Chapter 10

Engineering Gold Rushes: Engineers and the Mechanics of Global Connectivity

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Between 1848 and 1899, a series of explosive, short-term gold bonanzas struck California, Australasia, Southern and West Africa, and the Yukon Valley. These rushes unleashed waves of settlement, the forced displacement of indigenous peoples, and set in motion great transfers of capital, commerce, and technology around the world. Mining technologies and the broad-ranging expertise of geology, metallurgy, and hydrology were transferred overseas by the hundreds of thousands of migrants who flowed through great gateway cities such as San Francisco, Johannesburg, Melbourne, Dunedin, and Dawson. Enabling these currents of cross-border exchange were important network-builders and managers: engineers. Individually and collaboratively they redirected connectivity to new locales, integrated new expertise with existing networks, and created new institutions for supervising global industrial connections. "After dwelling in a lowland of drowsy accomplishment for centuries," argued one American engineer in 1914, the "great gold discoveries" of the late nineteenth century "sprang" the industry "into gigantic activity." "This has been brought about", he continued, "by the growth of knowledge through science, invention, and engineering … on a scale never dreamt of before, and thus giving man an almost Aladdin's power."[1]

In popular imagination, gold rushes sprang to life from moments of great luck. But actually their development depended upon engineers to manage the mass transfers of

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technologies and expertise between goldfields and empires.[2] To describe these complex patterns of long-distance connection, transnational and global historians frequently reach for metaphors that emphasize fluidity such as waves, currents, and flows. Such metaphors matter. They possess great interpretive power in our depiction of the vibrant mobility of goods, people, and culture in the past, but they do pose challenges. Analytically, these metaphors encourage historians towards a naturalized conception of the history of global interconnection that is at odds with the careful choices made about which technologies of trade, communication, and power would sustain the connecting world. Such transnational connectivity required constant management and decision-making on the part of engineers, about which they debated and shared information in new forums for cooperation and professional exchange. This chapter examines engineers as the key protagonists of transnational network-building and management.

Placing the mechanisms of global connectivity at its heart, this chapter draws on models of exchange and connection devised by historians of imperial science, technology, and transnationalism to bring the late nineteenth century gold rushes into a single analytical and comparative frame. Historians of British imperial science have successfully challenged models of technological diffusion between imperial metropoles and colonial peripheries as unidirectional and have instead highlighted the co-production of colonial knowledge and the multidirectional exchange of technologies.[3] Engineering expertise generated across various mineral frontiers in Africa, Australasia, and the United States circulated widely among highly mobile gold mine engineers who functioned as connectors between fellow professionals in distant places. The engineers examined here conceived of themselves as internationally mobile professionals equipped with the managerial expertise necessary for mediating multi-directional exchanges of expertise and technology. “Within the past twenty years this old-time practical miner has been slowly forced into the background," argued San Francisco's *Mining and Scientific Press* in 1903, "and in his place is found the technically educated man, who with a world-wide knowledge of his business is equal to almost any emergency."[4]

Drawn from experience on goldfields around the world, this expertise was spread rapidly by new transnational institutions. Consulting engineers were as much skilled network managers as specialized technical experts, prized for their ability to move between disciplines, managerial roles, and mineral fields.[5] Broadly speaking, engineers on the goldfields of the nineteenth century constructed mining engineering as a specialized global profession and contributed to unprecedented transnational exchanges of knowledge and expertise.[6] The mining profession was reshaped by non-governmental institutions and international congresses, which acted as transnational spaces for social networking and forums of cooperation. Knowledge and expertise did not simply "flow" along transnational currents; it was in these forums, and in the allied technical press, that active exchange took place. As one commentator termed it, the technical institutions, conferences, and the press were "kindred methods by which the news of progress circulates throughout the world."[7]

