American Mining Engineers and the Global Copper Industry, c. 1880–1945*

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Introduction

"The American mining engineer," according to the description by one in 1920, was a man of many talents,

> as much at home in some primitive, far-off revolutionary country, with his hat for an office, as in a city skyscraper ... He can throw a diamond hitch, cook his food, drive a mule or a tunnel, manage an Irish foreman, sun dodging Mexican or a Chinese coolie ...
>
> In discharging his duties, he travels many lands, and is in vogue in many nations. He is, in fact, a migratory creature, and he shuttles back and forth freely as he weaves the golden web of mineral production.[1]

This brief description neatly encapsulates the central themes of this chapter: first, mobility, especially transnational mobility, as a characteristic of the profession; second, the skills required by a mining engineer encompassed both wide-ranging technical competencies and labour management, which clearly was racialized.

In this chapter, I explore the implications of these two general characteristics of the American mining engineers who ran the copper industry between the late nineteenth century and the

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[1] Charles H. MacDowell, "The American Mining Engineer," *Journal of the Western Society of Engineers* 25 (1920): 163–64.

mid-twentieth century. The chapter makes two contributions to the literature. The first is a case study of the mobility of American mining engineers in the copper industry using a database constructed from the 1937 membership list of the Mining and Metallurgical Society of America (MMSA). This was an invitation-only society for mining professionals in the upper echelons of the industry, most of whom were closely connected to the copper industry.[2] It is often argued that mining engineers are particularly mobile professionals, and using this case study I show this quantitatively. The second contribution shows the strength of taking a global perspective by examining the connections among copper mining regions in North America, Latin America, and Central Africa.

I use these connections to explain how these distant and disparate places became similar to each other, a process Christopher Bayly referred to as the rise of "global uniformities."[3] One driver of the creation of these similarities was the activities of American mining engineers, who were remarkably and customarily mobile in their careers and consciously sought to emulate and reproduce ideas and practices from other mining regions. These ideas and practices went far beyond those related to mining technology since mining engineers had enormous confidence that what they regarded as social problems could be resolved with technical solutions (a confidence that has clear parallels with contemporary software engineers).

One striking feature of different copper mining regions in the late nineteenth century and early twentieth century was the similarities among them. I focus on one similarity: the racial organization of work and life in mining owns in North America, Latin America, and Africa. Racially stratified mining workforces were so common in such places that they were mainly noteworthy when absent. Geoffrey Blainey began his 1970 history of Mount Isa mines by noting the distinctive features of the property, which included the fact that, "of the main underground mines in the tropical zone of the globe, it is perhaps the only mine worked entirely by white men."[4] Jeremy Mouat's chapter in this volume explores the rise of American mining engineers and how they came to dominate a copper industry previously centred on South Wales, and this chapter focuses on these engineers for this reason: these men ran almost all

[2] Mining and Metallurgical Society of America, *Bulletin Number 241* 30, no. 3 (1937).
[3] C.A. Bayly, *The Birth of the Modern World, 1780–1914: Global Connections and Comparisons* (Oxford: Blackwell Publishing, 2004), 1.
[4] Geoffrey Blainey, *Mines in the Spinifex: The Story of Mount Isa Mines* (Sydney: Angus and Robertson, 1960), 1.

parts of the copper industry in this period, from prospectors' camps to multinational conglomerates.[5]

American mining engineers were not uniquely racist, and professional men in other imperial powers often shared the same views. The difference is that these American engineers were in a position to implement these ideas. American mining engineers, as Stephen Tuffnell argues, were central "to an unfolding transnational dialogue on the techniques required to manage racially divided labour worldwide."[6] These were not uniquely American ideas, however, emanating from the United States to a periphery. Instead, they are best understood as emerging in and among different mining regions. In this, there are parallels with David Lambert and Alan Lester's concept of "imperial careering": that is, careers that took men and women across the British Empire and whose "ideas, practices and identities developed trans-imperially, as they moved from one imperial site to another."[7]

Confidence in technical and geological processes fed into confidence about transforming social processes. John Hays Hammond, one of the wealthiest engineers of his day and a prominent public figure, referred to the American mining engineer as "a most important missionary of civilisation in opening up new territory,"[8] though this was comparatively restrained compared with one speech given in honour of Herbert Hoover:

> We see the dawn of a new day; truly there is a new order of things. The great centers of the world are now industrial centers. The prosperity and strength of nations in peace and war rest now upon the factory system, the shops, the railways and steamships, the mines, the smelters, and the public works. And who is responsible for these things? It is the engineer.[9]

Mining Engineers and Mobility

[5] Until the 1970s, it was the case in copper mining companies that "nearly all the middle managers and most of the general managers [we]re engineers," and the same was true for most executives. Thomas R. Navin, *Copper Mining and Management* (Tucson: University of Arizona Press, 1978), 8.
[6] Stephen Tuffnell, "Engineering Inter-Imperialism: American Miners and the Transformation of Global Mining, 1871–1910," *Journal of Global History* 10 (2015): 55.
[7] David Lambert and Alan Lester, *Colonial Lives across the British Empire: Imperial Careering in the Long Nineteenth Century* (Cambridge, UK: Cambridge University Press, 2006), 2.
[8] John Hays Hammond, "The Engineer in Public Life," *Mining and Metallurgy,* 10 March 1929, 115.
[9] Quoted from the *Bulletin of the American Institute of Mining and Metallurgical Engineers,* October 1919, in Ian Phimister and Jeremy Mouat, "The Engineering of Herbert Hoover," *Pacific Historical Review* 77, no. 4 (2008): 582.

