. 5 (Wuhan, 2008), pp. 213–14.

[98] The original idea seems to have been raised by Zheng Guanying in late 1896 and the college regulations were proposed by Li Weige in early 1897. See Z. Zhu 朱子恩, X. Wu 武曦, and J. Zhu 朱金元 (eds.), *Sheng Xuanhuai dang'an ziliao, di si juan: Hanyeping gongsi shang* 盛宣怀档案资料, 第四卷: 汉冶萍公司上 *[Collected Materials of Sheng Xuanhuai, vol. 4: Hanyeping Company, part one]* (Shanghai, 2016), pp. 253–54, 453–57. Similarly, a mining college was built at Pingxiang in Jiangxi Province in 1907, which was led by a German engineer named Gustav Leinung, employed by the Hanyeping Company. See Wu, *Empires of Coal*, pp. 118–20.

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Conclusion

To attain China's technological independence through purchasing (and later producing) China's own machinery-making machines and training China's own machinery-producing experts, late Qing training programmes had primarily focused on practical arts applied for military-related manufacturing industries. The reformers (especially Li Hongzhang, Zeng Guofan, and Zuo Zongtang) had already in the late 1860s shown their interest in industrialising China's economy, from building warships and weapons to mechanisation in agriculture, minting, textiles, and other industries, for which they had to start with establishing military industries.[99] Yet, rewarding 'engineers' (or a technical supervisor) for non-military purposes, as shown above, was still unusual or impossible in the late 1880s. Therefore, the historical significance of mining education and early mining practices lies not in identifying a turning point for educating whether civil (or mining) engineers or military engineers, but in recognising a turning point in the engagement of human–technology–nature through cultivating expertise and legitimising non-classical learning.

As Sheng Xuanhuai clearly articulated in one of his 1888 proposal drafts, establishing mining schools in China was aimed at controlling the source of wealth and making profit from nature.[100] In his view (and including those of his advisers), the past decade had witnessed rapid replacement of foreign mining engineers through educating native students in Japan; regretfully, if China had established a mining school at the very beginning along with the founding of other naval, military, and telegraph schools in the 1860s and 1870s, the same would have happened to revitalise Chinese mining industries.[101] Since his proposal was never submitted to the throne, Sheng Xuanhuai made himself finally heard by the Emperor Guangxu and the Empress Dowager Cixi in one vis-à-vis conversation in 1899: mining, as one way of making profit from nature, was a primary source of gaining wealth. Despite the reforms in the past decades, the major concern of the emperor and empress was still financial and foreign affairs that related to military defences.[102]

This article demonstrates that initiating mining education in China for regaining power and wealth was an evolving idea influenced by various factors. Among several other factors, distrust of foreign mining engineers and revitalising non-ferrous mining industries to solve the monetary crisis acted as principal stimuli to the generation of the idea. Sheng Xuanhuai's seemingly discrete mining-related efforts, partly viewed as failures, prepared the way for establishing a mining school in China and eventually led to the founding of a mining college at Wuchang and an engineering university at Tianjin. This trajectory reflected how engineering education for non-military purposes in late Qing China was institutionalised.

Within the framework of Qing mining bureaucracy, the demand for special expertise was fuelled by the global search for coal in the late nineteenth century. Capable and trustful field experts were considered especially crucial because they had to supervise the field and negotiate with local gentry and *fengshui* experts (the 'dragon-heads'). Circulation of translated book knowledge (including journals) in late Qing Western learning brought an

[99] H. Chen, 'China's paths to modern technology: from institutional innovations to Confucian scholarly learning of arts, 1860–1885', *Artefact* 18 (2023), pp. 223–56. For recent comprehensive studies on Zuo Zongtang's engagements in profit-making projects (especially agriculture and mining) in Xinjiang, see J. Kinzley, *Natural Resources and the New Frontier: Constructing Modern China's Borderlands* (Chicago, 2018); and P. B. Lavelle, *The Profits of Nature: Colonial Development and the Quest for Resources in Nineteenth-Century China* (New York, 2020).

[100] The proposal is entitled '奏為請開中國礦務學堂 以握致富之源 而收自然之利'; see *Sheng Dang*, file number: STSD012201, drafted in November 1888 (GX14/10).

[101] *Ibid*.