Underlying the emergence of specialist engineers and knowledge were national education systems that aimed at developing rival nationally or imperially bounded economies and systems of production. The impact of the proliferation of technical schools and trained miners was twofold. First, it created a culture of expertise—or as one commentator described it a "scientific habit of mind" —among mine engineers. Second, it helped to build and sustain a technical infrastructure that supplied the global mineral industries with a steady supply of highly trained technicians.[8] Technical schools and new forums of international cooperation thus enjoyed a mutually productive relationship, fueling each other's growth. The new institutions of international mining worked to mediate the tensions that resulted from the intersection of national and imperial infrastructure and identities. In short, the emergent global mineral industries spotlight the mechanics of late nineteenth-century global connectivity. Mining engineers were not the only experts responsible for overseeing this process. Railroad, civil, canal and submarine, and overland telegraph engineers of all nationalities, too numerous to list, transformed global communication, travel, and connection.[9] European empires opened opportunities for engineers in industries and colonial projects around the world. American bridge engineers, for instance, worked on viaducts in Uganda, Burma, Sudan, Australia, and throughout the Americas.[10] Irrigation experts from the United States and Australia had famously global horizons and travelled regularly to meet fellow experts and inspect works overseas—most frequently in British India, Italy, Egypt, and China.[11] Meanwhile nations like China and Japan imported foreign expertise (particularly French and German) to develop railroads, navy yards, iron foundries, and coal mines.[12] "Aladdin's power" did not transform the globe, but engineers and experts creating and supervising transnational connection.

Mechanisms of Organization

In the late nineteenth and early twentieth centuries, international networks and institutions developed around the world. Conservationists, lawyers, social progressives, missionary and church leaders, and anti-colonial nationalists among many others, interacted as never before thanks to cheaper and faster ocean travel, telegraphy, and mass publishing. Academic, technical, and professional social networks emerged to share knowledge, solve problems, and systematize the application of new technologies to the extraction of mineral resources.[13] Placer miners had organized themselves into "diggers' committees" to solve collective problems such as water supply and policing or to express grievances to goldfields authorities, but as alluvial mines transitioned to capital-intensive mining, more than twenty institutes for mining were founded across the globe. Such growth signaled the rapid development of the engineering profession and the desire of its members to demonstrate their technical credentials and social prestige. Each of these institutes sustained an administrative structure, chains of correspondence, monthly symposia, and annual conferences, the published proceedings of which were essential to a well-equipped engineering library. Their members were internationally mobile and nationally diverse, but all shared the belief that expertise could be extended and refined by sharing observations of techniques and practice from the mineral fields of the Anglo-American imperial world.[14]

Sustained by travel, shared membership, and the exchange of expertise, this series of networks was the mechanism by which the processes of globalization were managed and directed. While operating and organizing transnationally, the new professional societies did not arrive *ex nihilo* but responded to particular imperial or national pressures—to assert engineering mastery over the vast mineral wealth of the continental United States and to overhaul the mineral industries of Great Britain into an instrument of imperial development. Similarly, while the engineers participating in the creation of the new professional societies often claimed to be advancing universal goals and standards, they just as often framed these impulses around notions of national or imperial superiority. These two impulses—the universal and the national or imperial—and the tensions between them were intertwined in the mechanisms of organization and diffusion that characterized the global mineral industries.

Scientific and professional societies blossomed in the late nineteenth-century United States. In the five decades after the American Civil War, three times as many (forty eight) scientific societies were founded in the US as in all the decades that preceded it (fifteen), and professional associations grew at a similar speed during the same period.[15] Engineers created an industrial empire in the West: damming rivers, digging ditches, and carving railroads through mountain passes. With the increasing diversity and complexity of engineering projects in the United States, the discipline diversified into its major branches. The growing dominance of structural, hydraulic, and sanitary engineering in the profession's chief institution, the American Society of Civil Engineers, led a group of mine engineers to form the American Institute of Mining Engineers (AIME) in the town of Wilkes-Barre, in the center of Pennsylvanian coal country, in 1871.[16]

Established by twenty-two leading mine engineers, AIME sat at an intermediate position between a professional society and a trade organization. At this stage, professional interest did not equate to professionalization. In the words of Rossiter W. Raymond, AIME's domineering secretary, the institute's membership included "common miners, laborers, foremen, and people that cannot spell," in addition to some 20 percent of America's most distinguished "captains of industry."[17] The professional standing of AIME's members was therefore heterogeneous and as a result so were the varieties of mining it represented, encompassing silver, iron, coal, and aluminum in addition to gold. American mine engineers were "neither fish, flesh, nor red-herring" but generalists, or "a humdrum sort of fellow" who often had experience in surveying and tunneling diverse geologies, and in milling, refining, and extracting various ores.[18] Thanks to broad membership standards, AIME grew rapidly and had international appeal. Three years after its founding, the society had fifty-seven foreign members on its rolls, from Britain, France, Germany, Austria, Mexico, Russia, and Belgium.[19] By 1905, its membership had reached more than 3,600, representing mine engineers engaged in the gold, copper, and iron industries, in addition to chemists and geologists.[20]