What exactly did a mining engineer do? In his extensive study of American mining engineers, Clark Spence noted that the title was traditionally used somewhat loosely and, for his book, defined a mining engineer as "anyone – technically trained or otherwise – who did the work normally done by the profession."[10] But what was that work? Kathleen Ochs helpfully distinguished between technical jobs of "surveying, mapmaking, designing underground and aboveground plants and machinery, purchasing, prospecting, and examining new sites" and management jobs "to supervise, that is, to hire, fire, and manage men," as well as managing company-owned towns. Managerial jobs were more prestigious and better paid, and Ochs noted that successful engineers tended to shift from jobs primarily involving technical skills to jobs involving managerial skills over the course of their careers.[11] To this it is helpful to add, I think, a distinction between mining engineers involved in day-to-day operations, whether in a technical or a managerial capacity, and consulting engineers employed to assess the value of an orebody or mine or to advise on a specific problem.[12]

Moreover, the competencies demanded by the job changed and expanded over this period as mining became more technically complex and the scale of operations increased. In 1928, one engineer reflected that "increasing demands were being made upon the modern mining engineer" related not only to "his knowledge of mining, metallurgical, and mechanical details, but more particularly ... [to] his administrative and organising abilities."[13] Already in 1907, one MMSA member argued that the industry had become so complex that "pretension to know the whole mining business can be nothing but a fraud."[14]

Although they enjoyed great prestige, mining engineers were mostly employees. Some of the men in this chapter headed huge mining companies, others became financiers, but most worked for others, either in salaried positions or as consultants. David Noble describes how in this era professional engineers became inextricably linked with the advance of corporate capitalism and were regarded as experts in the management of technical problems and social

[10] Clark C. Spence, *Mining Engineers and the American West: The Lace-Boot Brigade, 1849–1933* (New Haven, CT: Yale University Press, 1970), 5.
[11] Kathleen Ochs, "The Rise of American Mining Engineers: A Case Study of the Colorado School of Mines," *Technology and Culture* 33, no. 2 (1992): 293. Her argument about career trajectories is supported by the evidence of the MMSA database.
[12] Sarah Grossman distinguishes between management and consultation roles and notes that they were "two of the most common types of work undertaken by mining engineers." Sarah Grossman, "Capital Mediators: American Mining Engineers in the US Southwest and Mexico, 1850–1914" (PhD diss., University of New Mexico, 2012), 5.
[13] Logan Hovis and Jeremy Mouat, "Miners, Engineers, and the Transformation of Work in the Western Mining Industry, 1880–1930," *Technology and Culture* 37, no. 3 (1996): 456.
[14] J.R. Finlay, "Requirements of Modern Mining," *Mining and Scientific Press* 94, no. 16 (1907): 507–8. I am grateful to Jeremy Mouat for drawing this to my attention.

relations, "lending to the power of capital the sanction of objective science."[15] The same applies to mining engineers, who deployed their specialized knowledge and skills in the service of their employers.

These kinds of skills were in high demand as the mining industry underwent massive expansion. In the United States, the supply of these skills rose as, like other kinds of engineering, mining engineering underwent a process of professionalization beginning in the late nineteenth century and mining education expanded. The United States became the pre-eminent centre of mining education, and other countries faced a persistent shortage of appropriately skilled and qualified engineers among their own nationals.[16] The proliferation of professional societies and specialist journals meant that education and knowledge sharing were not confined to mining schools, and American mining engineers formed "a community in which knowledge was freely exchanged."[17] Similarly, Tuffnell has written on what might be termed the "architecture" of a global gold mining industry – the emergence of professional associations, mining schools, and specialist journals – and the "constant management and decision making" by engineers regarding which kinds of mining technologies and expertise were transferred around the world.[18]

Part of this education was on the racial organization and management of labour. The standard textbook in American engineering schools was Herbert Hoover's *Principles of Mining,* first published in 1909. The book contains a section on quantifying racial differences in mining workforces and the implications of doing so for cost structures. Hoover asserted "with confidence" that "in simple mine work" "one white man equals two to three of the colored races," and for skilled work "the average ratio is as one to seven."

Like his contemporaries, Hoover claimed that this racial knowledge arose from his wide-ranging experience in the industry, specifically "experience in working Asiatics and negroes

[15] David Noble, *America by Design: Science, Technology, and the Rise of Corporate Capitalism* (Oxford: Oxford University Press, 1979), xxvi.
[16] For instance, among the seventy-six technical staff employed at Bewick, Moreing and Company in 1904, only eight were British. Charles Harvey and Jon Press, "Overseas Investment and the Professional Advance of British Metal Mining Engineers, 1851–1914," *Economic History Review,* New Series, 42, no. 1 (1989): 81.
[17] Jeremy Mouat, "Engineering Changes: The Cause and Consequence of Modern Mining Methods at Butte, Montana; Johannesburg, South Africa; and Broken Hill, New South Wales," in *Making Sense of Mining History,* ed. Stefan Berger and Peter Alexander (Abingdon, UK: Routledge, 2019), 74.
[18] Stephen Tuffnell, "Engineering Gold Rushes: Engineers and the Mechanics of Global Connectivity," in *A Global History of Gold Rushes,* ed. Ben Mountford and Stephen Tuffnell (Berkeley: University of California Press, 2018), 229–51, quotation on 230.

