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Capital Mediators: American Mining Engineers in the U.S. Southwest and Mexico, 1850-1914

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CAPITAL MEDIATORS

AMERICAN MINING ENGINEERS IN THE U.S. SOUTHWEST AND MEXICO, 1850-1914

by

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ABSTRACT

This dissertation analyzes the technical work and social milieu of mining engineers to understand the daily negotiations by which private U.S. capital reached up to and across the southwestern border as part of an ongoing project of American territorial and economic expansion. During the late nineteenth and early twentieth centuries, American mining engineers traveled all over the world as expert consultants and labor managers. The business negotiations, elite social networks, and gendered discourse of "expertise" invoked by these technocratic professionals were critical influences in bringing the hard-rock mining districts of North America into the economic system of the United States. By integrating the history of technical experts into the history of the transnational mining industry, my research contributes to an understanding of the process by which American economic hegemony was established in a border region peripheral to the federal governments of both Washington, D.C. and Mexico City.

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Introduction

"Are you still a candidate for the superintendency of a mine?" James D. Hague inquired of his colleague, Ellsworth Daggett, in 1885, before proceeding to bombard Daggett with details of the project he had in mind. The mine in question was actually a group of silver mines, owned by the Cusihuiriachic Mining Company, an American-owned company with offices in Boston. Hague was a consulting mining engineer; Daggett, who was Hague's choice to be the on-site superintendent of the Cusihuiriachic mines, was also an American mining engineer. The mines themselves were in Chihuahua, Mexico. Daggett accepted Hague's proposal, and moved to Mexico to oversee the project of getting the mines up and running. Previous management had made some minor improvements to the site – there was a 40-stamp mill and a lixiviation (or washing) plant in operation -- but Hague thought they needed significant technological intervention to begin paying dividends. He offered $500 a month to Daggett for the position, explaining that "the whole thing needs clever management, and the mine especially wants to be taken in hand by an experienced man."[1]

Hague and Daggett exchanged hundreds of letters over the next two years while working for the Cusihuiriachic Mining Company. They discussed all aspects of the mining company's operations, including the number of letters Daggett was required to produce for the investors in Boston, describing how work proceeded in Chihuahua; the

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[1] James D. Hague to Ellsworth Daggett, 23 November 1885; James D. Hague to Ellsworth Daggett, December 7, 1885; James D. Hague to Ellsworth Daggett, January 26 1886, all M-12, James D. Hague Papers, Huntington Library, San Marino [hereafter JDH].

tariff laws of the United States and how they affected the decision to ship sulphides to New York rather than bullion; the possibility of revolutionary violence among the local residents of Cusi; the overall debt burden of the company; and the weather; as well as the health and activities enjoyed by Daggett and his wife, who joined him in Mexico for a time.[2] There were few aspects of the operation of the mines that did not fall under the purview of either Daggett or Hague, and the men took a keen interest in the fortunes of the company – Daggett kept Hague apprised of action on the ground, while Hague kept Daggett apprised of the mood of the investors. Their correspondence regarding the Cusihuiriachic Mining Company ended shortly after Hague announced to Daggett that the death of one Mr. Barney, an investor in the mine, "removes a principal supporter" of the operation, and that he could "foresee trouble if it has got to be supported by money drawn from here [Boston]."[3] Finding that operations at Cusi were not self-sufficient, both Hague and Daggett moved on to other mining ventures.

The Cusihuiriachic Mining Company was part of a broader trend of American investment in mining opportunities on and around the U.S.-Mexico border in the aftermath of the U.S.-Mexico War, particularly in Arizona, Sonora, and Chihuahua. In addition to being located far from major metropolitan centers – and in many cases, far from easy transportation hubs or even roads or rails -- these mining operation also frequently shared investors, technical experts, and even work crews. While some Americans who sought wealth in these newly publicized mineral districts were independent prospectors, the majority were involved in mining and speculation

[2] James D. Hague to Ellsworth Daggett, Feb 9, 1886 – February 19, 1887, all M-12, JDH.

[3] James D. Hague to Ellsworth Daggett, February 19, 1887, M-12, JDH.

companies, both small and large. The officers and founding members of these companies were often men who had traveled through the region, either with the army or independently, but the trustees and investors tended to be less experienced either in mining or with the region. As a result, investors sought the advice of expert consultants and knowledgeable men such as Hague and Daggett: mining engineers whom they could employ in the field.