AIME set the organizational pattern for a wave of institutional organization that began in the mid-1890s, when gold rushes in South Africa and Western Australia, soon to be joined by the Klondike, energized the mining industry. As more than 435 million ounces of gold was dug from some of the world's largest goldfields between 1848 and 1891, an influx of new people entered the mining industries.[21] To set themselves apart from the technicians and diggers, trained consulting engineers set about organizing their profession through new institutions and established new channels for sharing the technical know-how required to tackle the complex geology of goldfields in Southern Africa and Australia.

Britain's Institution of Mining and Metallurgy (IMM) was the first of a series of institutions founded at the peak of the late nineteenth century rushes. The IMM was founded in 1892 by a group of gold miners who hoped to provide a focal point for the exchange of ideas and expertise and to restrain professional irregularities, which undermined the confidence of investors who funded new mining corporations. In Britain, the growth of professional mining institutions was rooted in an imperial context.[22] Engineering and its allied exploration sciences were an important instrument of British colonial development. They enjoyed a close relationship with metropolitan organizations of exploration, such as the Royal Geographical Society and the Geological Society of London, which aimed to subject the Empire to scientific inventory.[23] "The discovery of mineral wealth," wrote Warrington Smyth, geology lecturer at the Royal School of Mines, in 1864, "is the most powerful incentive of the exploration and settlement of distant lands."[24] As a result, the IMM joined the information industry, feeding policy-formulation at the Colonial Office and the decision-making of investors in the City of London.[25]

Unlike its American counterpart, the IMM used membership policies to govern standards of admission into the mining profession—all applicants required the sponsorship of at least three existing members who could vouch for their expertise. At the end of its first year, the IMM's membership was close to two hundred mostly British miners. By the mid-1890s it was almost one thousand, representing every continent barring Antarctica.[26] As its membership grew, the proportion of members based in Britain fell below 50 percent, but it remained a largely Anglophone body with South Africans, North Americans, and Australasians making up the bulk of the remaining membership.[27] It was, declared its turn of the century president, "an eminently cosmopolitan body," "the most ardent advocate of Imperial or Anglo-Saxon unity," and the "hand of brotherly friendship … stretched out to [our] American and colonial cousins."[28]

Mining institutes founded in the colonies were a vital social glue for the transnational engineering diaspora. These institutions were closely modeled after one another, borrowing membership codes, committee structures, and publication schedules. In London, at the first meeting of the Institute for Mining and Metallurgy, Arthur Charleton described the American Institute of Mining Engineers as "at once a reproach and an example to us."[29] Transnational social networking also proceeded through shared memberships and committee members. After its foundation in 1894, the membership of Johannesburg's Cyanide Club increased tenfold to more than five hundred by the outbreak of the Boer War in 1899.[30] Its first president was the Californian cyanide specialist Charles Butters, who was also a member of the IMM in London. Butters was joined by fellow IMM members, including the Americans Hennen and Sydney Jennings, John Hays Hammond, Herbert Hoover, and Thomas Leggett; Lionel Phillips and Edgar Philip Rathbone from Britain; the German banker and Randlord, Hermann Eckstein; and the Australian brothers George and Henry Denning.[31] Similarly, the

Institute of Mining and Metallurgy in London awarded honorary membership to Rossiter Raymond and Richard Rothwell, founders of the American Institute of Mining Engineers.

Together, the proliferating engineering institutions built a transnational infrastructure that facilitated knowledge exchange and social networking.[32] They also supplemented a similarly broad infrastructure of like-minded organizations that included geological and geographic societies, Academies of Science, and state-sponsored Chambers of Mines such as those in New South Wales and the Transvaal, which published their own journals, lobbied government to improve labor legislation and monitored the industry's output.[33] Together, the interleaved institutions of the mining industry sped the emergence of a professional culture amongst mine engineers and managed the conduits through which expertise circulated.