as well as Americans and Australians in mines."[19] This aspect of *Principles of Mining* has often been overlooked – one of Hoover's biographers refers to it in passing as one of "the book's idiosyncratic touches"[20] – but Hoover himself took it seriously. He provided a table purportedly showing how working costs in gold mines that he was familiar with in the United States, Australia, South Africa, and India were lower in "white-manned mines."[21] For Hoover and his contemporaries, racial knowledge was part and parcel of the expertise of engineers. Supply and demand underlaid the international mobility of American mining engineers. This mobility is readily apparent from a perusal of contemporary industry publications or from biographies of engineers in the existing literature, though often the concentration is on the gold industry or on Hoover, easily the most prominent engineer of his generation, as a stand-in for the profession.[22] Spence provides extensive details of the contributions of American mining engineers to mining regions around the world and clearly illustrates the extensive geographical reach of this group: "The personal column of a single issue of the *Engineering and Mining Journal* shows American engineers in, en route to, or coming from Alaska, London, Cornwall, Mexico, West Africa, South Africa, Kalgoorlie, Asia Minor, China, Tibet, Chile, Newfoundland, and Nicaragua."[23]

Mouat notes that American mining and engineering techniques – such as the "modern mining" methods of overcoming rising costs and declining ore grades with mass production and economies of scale – relied on "notions of portability and replicability" and could "be successfully applied in South African or South American mining camps."[24] The same was thought to be true of techniques of labour management, and scholars have been attentive to the ideas that American mining companies and mining engineers brought with them alongside technological innovations. David Roediger and Elizabeth Esch claim that "the greatest US export in the quarter century after 1890 was the mining engineer," who brought with him "US capital goods and US race management ideas." More broadly, they argue that racialized knowledge about labour was central to managerial knowledge and used in the organization of production in a variety of different economic sectors.[25] Both Elaine Katz and John Higginson

[19] Herbert Hoover, *Principles of Mining, Valuation, Organization and Administration: Copper, Gold, Lead, Silver, Tin and Zinc* (New York: McGraw-Hill, 1909), 163.
[20] Kenneth Whyte, *Hoover: An Extraordinary Life in Extraordinary Times* (New York: Alfred A. Knopf, 2017), 117–18.
[21] Hoover, *Principles of Mining,* 164.
[22] Ian Tyrell, *Transnational Nation: United States History in Global Perspective since 1789* (New York: Palgrave Macmillan, 2015), 127–28; David Roediger and Elizabeth Esch, *The Production of Difference: Race and the Management of Labor in US History* (Oxford: Oxford University Press, 2012), 117–21.
[23] The issue is from 16 April 1904. Spence, *Mining Engineers and the American West,* 280–81.
[24] Mouat, "Engineering Changes," 69.
[25] Roediger and Esch, *Production of Difference,* 115. See 115–21 for the section on mining engineers.

have examined the central role of American mining engineers in South Africa's gold mining industry, particularly in relation to the racial organization of underground work, and Tuffnell has situated this in a firmly global perspective.[26]

What I offer in this chapter is a more systematic study of mining engineers, their mobility, and how it connected disparate parts of the world as an alternative to selecting individual engineers whose careers took them around the world as representative of the profession. The literature on engineers in this period sometimes gives the impression that these men moved freely around the world. This was true to some extent, especially in the sense that there were few formal restrictions on their mobility. However, though their movements were global, their circuits were circumscribed since they were largely restricted to the copper industry. The language used in global history has been criticized by Stefanie Ganger for being imprecise and erratic, but in this chapter I aim to give substance to claims of connection and circulation.[27] Terms such as "circuits" and "circulation" are appropriate here since there is a certain fixity in mining; minerals are either there or not there. American mining engineers moved among places on a circuit established and fixed by geological conditions and circulated between different mining sites, not simply from and to the United States.

This more systematic approach to creating a detailed picture of the movements of mining professionals is possible from the late nineteenth century because of the emergence of professional associations and the excellent record keeping of these associations. In this regard, I was assisted by the retention of a membership directory of the Mining and Metallurgical Society of America in the Western mining collection of the Huntington Library, Los Angeles. This directory forms the basis of the following section.

The MMSA Database

I created a database from the 1937 MMSA membership list, which contained brief information on the education and careers of almost all of the society's 301 members.[28] There are several advantages to using this society as a case study, both practical and related to the nature of the society itself. Its membership was relatively small, therefore making it manageable to look

[26] Elaine Katz, "The Role of American Mining Technology and American Mining Engineers in the Witwatersrand Gold Mining Industry, 1890–1910," *South African Journal of Economic History* 20, no. 2 (2005): 48–82; John Higginson, "Privileging the Machines: American Engineers, Indentured Chinese and White Workers in South Africa's Deep-Level Gold Mines, 1902–1907," *International Review of Social History* 52, no. 1 (2007): 1–34; Tuffnell, "Engineering Inter-Imperialism."

[27] Stefanie Gänger, "Circulation: Reflections on Circularity, Entity, and Liquidity in the Language of Global History," *Journal of Global History* 12 (2017): 303–18.