[102] *Sheng Xuanhuai Dang'an*, date of 6 October 1899 (GX25/9/2), file number: 03-008B-013B (https://repository.lib.cuhk.edu.hk/en/item/cuhk-1719446).

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understanding of global mining knowledge to those Confucian literati-officials. When Western-style mechanisation began to attract the attention of Chinese reformers, field managers in the mining bureaucracy also reacted to innovative solutions instead of totally trusting foreign professional authority or engineers. For example, costly labour-saving machinery did not suit the local miners in borehole drilling for prospecting for coal. Moreover, Samuel J. Morris's failure in Hubei's coal prospecting in around 1875–76 weakened the trust of Chinese officials in Western engineering professions. The narratives of 'incompetent' Western engineers (or 'artisans', as they were termed at that time) changed late Qing intellectuals' attitudes towards expertise and acted as a stimulus to train China's own mining experts. Subsequently, the first generation of Chinese mining students (five in total) returned from Europe in around 1881.

Finding solutions to the urgent monetary crisis drew the search for non-ferrous metals or mint metals back to the focus of the Qing mining bureaucracy. The 1887–88 coinage reforms turned the reformers' attention to opening mines in Shandong and to investigating Japanese minting and mining technology. These factors reinforced the need for training China's own mining engineers for economic reasons. Sheng Xuanhuai, with one of his closest advisers, Zhong Tianwei, happened to be commissioned to investigate Japanese copper production and minting machinery. Chinese ambassadors in Japan, including Li Shuchang, made the accomplishments of technical education in Meiji Japan visible to late Qing reformists. Li's effective communication with Sheng played a catalytic role in pushing forward the mining-school plan. As demonstrated above, a global recruitment of foreign engineers and teachers from England, the USA, and Belgium, as well as Japan, was instituted by late Qing officials with the aids of networks built by Chinese ambassadors overseas, missionaries, foreign consulates in China, and officers of the Chinese Maritime Customs Service. Emile Braive was hired in the end, but the results of his field surveys reactivated Sheng's ambition in focusing on building a large Chinese iron and steel works in Hubei, to support Zhang Zhidong's railway plan. From the idea of establishing a mining school to the founding of iron and steel works, mining education became embedded in the Chinese mining industries.

Certainly, a mining school had to be anchored within China's cultural, social, and political settings. Sheng's mining-school proposal suggests a placement of such a mining school in the Qing institutions through joint state–merchant investment and supervision. Since the idea of establishing a mining school did not originate from the Confucian educational system, the mining-school proposal never posed a threat to the existing imperial examination system. After all, only around ten Chinese men would become mining engineers. Late Qing reformers treated educational reform as merely a provisional strategy for coping with crises. Nevertheless, qualification and award of the graduates from the planned mining school aroused some controversy because the mining students were not equal to those from navy or military schools. After a detour, Sheng materialised his plan of mining education in both Tianjin and Wuchang.

As part of the long-term continuous late Qing reform process, the two educational institutions were significant experiments in China prior to the 1898 reform. That later reform popularised Zhang Zhidong's principle of 'Chinese learning as principle, Western learning as function'[103] and a new-style school system was established in China after 1902 by rapidly modelling the Japanese pattern. As this study demonstrates, the Japanese educational pattern had already been studied by the pre-1895 reformers. In particular, Zhang Zhidong, the post-1895 authority on promoting educational reform, was a supporter and co-player of the pre-1895 mining education initiatives. Therefore, taking the post-1895 reforms into account, the history of mining education mirrored

[103] See W. Ayers, *Chang Chih-tung and Educational Reform in China* (Cambridge, MA, 1971), pp. 3–5, 159–60.

how the training of Chinese technical experts was built, reinforced, and incorporated into the general educational system.

Despite its late development of modern or Western-style mining technology and education, China's experience in institutionalising mining knowledge still witnessed parallels with those of Europe; the history of mining education provides a new angle from which to understand the question of why and how mining mattered to China's transformation in general, and to the rising engineering education and broader educational system in particular, when the German and French models were widely diffused into the rest of the world along with the European expansion (albeit with many local variations).[104]

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Conflicts of interest. None.

[104] For technical education in European colonies such as India and Egypt, see D. R. Headrick, *The Tentacles of Progress: Technology Transfer in the Age of Imperialism, 1850–1940* (Oxford, 1988), pp. 309–51. See also Guagnini, 'Technology', pp. 611–17.

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