Mechanisms of Transfer

If the new institutions were centers for organizing national and international mineral industries, they were also transfer mechanisms. Each of these institutions acted as centralized databanks, where knowledge could be organized and disseminated. At their core was a set of reform-minded engineers engaged in a crusade to disseminate new scientific methods throughout the mining industry. Their field of vision extended not only to the goldfields of the Anglo-settler societies of the Pacific Rim, but also to other new fields in places as diverse as China, Korea, and Mexico.[34] This core of engineers embraced the positivist faith that the collection and circulation of data and observations ought to be "thrown into a common stock" as part of an international collective learning phenomenon.[35] According to one of its presidents, the American Institute was "to constitute a rich and convenient store-house of reference" for the versatile mine manager charged with overseeing the development of vast industrial systems.[36] As AIME's turn of the century president, Canadian-born Arizonan copper baron James Douglas reflected, the “impulse” behind the organization was the “desire for reciprocity.”[37] Nevertheless, such a desire conflicted with the delimiting of participation in professional organizations on both educational and racial grounds.

The diffusion of mining expertise depended on the new medium of technical journals, which grew rapidly in number and circulation from mid-century. A wide variety of these were the product of the proliferation of international engineering congresses that met frequently from the final third of the century.[38] The American Institute of Mining Engineers' *Transactions* (and beginning in 1893, its annual volume *Mineral Statistics*) and those of the Institute for Mining and Metallurgy in London joined an already strong international mining press. Rossiter Raymond's weekly *Engineering and Mining Journal*, the *Mining and Scientific Press* published in San Francisco, and the weekly *Mining Journal*, published in Britain by Henry English, all enjoyed large subscriptions. The *Engineering Magazine*, meanwhile, published in New York from 1890 and London from 1897 under distinct editorial boards, used the motto “the world is its field” on its masthead. These were aimed at an imagined international audience of mining specialists, interested not only in technical matters but impressionistic travel accounts of the world's diverse mineral fields.

[FigRef10.1]

Away from the great mining metropoles of the British Empire and the American West, local journals enjoyed wide readerships. In Australia, the *Kalgoorlie Miner* and specialist *Australian Mining Standard* thrived; in Canada the *Canadian Mining Review,* founded in 1879 by the phosphate miner W. A. Allan, and the Canadian Institute of Mining's *Bulletin* were most prominent. The published reports of Chambers of Mines, geological surveys, and government mining departments the world over contributed to the ocean of printed matter. The Transvaal Chamber of Mines, founded in 1887, stocked its library with reports from, and dispatched its own transactions to, partner institutions around the globe.[39] For engineers working on the frontier of extraction, importing books and technical journals was a form of "academic internationalism" that spread knowledge and went some way to overcoming the geographic isolation of the goldfields.[40]

As a compendium of up-to-date practice, the technical press was crucial to the rapid dissemination of new techniques and machinery to the mining frontier. It provided easy access to geological reports, assessments of labor conditions, reviews of equipment, and descriptions of new milling, amalgamation, concentrating, and refining methods. Yet, we should be wary of the teleology of "professionalization" or the claims made by engineers of their faith in the so-called neutral character of expertise. Privileging the expertise of a select number of university educated engineers and a select group of journals and institutions was one of the ways in which status-conscious engineers marked their standing as a professional and social elite—and excluded untrained artisans and mechanics from their number.[41]

International cooperation was driven by the desire of engineers to progress towards internationally recognized professional standards and to create an exclusive, professional community centered on mine engineering. In London, the IMM advocated the establishment of uniform (British) standards across the gold mining industries through symposia and its *Transactions*.[42] In articles placed in the international mining press, Arthur Charleton, the IMM's president between 1902 and 1903, tried to persuade his readers of the need to move towards a mineral industry governed by standardized practices.[43] As president of the IMM, Charleton established a standardization committee in 1902 to address accounting practice, weights and measures, assaying, and mining law—all with the aim of placing "mining on a firm professional and business basis" and to "free it from the moral reproach and the stigma of being a lottery."[44] In this respect, the IMM joined other movements, such as those identified by Martin Geyer and Johannes Paulmann, that might be identified as *professional internationalism*—an ethos and a set of practices constructed from overlapping communities of experts who communicated regularly through international meetings, shared publications, and personal networks, and worked towards establishing international standards of practice.[45]