[28] Mining and Metallurgical Society of America, *Bulletin.*

at the careers of the members in some depth, in contrast to a study of the Institution of Mining and Metallurgy or the American Institute of Mining Engineers, which had over 3,600 members by 1905.[29] The alumni records of the various mining schools are similarly vast. Ochs, for instance, examined the records of the Colorado School of Mines Alumni Association, though even for the years 1900–40, the focus of her study, the records were so extensive that taking a sample was necessary.[30]

The other practical advantage is that this membership list represents the collation of a substantial amount of retrospective career information about mining professionals collected toward the end of the period of dominance of American mining engineers. It is therefore a useful proxy to assess the mobility of this occupation during the late nineteenth century and early twentieth century. Such information on the employment and mobility of engineers is available from other sources but rarely in such a condensed source. Other professional mining associations published annual membership directories, which often noted annual changes of location or address, but compiling changes across a suitably illustrative time period would be an arduous task. The same problem is present in the other obvious source from professional associations – obituaries of members – though the Northern Mines Research Society has made obituaries of members of the Institution of Mining and Metallurgy from 1892 to 1968 available online.[31]

The MMSA itself is a useful case study because its members ran the industry. The organization was self-selecting since membership was by invitation, and invitation was extended only to the upper echelons of the industry – members included Daniel Jackling, Herbert Hoover, E.T. Stannard, and Pope Yeatman. There were 115 members at the foundation of the society in 1908, and membership reached 301 by 1917, thereafter remaining around that figure for the period under consideration here. The MMSA was not intended to be a technical institute for all mining professionals. The organization described its purpose as discussing and acting on:

> the broad principles and questions that affect the mining industry ... [and] exclude[ing] from consideration technology methods, detail and special interests in order to

[29] Tuffnell, "Engineering Gold Rushes," 233.
[30] Ochs, "The Rise of American Mining Engineers," 284–85.
[31] Northern Mines Research Society, "Obituaries of Members," https://www.nmrs.org.uk/resources/obituaries-of-members/

> concentrate more effectively on the fundamental principles and problems affecting the industry such as labor relations, legislation, economics, and education."[32]

The other reason that the MMSA is a particularly useful case study is that its members were involved primarily in the copper industry.[33] Collectively, members claimed expertise in the extraction and processing of aluminum, antimony, asbestos, bauxite, coal, copper, diamonds, fluorspar, gold, iron, lead, manganese, nitrate, nickel, oil, phosphates, platinum, potash, radium, silver, sulphur, tungsten, vanadium, and zinc. Copper, though, predominated.

The profiles of 281 members referred to their expertise or experience in a particular area, and 178 of them mentioned that the members had been employed at a copper mine, smelter, refinery, or in some other aspect of the industry. The next most common area of expertise was gold (mentioned by eighty-three members), followed by zinc (forty-eight) and lead (forty-one). MMSA members primarily developed professional competencies in one or two minerals (usually copper), and only a handful claimed experience in more than three, though one man, Edwin Berry, a New York–based consulting engineer associated with the Guggenheim companies, claimed eight.[34] The focus on copper was not representative of the profession as a whole. Albert Fay's 1917 survey of 7,500 American mining engineers listed them "according to the different kinds of mines in which they had actual mining experience," and copper was only the third most common experience, behind gold and coal.[35]

In other ways, the MMSA membership did reflect the wider profile of the mining industry. The membership was almost entirely white – though there were two Chinese members listed who had studied at universities in the United States – and was entirely male. The1900 US census found only three female mining engineers in the entire country.[36] Few women were even admitted to the kind of professional training increasingly required for the job. For instance, the University of California's College of Mining awarded 1,030 degrees between 1877 and 1936, but not a single woman graduated from the institution.[37]

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[32] Mining and Metallurgical Society of America, *Brief Overview and History, 1908–2016,* 2016, http://www.mmsa.net/pdfs/MMSAHistoryBook2016.pdf

[33] The society was established by leading members of the copper industry.

[34] Mining and Metallurgical Society of America, *Bulletin,* 57.

[35] Fay considered gold and silver mines as one category. The figures were 1,840 for gold and silver mines, 1,795 for coal, and 1,748 for copper. Albert Fay, *Preparedness Census of Mining Engineers, Metallurgists and Chemists* (Washington, DC: US Bureau of Mines, 1917), 9.

[36] Spence, *Mining Engineers and the American West,* 6.

[37] E.T.H. Bunje, F.J. Schmitz, and D.T. Wainwright, *Careers of University of California Mining Engineers 1865–1936* (Berkeley: Works Progress Administration, 1936).

Most entries in the membership directory contain each member's name, address, job title, education, and employment history, including job titles, companies worked for, locations of companies, duration of employment, and claimed responsibilities. I say "claimed" because the entries are based upon self-reporting, so the quality varies considerably. Six members provided no information about their careers. Other profiles are very brief. The entry for Edward H. Clark, for instance, reads in its entirety "1893–1937: Connected with Homestake Mining Co. Pres., since 1914; Connected with the Cerro de Pasco Copper Company. Pres., since 1921."[38] The majority, however, did provide detailed information, and there is at least some information on the careers of 295 MMSA members.

Mining engineers formed the mainstay of the organization: 293 members listed their present occupations, and 104 described themselves as mining engineers, 65 described themselves as consulting engineers or consulting mining engineers, and dozens listed themselves as metallurgical engineers, geologists, general managers, vice-presidents, and presidents (usually of companies, though Hoover listed his occupation as President of the United States).

Transnational experience was a key part of the careers of the men at the top of the copper industry. The employment histories of MMSA members demonstrate that these mining engineers were a highly mobile group and that this mobility was linked to their occupation. Almost all of the places mentioned in Table 3.1 are major copper producers. The obvious exceptions are the United Kingdom – though some members were employed by copper companies headquartered in London – and South Africa.[39] Collectively, members' profiles refer to employment in sixty-six countries or geographical regions covering virtually all parts of the world, from the Arctic to the Pacific islands. Mostly, they are countries, but several entries note mining experience in "South America" or "Africa" with no greater precision. Some entries are even less precise. Forest Rutherford noted in his entry that his work as a consulting mining engineer had "necessitated my going abroad on several occasions."[40]

Although transnational work experience was not universal, it was the norm, and the average member worked in two and a half countries/regions during his career. The information in Table 3.1 corresponds with the information obtained by Fay, which showed that Mexico by far was the most common foreign country where American mining engineers had experience working, followed by Canada and "South America." However, MMSA members, collectively, were