This dissertation traces the social and professional world of mining engineers in the border region between the southwestern United States and northern Mexico through the late nineteenth and early twentieth centuries, an era in which both the industry of mining and the field of mine engineering expanded and bureaucratized rapidly. Focusing on mining operations in the southwestern U.S. and in northern Mexico, I highlight the role of mining engineers in the expansion and corporatization of U.S. industrial and economic influence across the continental United States and into Mexico. Mining engineers were instrumental in creating and supporting a vision of the American industrial landscape as a quantifiable exploitable space, readily managed by a cohort of well-trained technological elites: a technocratic landscape.[4]

The expertise of mining engineers was the key to success in the mining industry. In the transnational space of the U.S.-Mexico borderlands in the late nineteenth and early twentieth centuries, mining engineers were the critical technologists responsible for drawing private investment capital into a region that was distant from the metropolitan finance capitals of New York and San Francisco, and relatively inaccessible by road or

[4] John G. Gunnell, "The Technocratic Image and the Theory of Technocracy," *Technology and Culture* 23:3 (July 1982): 392-416.

rail, even by the standards of the times.[5] Mining engineers were usually the most highly educated people working in the minerals industry. Prior to making a mining deal, speculators, financiers, and company bosses relied on mining engineers to make accurate surveys and estimates of the value of selected ore bodies. After purchase, mining engineers drew up operating plans; mapped the underground works; selected and installed machinery; and, if they were talented and/or lucky, did all of this within a budget that ensured a return on a company's investment.[6] Analyzing the professional

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[5] The historiography of the extension and integration of the infrastructure of the United States in the 19th century is long, so I will be brief: critical classic works include Alfred Chandler, *The Visible Hand*: *The Managerial Revolution in American Business*, (Cambridge: Belknap Press, 1977) and Robert H. Wiebe, *The Search for Order, 1877-1920*, (New York: Hill and Wang, 1967). Howard Lamar, *The Far Southwest, 1846-1912: A Territorial History*, Rev. ed., (Albuquerque: University of New Mexico Press, 2000); William G. Robbins, *Colony and Empire: The Capitalist Transformation of the American West*, (Lawrence: Kansas University Press, 1994) offer concise analyses of the way these changes effected the southwestern United States. More recently, Rachel St. John, *Line in the Sand: A History of the Western U.S.-Mexico Border*, (Princeton: Princeton University Press, 2011), and Samuel Truett, *Fugitive Landscapes: The Forgotten History of the U.S.-Mexico Borderlands*, (New Haven: Yale University Press, 2008) extend the narrative by considering how these changes play out on both sides of the Mexican border.

[6] Clark Spence, *Mining Engineers and the American West: The Lace-Boot Brigade*, (New Haven: Yale University Press, 1970); Kathleen Ochs, "The Rise of American

practice and rhetorical strategies of mining engineers in the U.S.-Mexico borderlands throughout the period of 1860-1920 illuminates how decisions regarding the investment of private American capital were made during a period notable for the rapid expansion of the U.S. economy and the westward movement of large numbers of American citizens.

The correspondence between James Hague and Ellsworth Daggett concerning the Cusihuiriachic Mining Company illustrates two of the most common types of work undertaken by mining engineers in the late nineteenth century: field management (Daggett) and consultation (Hague). Their roles speak to their relative prominence within the profession. Hague was one of the earliest generation of German-educated American mining engineers to seek a career in the mining fields of the western US and northern Mexico. He was also a financier and investor in his own right, and went on to

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Mining Engineers: A Case Study of the Colorado School of Mines," *Technology and Culture* 33:2 (April 1992): 278-301; Eda Kranakis, "Social Determinants of Engineering Practice: A Comparative View of France and America in the Nineteenth Century," *Social Studies of Science* 19:1 (February 1989): 5-70; Eric Nystrom, *Learning to See: Visual Tools in American Mining Engineering, 1860-1920*, (Baltimore: Ph.D. Dissertation, The Johns Hopkins University, 2007). Tim LeCain, *Mass Destruction: The Men and Giant Mines that Wired America and Scarred the Planet*, (New Brunswick: Rutgers University Press, 2009); Jeremy Mouat and Logan Hovis, "Miners, Engineers, and the Transformation of Work in the Western Mining Industry, 1880-1930" *Technology and Culture* 37:3 (July 1996): 429-456.

phenomenal success running a large mine at Grass Valley in northern California.[7] Daggett, a few years younger than Hague, was trained at the Sheffield Scientific School in New Haven, Connecticut, and worked during his career in a variety of mines throughout Mexico and the southwestern U.S.[8] Hague was in a general sense an overseer, engaging in lengthy conversations and correspondence with the principal investors in the property as the chief technical advisor, his knowledge gained from his own initial survey of the property and his extensive correspondence with Daggett. Daggett, armed with information from Hague as to the financial situation of the company, the attitude of the investors, and guidance over his budget, had a relatively free hand in how he handled the day-to-day operation of the mines, determining which mines to focus on; assessing technological needs; and overseeing the hiring and firing of labor. Between them, Hague and Daggett made virtually all the significant decisions at the mine, from choosing the site of initial investment (Hague) to devising a plan of operations (Hague and Daggett) to overseeing labor, choosing equipment and bringing it in (Daggett), and determining where and how profits could be made (Hague and Daggett). Mining engineers were the most influential workers managing the expansion of capital into the borderlands.