Internationalization of this sort was, however, highly contested. Rossiter Raymond, editor of both the *Engineering and Mining Journal* and AIME's *Transactions,* refused to endorse written codes for engineers, believing instead that artisanal American miners practiced a model "national style."[46] In this way, the attempt to establish universal standards of practice and measurement was both a self-conscious effort at network creation *and* an assertion of metropolitan dominance aimed at enhancing the reputation and dominance of particular national mineral industries.[47] As James Herbert Curle termed it, the standards were the "lever for raising the whole mining status."[48] With their libraries of technical journals, monthly symposia, and in-house publications, mining associations acted as hubs for the organization and dissemination of expertise. As they spread globally, these transnational entities provided a network of cooperative forums through which to advance these goals. Yet, despite many engineers' faith in the "neutral" character of expertise, they repeatedly demanded that other nations accept the preeminence of their standards. In 1891, the *Engineering and Mining Journal* described its mission as "the creation of a technical literature that will make the whole world recognize the pre-eminence of American practice."[49]

Nations, Mining Schools, & Academic Networks

Contemporaries often viewed mining engineering in terms of distinct national professional identities, rooted in mining education and practice.[50] Claims to national preeminence existed in tension with the simultaneous operation of transnational professional and intellectual connections. "The whole world looks to American experts and mechanics for the best practice, and American engineers are now found in the management of great enterprises in every part of the world," boasted the New York based *Engineering and Mining Journal*.[51] In London, Charles Edgar Allen similarly claimed in *Feilden's Magazine* that "British engineers are first the world over."[52] Yet, the national components of professional identities were not as salient as the descriptive categories used by contemporary observers. By paying attention to the movements of personnel—where they traveled, who they were influenced by and in turn influenced, and what organizations they belonged to—the patterns of transnational exchange that underwrote national education systems are brought into analytical focus.

In the United States, mining education developed rapidly after passage of the 1862 Morrill Land-Grant Act, which included provisions for the support of agricultural and mechanical colleges, and was sped further by the opening of the Comstock Lode. Until the 1870s, American students travelled overwhelmingly to the École Impériale des Mines in Paris and the Königliche Sächsische Bergakademie Freiberg prompting one Comstock manager to complain that too many Americans "studied mineralogy at the opera houses of the European capitals."[53] Freiberg's prestigious Bergakadmie trained an international body of students, but in the late 1860s as much as half of its enrollment came from the United States.[54] The migration of European experts and technologies was essential to the development of American mining more broadly too.[55] The mining engineers of the American

West were drawn from many overseas backgrounds including France (as many as thirty thousand in the California gold rush), Belgium, Russia, and, of course, Cornwall.[56] German engineers also worked extensively in the American West, particularly in the copper mines of Arizona and on the Comstock Lode in Nevada where they introduced square set timbering and adapted Mexican and Washoe amalgamation techniques with innovations from Freiberg.[57] The smelting techniques that arrived in Colorado, after its brief alluvial phase was over, similarly arrived by way of graduates from Freiberg, the Royal School of Mines in London, and Welsh iron mines near Swansea.[58]

Such circulations continued even while US universities gradually assumed responsibility for the training of technical experts. By 1893, more than twenty American schools offered instruction in mining.[59] On the west coast, the College of California, and on the east coast, the Columbia School of Mines and Metallurgy (CSM) in New York, both of which were founded in 1864, were the first of these new institutes. The Columbia School of Mines, for instance, aimed to be "more scientific than Freiberg, more practical than Paris," but depended on foreign expertise to jump start the development of theoretical approaches to metallurgical chemistry in the United States.[60] CSM's founder and professor of mineralogy and metallurgy, Thomas Eglestone and its professor of mining, Francis L. Vinton had both studied at the École in Paris. The chemist Charles F. Chandler, CSM's first dean, was a graduate of the University of Göttingen.[61] Fewer than half of all Columbia students graduated in its early years and chose instead to move to new rush-towns such as Deadwood or to the copper belts of Arizona, New Mexico, and Sonora.[62] Nevertheless, by the early 1890s, CSM graduates constituted more than 40 percent of the mining industry's college trained personnel in the US.[63] More broadly, between 1870 and 1920 as American mining transitioned to the post-rush phase of capital intensive deep level mining, which required complex chemical processes to break down pyritic ores, the number of trained engineers in the US grew dramatically from seven thousand to 136,000.[64] Many of these graduates fed the developing administrative agencies of the US state devoted to inventorying and developing the continent's natural resources into productive capital such as the Geological Survey, Bureau of Reclamation, and Inland Waterways Commission.[65]