[38] Mining and Metallurgical Society of America, *Bulletin,* 64.
[39] Most MMSA members with experience in South Africa had worked in the gold industry, but several had managed copper mines there, at Messina and O'okiep.
[40] Mining and Metallurgical Society of America, *Bulletin,* 102.

significantly more mobile than the profession as a whole had been at the time of Fay's survey in 1917. The large majority of the mining engineers whom Fay surveyed had worked only in the United States, suggesting that transnational work experience was more common for those in the upper echelons of the industry.[41]

Table 3.1: Selected international work experience of MMSA members

Country/region	MMSA members
United States	286
Mexico	87
Canada	64
Chile	37
Peru	29
South Africa	22
United Kingdom	19
Bolivia	17
Zambia	15
Australia	15
South America	14
Cuba	11
Congo (currently the Democratic Republic of the Congo)	10

Note: The table only contains countries or geographical places with more than ten entries in the database. In the database, only work experience in mining, metallurgy, and related industries is counted.

Ninety-three MMSA members had worked in only one country (overwhelmingly the United States, though a few had worked only in Canada). This number included members who were not practising mining engineers, such as academics working at the various schools of mines or for state institutions such as the US Bureau of Mines. For instance, Melville Coolbaugh, president of the Colorado School of Mines from 1925, had graduated from Colorado University in 1905 and then taught chemistry at Columbia University and the South Dakota School of Mines and undertaken research work at the Massachusetts Institute of Technology.[42] It also

[41] Fay, *Preparedness Census,* 11.
[42] Mining and Metallurgical Society of America, *Bulletin,* 66–67.

includes some who worked for their own or their families' companies and whose career advancement therefore did not depend on wide transnational work experience.

A small number of men achieved professional success working for one company in one place, such as Anaconda's chief geologist, Reno Sales, who had worked for thirty years with the company in Butte, Montana, or Henry Walker, vice-president at American Smelting and Refining, who had steadily moved up the company's ranks over twenty-five years.[43] These were the exceptions to the norm. The focus on international movement in the database does obscure one aspect of mobility: movement within the United States. The careers of Sales and Walker were unusual since even those MMSA members who worked only in the United States moved frequently in their careers. J.R. Finlay, for instance, a Harvard University–trained mining engineer, acquired experience working in Arizona, Colorado, New Mexico, and "all mining properties in Michigan" over a forty-year period.[44] Those who remained in the United States could also move great distances for work; Copper Queen Mine in Arizona to Bonanza Mine in Alaska, for instance, is a distance of some 6,000 kilometres and a much greater distance than an international move of 75 kilometres from Copper Queen Mine to Cananea Mine in Sonora, Mexico. International mobility sometimes did not mean much geographical mobility.

The other limitation in the database is the need for brevity in the profiles of MMSA members, many of which are only a few lines long. This means that details of careers are truncated and thereby understate the mobility of some individuals. Most notably, Herbert Hoover did not list any country or place that he worked in his entry, which considerably understates his mobile career as a mining engineer, and the same is true for less prominent individuals. Donald Hamilton McLaughlin is listed as working in the United States and Peru in his MMSA member profile, but his entry in a list of graduates from the University of California's College of Mining notes that he had also

[43] Mining and Metallurgical Society of America, *Bulletin,* 103, 114.
[44] Mining and Metallurgical Society of America, *Bulletin,* 73.

Table 3.2: Selected tertiary education of MMSA members

University/College	MMSA members
Columbia School of Mines	41
Massachusetts Institute of Technology	24
California College of Mines	21
Michigan College of Mines	19
Harvard	17
Yale	13
Colorado School of Mines	12
Columbia	12
Stanford	7
Wisconsin	7
Cornell	6
Freiberg	5

Note: The table includes only universities or colleges with five or more entries in the database.

Many MMSA members had been educated at two or more universities, but the database captures only the university that awarded the terminal degree. Th at degree was usually the one that related most directly to the members' professional expertise. worked in Mexico, Canada, Australia, and Africa.[45] Similarly, James Douglas, who ran the mining giant Phelps Dodge, listed only his work in the United States and Mexico, though he had also worked in Canada and Chile.[46]

The displacement of the "practical man" (often a Cornish miner) by professionally trained engineers across the mining industry in the late nineteenth century is well known and reflected in the database.[47] Two hundred and fifty-fi ve MMSA members listed university-level education, often at elite American universities (see Table 3.2). Interestingly, most of the handful of MMSA members born in Britain had undertaken only practical training. George Collins, for example, noted that he had "professionally trained under his father, J.H. Collins," who had been the president of the Institution of Mining and Metallurgy, and John Callow had

[45] Bunje, Schmitz, and Wainwright, *California Mining Engineers,* 77.

[46] Mining and Metallurgical Society of America, *Bulletin,* 69; William W. Culver, "James Douglas in Chile," *Mining History Journal* 23 (2016): 1–16.

[47] Hovis and Mouat, "Transformation of Work," 431–35. See also Thomas Rickard, *A History of American Mining* (New York: McGraw-Hill, 1932), 246–48; Harvey and Press, "British Metal Mining Engineers," 72; and Ochs, "The Rise of American Mining Engineers," 278–301.

been an articled pupil under a consulting engineer in Norwich, England.[48] The database also reveals the total eclipse of European centres of education. In the 1860s and 1870s, many Americans went to study in Europe, especially to Freiburg in Germany, and mining companies in North America often hired men trained in German universities, "known for their superior education in modern mining and metallurgical techniques."[49] This had ceased by the early twentieth century for the copper industry. Almost all MMSA members received professional training in the United States, and Freiburg was the only non-American institution that trained five or more MMSA members.

The most common sources of mining education for MMSA members were elite universities in the United States, and the Columbia School of Mines (training forty-one members) and Columbia University (training a further twelve members) were pre-eminent in this regard. It can be surmised safely that most MMSA members were drawn from a narrow social stratum able to access and afford such an expensive education. The biography of Daniel Jackling, an orphan who came from poverty to work his way through mining school, was a very unusual one in these circles.[50] Despite the predominance of formal technical education, there remained an emphasis on the value of a practical education. Many members' profiles refer to employment in manual jobs in the mining industry immediately after graduating. Arthur Notman, later a consulting engineer and a director of United Verde Extension, was likely the only Harvard University graduate who worked as a miner in Morenci, Arizona, in 1904, which surely he was not doing because he needed the money. Similarly, G.M. Colvocoresses, a consulting engineer with experience in six different countries, noted that he had worked as a day labourer in a smelter after graduating from Yale in 1900, and Harold Titcomb, who had a similarly wide-ranging career geographically, worked as a labourer in lead and zinc mines in Missouri after graduating from the Columbia School of Mines.[51]

Global Connections in the Copper Industry

Beginning in the late nineteenth century, mineral deposits were usually discovered in areas remote from existing infrastructure, populations, or state authority, whether in the American Southwest or in Central Africa. Mining companies, therefore, had become accustomed to creating new urban centres and infrastructure and to recruiting a new workforce, often through coercion. This gave mining engineers – who usually operated at some distance from the

[48] Mining and Metallurgical Society of America, *Bulletin,* 63, 65.
[49] Sarah Grossman, "Mining Engineers and Fraud in the U.S.-Mexico Borderlands, 1860–1910," *Technology and Culture* 55, no. 4 (2014): 824; Spence, *Mining Engineers and the American West,* 29.
[50] Spence, *Mining Engineers and the American West,* 14.
[51] Mining and Metallurgical Society of America, *Bulletin,* 66–67, 95, 111.

companies that employed them – considerable latitude to organize things as they saw fi t. In this sense, the development of industrial copper mining was different from that of industrial gold mining. The latter often developed in the wake of gold rushes, and companies had to contend with the organizations and built environments established by diggers often hostile to corporate concerns. Copper companies, for the most part, did not have to contend with such things. Mining engineers in the copper industry often had what they considered to be a tabula rasa on which to work.

In this section, I draw from information in the 1937 MMSA membership list to examine connections and similarities among copper mining regions in North America, Latin America, and Central Africa in the interwar years. As will be seen, mining engineers crossed continents but largely moved among mining sites that approximated their experience elsewhere in the world. In mining camps on all three continents, American mining engineers encountered and enforced the same kinds of racial hierarchies. This was not simply a question of exporting peoples, ideas, and practices from the United States to other parts of the world, though often the literature focuses on this aspect. Roediger and Esch, for instance, characterize mining engineers as first gaining experience in the mines of the western United States and then applying it at mines in other parts of the world.[52] Yet few mining engineers remained outside the United States for their entire careers, and periods of employment abroad were often interspersed with periods of employment in the domestic mining industry, and consulting engineers who travelled frequently usually maintained offices in New York or San Francisco. The transnational work experience of mining engineers also brought ideas and practices back into the United States.

In her classic study of American multinational businesses, Mira Wilkins described the typical American company town in Latin America:

> When a company started in an out-of-the-way area, a new town became essential. The enterprise first constructed housing for the American staff , usually built to American middle-class specifications. Then, if there were families with children, an American school opened. A sports field or golf course came next, and also a staff club house ...
>
> [In addition,] the company constructed homes for the workers and started a “workers’ camp.” The workers’ living quarters were usually set off from the staff ’s houses. Often

[52] Roediger and Esch, *The Production of Difference,* 115.

> the offices or the plant operations would be located in between the workers' housing and the staff quarters.[53]

Wilkins could be describing here almost any copper camp in the world during this period, and to the racial segregation of housing outlined above could be added racial segregation and stratification of the mining workforce. The construction and operation of these camps were overseen by American mining engineers, who did not have to be physically present to have an influence on these camps. Some in executive positions in Europe and North America were responsible for mines that they never visited but for which they nevertheless made decisions. Charles Harvey and Jon Press pointed to "a London-based mineral industry elite of bankers, merchants, engineers, accountants, and lawyers which, to a certain extent, could co-ordinate mining activity in distant land[s]," and the same could be said for Boston or New York.[54] Alfred Chester Beatty, for instance, visited only one mine during his three decades as chairman of the Selection Trust even though his company owned and operated mines around the world. Nevertheless, it was Beatty who announced that new copper mines established in the Central African Copperbelt in the late 1920s "should be equipped and worked along lines closely similar to the great mines of the American Continent."[55]

At these new mines, the workforce was sharply divided along racial lines. Whites were recruited for skilled positions, and Africans largely performed manual work, and the two sections of the workforce received vastly different wages and were housed in segregated camps. This was a familiar setup for Beatty. He had been a consulting engineer for the Utah Copper Company, where Japanese and Greek workers in the open pits received much lower wages than those deemed white.[56] Among Beatty's other jobs in this period was assessing the Santa Rita Mine in New Mexico, and later he was on the board of the company that ran it. Here, the company town segregated Mexican and white workers and a dual wage system existed based upon race.[57] Similarly, Preston Horner, a construction superintendent for Union Minière du Haut Katanga (UMHK) and then the general manager from 1912 to 1919, had also worked for the Utah Copper Company, and had joined UMHK from the Nevada Consolidated

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[53] Mira Wilkins, *The Maturing of Multinational Enterprise: American Business Abroad from 1914 to 1970* (Cambridge, MA: Harvard University Press, 1975), 123–24.54.