In many cases, developing the inland empire prepared engineers for transnational lives.[66] The Californian John Hays Hammond and the Iowan Herbert Hoover were famous in their own lifetimes as globetrotting engineer-entrepreneurs: Hoover worked for corporations in Australia, Burma, and China between 1897 and 1914; Hammond in the Transvaal, Mexico, Russia, Panama, and Turkey in a similar period. Not all miners amassed fortunes the size of Hammond's and Hoover's, but many were lured by opportunities for research and employment overseas as the resumés of two more engineers demonstrate. Charles Butters, a University of California graduate, ran stamp mills in the western United States before moving to the Rand in 1888 where he worked as a chlorination expert for H. Eckstein & Co. After eight years on the Rand, Butters was exiled by the Boer government for his role in the Jameson Raid of December 1895 and subsequently worked in the United States' informal empire at mines in El Salvador, Sonora, and Nicaragua where he owned and managed the San Albino Mine—at least until 1927, when Sandinista rebels destroyed the mine and he fled the country.[67] Equally globetrotting was the geologist George Ferdinand Becker. After studying at Harvard, Heidelberg, and the Royal School of Mines in Berlin, Becker lectured in mining and metallurgy at the University of California, before, in 1879 becoming geologist in chief of the US Geological Survey. Becker assayed mineral deposits in Nevada, California, southern Alaska, and the Pacific Slope on behalf of the survey, and mapped gold deposits on the Transvaal for S. Neumann & Co. With the outbreak of the Spanish-American War, Becker was detailed to serve as geologist for the United States Army in the Philippines and then consulted on landslides at the Panama Canal.[68]

In Britain, a broader effort to reorganize imperial statecraft around the exploitation of natural resources underlay efforts to reform mining education and strengthen the relationship between the state and thriving new institutions of scientific research. While engineers were trained through apprenticeships and regional mechanics' institutes until well into the nineteenth century, the Royal School of Mines (RSM) played a key role in the evolution of British mining expertise and technology.[69] Initially known as the Government School of Mines and Museum of Practical Geography, the RSM opened in 1851 to provide instruction in geology, mineralogy, and metallurgy and to address persistent fears of British economic decline.[70] The school built on the informal networks of mineral reconnaissance and training performed by the Geological Survey of Great Britain, but aimed to expand them to create a national center for scientific and technical education.[71] Imperial rivalry, as much as a commitment to British science fueled this transformation. In the words of the Royal School's second director, Sir Roderick Murchison, the school would be to Great Britain "what the *Bergakademie* of Freiberg and the *Ecole de Mines* of Paris are to Germany and France."[72]

Between 1850 and 1920, 1,155 students graduated from the Royal School of Mines, one third of whom worked most of their lives outside of Britain, and three quarters of whom spent at least some time overseas.[73] Graduates of the school were consistently appointed to staff colonial geological surveys or made their way to the mineral fields of the settler empire as mine engineers, chemists, metallurgists, and assayers. These graduates formed a network of experts who were the conduits of knowledge both to advance British science and consolidate the Empire's commercial, industrial, and mineral supremacy.[74] The growth in numbers of technically-trained engineers underpinned the spread of the international mining institutes outlined above. To put it simply, knowledge did not simply "flow" transnationally, it was carried overseas by individuals who then shared it with fellow engineers and students in universities and new international forums.