[54] Harvey and Press, "British Metal Mining Engineers," 69.

[55] John Philips, "Roan Antelope: Big Business in Central Africa 1890–1953" (PhD diss., Cambridge University, 2000), 153.

[56] Charles Caldwell Hawley, *A Kennecott Story: Three Mines, Four Men, and One Hundred Years, 1897–1997* (Salt Lake City: University of Utah Press, 2014), 17.

[57] Christopher Huggard and Terrence Humble, *Santa Rita del Cobre: A Copper Mining Community in New Mexico* (Boulder: University Press of Colorado, 2011), 64, 92, 110.

Copper Company, in whose camps Japanese and Greek workers were on a lower pay scale and residentially segregated from those designated white.[58]

Others followed Horner to Central Africa as operations expanded. Raymond Brooks had worked in Canada and all across the United States before he became the manager of UMHK's Western Mines, and subsequently he took charge of prospecting camps across the border in what is now Zambia.[59] The superintendent at UMHK's Kambove Mine was an American mining engineer with a characteristic globe-trotting career, Daniel Butner. He had graduated from the Colorado School of Mines and worked at mines in Utah, Mexico, Arizona, and Cuba before becoming the superintendent at Kambove Mine. After six years with UMHK, Butner signed up with the South African mining conglomerate Anglo American as a superintendent at one of its new mines in the Copperbelt (see also Chapter 11 in this volume).[60]

The engineer hired by Anglo American to oversee the construction of its new operations and towns was Alma Ek, recruited from the Braden Copper Company, which owned and operated El Teniente Mine in Chile.[61] Ek was assisted by Alexander McNab, who had experience overseeing mining operations in Canada and the United States.[62] Locals at El Teniente interviewed by Thomas Klubock in the early 1990s recalled that the mine had two segregated camps and that

> they were not allowed to step a foot into the North American camp, how the hospital had separate wards for North Americans and Chileans, how North American children attended separate schools, and how participation in the North American social clubs and cultural activities w[as] prohibited to Chileans ... Similarly, they describe how the camps were divided into three social tiers and how there was a lack of respect for those people who lived in the poorest barracks for obreros.[63]

[58] Mining and Metallurgical Society of America, *Bulletin,* 81; Phylis Cancilla Martinelli, *Undermining Race: Ethnic Identities in Arizona Copper Camps, 1880–1920* (Tucson: University of Arizona Press, 2009), 6.
[59] Mining and Metallurgical Society of America, *Bulletin,* 60.
[60] "Mine Alumnus Is Making Good in Far Away Africa," *Colorado School of Mines Magazine,* February 1930, 29.
[61] J.A. Bancroft, *Mining in Northern Rhodesia: A Chronicle of Mineral Exploration and Mining Development* (London: British South Africa Company, 1961), 158–59.
[62] Mining and Metallurgical Society of America, *Bulletin,* 89.
[63] Thomas Klubock, *Contested Communities: Class, Gender and Politics in Chile's El Teniente Copper Mine, 1904–1951* (Durham, NC: Duke University Press, 1998), 178.

A dual wage system for white American and Chilean workers was also in place at El Teniente.[64]

Th ere was another Latin American connection at Anglo American's Copperbelt operations. Recruited as the manager of these new mines was Arno Winther, an American engineer who had spent six years as the mine foreman and chief engineer at Cerro de Pasco Copper Company in Peru and over a decade as the superintendent at Bingham Canyon, Utah. Winther subsequently went to work in the United States in 1936 and became the manager of the Miami Copper Company in Arizona. His superior at Anglo American was Harold Munroe, who had experience in mines in the United States, Canada, Mexico, and Latin America. Munroe was a crucial figure in the establishment of a racially segregated workforce and headed the body responsible for recruiting African labour for the Copperbelt mines.[65] These engineers moved in what could be highly circumscribed circuits and, as suggested by the above, often had similar transnational work experiences. This is demonstrated further by the example of the first two general managers of the mine established by Beatty's Rhodesian Selection Trust in the Copperbelt, Roan Antelope Mine. The first was David Irwin, who oversaw construction of the new mine and adjacent town. Irwin was recruited from Phelps Dodge and had been the general superintendent at Copper Queen Mine in Bisbee, Arizona.[66] Bisbee was a self-proclaimed "white man's camp" where Mexicans lived separately from whites and where Chinese were barred entirely. Copper Queen Mine had separate pay scales for white and Mexican workers, even if they performed the same jobs, and the best paid underground jobs were reserved for whites.[67] Prior to working at Copper Queen Mine, Irwin was the general superintendent of the Moctezuma Copper Company in Sonora, Mexico. Again, segregated camps and workforces were the norm:

> American families lived in elegant house[s], had clubs, lavish hotel dining rooms, and tennis and golf courses for their exclusive enjoyment, and sent their children to company built, segregated schools, while the Mexican workers lived apart, in shacks which they owned themselves or rented from the companies.[68]

[64] Hawley, *Kennecott Story,* 127.
[65] Mining and Metallurgical Society of America, *Bulletin,* 93.
[66] "Company Meetings: Rhodesian Selection Trust," *Times* (London), 18 December 1928, 18.
[67] Katherine Benton-Cohen, *Borderline Americans: Racial Division and Labor War in the Arizona Borderlands* (Cambridge, MA: Harvard University Press, 2011), 84–85.
[68] Robert Vitalis, *America's Kingdom: Mythmaking on the Saudi Oil Frontier* (Stanford, CA: Stanford University Press, 2007), 44.