Transnational patterns of migration and knowledge exchange also transformed the curriculum of the School of Mines itself. In 1901, the Institute for Mining and Metallurgy undertook to raise standards at the Royal School of Mines by forming a committee under the leadership of Hennen Jennings, a Kentuckian engineer who had studied geology at Freiberg and at Harvard's Lawrence Scientific School. Jennings' subsequent report recommended higher entrance standards, training in mechanical and electrical engineering, and instruction in the commercial aspects of mining.[75] Technical education enjoyed a close relationship with the new international institutes. The IMM's membership, for example, boasted more than 160 graduates of the Royal School and offered scholarships for students to enroll at the RSM, the Camborne School of Mines in Cornwall, and the Durham College of Science.[76] Many of these exchanges were driven by the trans-imperial lives of late nineteenth century consulting engineers. In 1905, the American-born Jennings, then president of London's Institute for Mining and Metallurgy and operating from London as an independent consulting engineer, endowed an annual postgraduate scholarship through the institute. This substantial donation followed a gift of $10,000 made by Jennings to Harvard's Lawrence Scientific School in 1897.[77]

Increasingly, the industrial corporations dominating the mineral industries sought to increase their ties with both the professional societies and universities. In October 1901, for example, Cecil Rhodes' firm Consolidated Gold Fields endowed a prize medal for individuals furthering the objects of the IMM.[78] Through the IMM, Bewick, Moreing & Co. sponsored postgraduate scholarships in Australia; Rawlinson Bayliss of the London Exploration Company arranged postgraduate training at their properties in El Oro, Mexico, and the John Boy mine, Colorado; and similar arrangements were made at the Boulder Perseverance Mines, in Western Australia and at the Wallaroo copper mines in New South Wales.[79] These connective mechanisms maintained relationships between the technical schools and the industry they supported. The distant mineral fields connected by visiting scholars therefore also acted as research sites, in turn facilitating the circulation of expertise amongst academic institutions.

The network of structures, institutions, and individuals that constituted the gold mining industry were strikingly polycentric. This was especially so in the case of the mining schools established in Britain’s settler colonies, which functioned simultaneously as imperial and national spaces. As was the case with the United States, technical education in the colonies grew rapidly around centers of mineral production.[80] The Engineering Institute of Canada, founded in February 1887, expanded over time to twenty-four branches and a membership of 2,750 by 1910—a tenfold increase from its founding.[81] By 1891, there were as many as twelve mining schools in the Australian colony of Victoria alone, catering to working miners and often associated with mechanics’ institutes.[82] With the exception of university schools in Melbourne (founded in 1871), Adelaide (1889), and Sydney (1893), mining schools in the Australian colonies remained small, practically oriented colleges.

[Figref10.2]

The "imperial careering" of Australian experts played a vital role in the transformation of technical institutions.[83] Archibald Liversidge envisaged the University of Sydney's School of Mines as a center of imperial science, where mining education was provided in the city rather than the mining districts, in the mold of his *alma mater* the RSM in London. After a rail trip across the United States in the late 1880s, during which he visited California's Geological Museum and the headquarters of the US Geological Survey and Smithsonian in Washington, DC, Liversidge drew on US models for the Sydney curriculum.[84] After opening in 1893, its output was initially modest, totaling a mere six graduates between 1895 and 1899—although by 1900, eighty students had enrolled on the course.[85] Similarly, in Victoria, Redmond Barry sought advice on the new Ballarat School of Mines' curriculum from the RSM's director, Sir Roderick Murchison.[86] This was not a simple process of metropolitan diffusion to the colonial periphery. In both Sydney and Ballarat, academics hoped to develop local supplies of scientific engineers to wean the colonies from a reliance on imported British expertise and to consolidate the Australian colonies' centrality to the world of British imperial science. By the 1890s, Australian mining engineers traveled routinely to New Guinea and Malaya where they developed extensive gold and tin mining operations.[87] Borrowing from metropolitan models, then, Australian engineers embarked on the process of developing a distinct "Australian" identity without compromising loyalty to the Empire.[88]