Irwin's successor as general manager at Roan Antelope, Frank Ayer, had been employed in the same job in Sonora, and then subsequently worked for Phelps Dodge in Arizona, though at Morenci rather than Bisbee.[69] The two men had virtually identical careers.

Ayer spent ten years running Roan Antelope Mine and subsequently became the head of the War Production Board's copper division during the Second World War. He was like many of the men described above who went on to occupy prominent positions in the mining industry, and other spheres, in the United States after accumulating significant experience working elsewhere in the world, though none more so than Arthur Storke, Irwin's and Ayer's superior. Storke was an American mining engineer trained at Stanford University but had only a few years of experience working in the United States. He spent twenty years based in London, from where he made frequent visits to the mines of the American Metal Company and Selection Trust in various parts of Africa.[70] Storke was subsequently appointed to a senior position at Kennecott Copper and would have succeeded E.T. Stannard as head of the company, except that both men were killed when the plane they were travelling on was blown up by a man who sought to murder his wife, also on board.[71] Still, this provides an example of American mining engineers who brought transnational influences and experiences to the domestic mining industry in the United States, complicating a narrative of the flow of people and ideas from the United States to the periphery.

Conclusion

American mining engineers had the means, the motives, and the opportunities to transform the global copper industry in the opening decades of the twentieth century. Supremely confident in their abilities to resolve both technical and social problems, and in positions of power in the copper industry the world over, these men were central to the transmission and implementation of the racial organization of life and work at the mines. Biographical information from the Mining and Metallurgical Society of America's membership list allows us to trace connections among mining sites and identify some of the ways that these ideas, practices, and experiences moved around the mining industry. The database constructed from this membership list also demonstrates clearly that transnational mobility was a characteristic feature of mining engineers in the copper industry. This mobility was global in scale but not unfettered; it was directed by the parameters of the mining industry and the corporate organization of transnational mining companies. This mobility was important in facilitating the

[69] Mining and Metallurgical Society of America, *Bulletin,* 53.
[70] Mining and Metallurgical Society of America, *Bulletin,* 109.
[71] "Quebec Air Crash Kills 23; 3 Kennecott Corp. Heads Die," *New York Times,* 10 September 1949, 1.

emergence of similarities among different mining regions as men with specific sets of experience and education exercised great control over the organization of new mine sites around the world. Racial segregation in jobs and company towns around the mines was the norm in this period.

The MMSA database is particularly useful for examining the role of American mining engineers in the copper industry since it was produced toward the end of the period of their dominance and therefore effectively forms a retrospective survey. The global reach of these engineers is relatively well known among historians, but the diminishing of their reach and the shrinking of the networks that they established have attracted much less discussion. Beginning in the 1940s, the presence of American mining engineers in the copper industry elsewhere in the world declined markedly, but it is not clear what drove this change. Mining and engineering education in other countries did expand, closing the gap with the United States, and several countries, key copper producers among them, passed legislation limiting the employment of non-nationals in the 1930s.[72] It is possible as well that the oil industry became more lucrative and that mining was no longer the place where the most prestigious jobs and the highest salaries could be obtained. Only fifteen MMSA members listed experience working for oil companies or on oilfields, but a 1936 study of University of California College of Mining graduates remarked that it was "noticeable that in the last few years more of the graduates of the College of Mining have entered the petroleum field."[73]

More importantly, the job of the mining engineer had changed by the mid-twentieth century. I began this chapter with a description of the mining engineer as a jack of all trades, able to tackle competently a variety of practical problems and management issues. During the period under consideration here, this altered as industrial enterprises, mines among them, became too large and complex for any one person to have the requisite knowledge for the whole operation, and this led to specialization. Specialization was encouraged, or enforced, by changing attitudes toward labour management, which circumscribed the power of mining engineers over operations.

The development of personnel and welfare departments in the early twentieth century represented alternative sources of control within companies and the professionalization of labour management. These new departments, as Sanford Jacoby argues in relation to American manufacturing, took labour management out of the hands of managers and

[72] Wilkins, *The Maturing of Multinational Enterprise,* 191.
[73] Bunje, Schmitz, and Wainwright, *California Mining Engineers,* 3.

signalled a new approach by which "employment policy would now be treated as an end in itself rather than as a means to the production division's ends."[74] Kennecott, for instance, established a Department of Industrial Relations in 1942 to revise its approach to labour management and recognized trade unions.[75] The emergence of personnel departments was accompanied by legislative changes in the 1930s and 1940s in many countries, including the United States and across the British Empire, that made unionization explicitly legal and undercut anti-union policies among mining companies. The emergence of a more consensus-based approach to labour management necessarily involved a curtailing of the mining engineer's domain. By the 1950s, the mining engineer was no longer what he once was, for the structure and requirements of the industry changed in ways not shaped by American mining engineers.

[74] Sanford Jacoby, *Employing Bureaucracy: Managers, Unions, and the Transformation of Work in the Twentieth Century* (Mahwah, NJ: Lawrence Erlbaum, 2004), 5.

[75] Hawley, *Kennecott Story,* 272. For other examples in the metal mining industry, see Erik Eklund, "'Intelligently Directed Welfare Work'? Labour Management Strategies in Local Context: Port Pirie, 1915–29," *Labour History* 76 (1999): 125–48; and Noreen Suzanne Kirkman, "Mount Isa Mines Social Infrastructure Programs 1924–1963" (PhD diss., James Cook University, 2011).