Transnational professionalization did not stop engineers from different nations claiming global preeminence. American miners, for instance, marketed themselves internationally as the "most important missionary of civilization" and the American West as "the most fertile field" of technological innovation in the world.[89] It also stoked rivalry with supposedly "traditional" patterns of industrial organization. Proponents of new mining schools worked hard to overcome the deeply ingrained skepticism of the "practical men" who argued that technically-trained men lacked the *élan* of those schooled down the mine shaft.[90] Graduates from Australia's science-based degree programs for one found their job prospects limited in a culture in which, according to one mine manager in 1890, it was felt that "the most skilled managers are men who could not pass an examination in science."[91] Yet, in reality, as figure 10.2 shows, many university courses incorporated elements of practical observation and training. In the US, some lamented the loss of "the itinerant, self-reliant miner, jack of all trades and master of several." Because their careers followed "the line of succession from mucker to manager" it was deemed "a democratic and thoroughly American system."[92] But, despite widespread hostility of this kind, by 1921 an estimated six out of every seven miners in the United States were college trained.[93] A key marker of the engineer's prestige, the reformers argued, was their transnational success. "Do not the force currents that have been generated from mining products, and *controlled* and *set in circulation* by engineering skill, supplement or supplant manual work and thus constitute the basic cause of the growth and might of modern wealth?" asked Hennen Jennings in 1914, by which time engineers were widely regarded as a professional, even gentlemanly, elite.[94]

Historians should treat these claims with caution. Anglo-Saxon racial exceptionalism continued to frame many engineers' endorsement of their activities overseas. "Neo-Anglo-Saxons" or "Anglo-Americans" were "commingling" on goldfields across the world, wrote one essayist in the *Engineering Magazine,* forming "on a gigantic scale, a new race of men, built on the strongest lines on which it is possible to construct human beings."[95] Yet, even this imperial internationalism remained fragile as a result of tensions over where the boundary between the national and the international lay. In fact, many assumed that global interconnection would inevitably lead to the preeminence of one nation above all others. Since "the world's primary supplies" and "technical experience, are becoming more and more the heritage of all," argued James Douglas, "the lead will be taken by the nation whose technical managers possess skill ... to prevent them from sinking to the level of mere cogs in wheel of a soulless industrial machine."[96]

Conclusion: The Danger of Recapture

Operating on a global scale, mine engineers developed the mechanisms for overseeing and maintaining the technologies of empire and extraction that converged on the goldfields. As Thomas A. Rickard, editor of the *Mining and Scientific Press* and a prolific writer on mining topics, termed it, "the British empire and the American commonwealth alike have advanced in the track of the miner."[97] While the gold mining industry accelerated the redistribution of industrial capital and technologies around the world, it was engineers who constructed the mechanics of connectivity. They did so through a process of creative knowledge exchange and problem solving in the transnational venues and networks they had created. In the revised 1905 edition of his influential *Gold Mines of the World,* James Herbert Curle opined that "in the mining world the man of knowledge is *at last* being called to his kingdom."[98] Mine engineers had been creating cooperative forums and professional networks, the mechanisms of organization and diffusion, for close to twenty years by the time Curle was writing, but this process did not preclude claims to national or imperial preeminence. In fact, engineers reveal the manifold interactions between the global and the national.

In the greater scope of global connectivity, mining engineers were just one of the many forces transforming the world in the nineteenth century. As the introduction to this volume discusses, gold rushes contributed dramatically to the increased scale of human mobility, goods, and capital from the middle of the nineteenth century. Mobility and circularity were accelerated by globe-spanning technologies that had rapid and dramatic impacts on human experience. Such stories grab the attention of historians thanks to the powerful ways in which globalization shapes our own time and sense of contemporary events. But, once uncovered, we must resist the temptation to view these processes as "natural." Fifteen years ago, Thomas Bender warned US historians of the "danger of recapture" presented by the challenge of historicizing globalization—most especially of replacing a national "blindness" with a global one.[99] The work of historicizing global connectivity invites closer examination of the individuals managing, building, and making decisions about the forms of infrastructures, technologies, and institutions required to sustain global connection and exchange. Mining engineers were key protagonists in this process, but as this chapter has made clear, their claims to expertise also reflected the transnational contexts of imperial power and the uneven impacts of their work across regions and hemispheres. Closer examination of the engineers cabling the planet, laying railroads, managing shipping lines, sinking shafts in search of subterranean wealth, and digging oceanic canals across isthmuses and deserts therefore enables historians to explore the precise characteristics of global connection and the outcomes it produced.

Notes

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