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[7] Rodman Paul, ed., *A Victorian Gentlewoman in the Far West: The Reminiscences of Mary Halleck Foote*, (San Marino: Huntington Library, 1972), 36, 362, 372-384.

[8] "Preliminary Roll of the Sheffield Scientific School, 1846-1869," Sheffield Scientific School, Yale University, Records (RU 819). Manuscripts and Archives, Yale University Library.

Between 1881 and 1901 copper production in the Arizona Territory expanded from an annual output of 10,000 tons to an annual output of 1.3 million tons.[9] The work of engineers explicitly supported the interests of capital, generally personified by investor groups and Boards of Directors. They also directly oversaw workers; had a much better idea of labor conditions at the mine than other workers in the management hierarchy; and were responsible for the purchase of industrial equipment and the training of workers to run it. By the twentieth century, mining engineers at the larger mining companies along the border – the Cananea Consolidated Copper Company, Phelps Dodge, Arizona Copper – were among the chief proponents, and in some cases the orchestrators, of both the segregationist and paternalistic policies that became important features towns dominated by the mining industry, such as Bisbee or Morenci in Arizona, or Nacozari, in Sonora.[10] That mining engineers, whose training and expertise equipped them to be technical

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[9] *Historical Statistics of the United States*, Table DB73-78, Millenial Edition online.

[10] On company towns, and the impact southwestern mining companies on towns that weren't formally-planned "company towns, see: Duane Smith, *Rocky Mountain Mining Camps: The Urban Frontier,* (Lincoln: University of Nebraska Press, 1973); John S. Garner, ed., *The Company Town: Architecture and Society in the Early Industrial Age,* (New York: Oxford, 1992); Linda Gordon, *The Great Arizona Orphan Abduction*, (Cambridge: Harvard University Press, 1999), 172-185; Monica Perales, *Smeltertown: Making and Remembering a Southwest Border Community*, (Chapel Hill: UNC Press, 2010); Katherine Benton-Cohen, *Borderline Americans: Racial Division and Labor War in the Arizona Borderlands*, (Cambridge: Harvard University Press, 2009), 106-108; Truett, *Fugitive Landscapes,* 106-108.

consultants, were ultimately responsible for making decisions in all the varied aspects of mine management is crucial to understanding the development of the mining industry through the transnational region of the U.S.-Mexico border.

The breadth of activities in which mining engineers engaged was recognized by the nascent engineering industry as a whole. When the first engineering societies were founded in the United States, the American Institute of Mining Engineers was remarkable for being fairly open in its membership.[11] The mining engineers were happy to welcome capitalists and financiers to their conferences, possibly because it was helpful for mining engineers if their employers understood their work better. More likely the AIME's policies were an acknowledgment that mining engineers had to be closely attuned to the desires of their financiers. Mine engineering requires money; ergo, mining engineers believed that money men should be intimately involved in the business of mining engineers.

The ability to tell wealthy financiers and mine owners that their investments were no going to pay out was a key aspect of the work of mining engineers, especially in the early years of the profession. In addition to hotly discussed codes of ethics, mining engineers relied on an important self-identified characteristic of their professional identity: their institutionalized and somewhat romantic belief that they were self-reliant, practical men whose job was to speak plainly and directly at all times. Throughout the late nineteenth and early twentieth century, many aspects of mine engineering changed, including the credentialing process for joining the profession, the job trajectory of an

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[11] Edwin Layton, *The Revolt of the Engineers: Social Responsibility and the American Engineering Profession,* (Cleveland: Case Western, 1971) 29.

individual engineer, the university training necessary for becoming an engineer, and many, if not most, features of the work itself. The professional identity of mining engineers, however, remained remarkably constant over more than a half-century of significant industrial change and the transformation of the borderlands region both physically and economically.[12] At the same time that they were captured into corporate bureaucracies and implicated in corporate influence, they continued to see themselves as rugged, independent individualists.

For mining engineers in the southwest and northern Mexico, the role of mediating between capital and labor was animated by factors specific to the region that their professional colleagues in the north did not have to contend with to the same extent. An

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[12] As Ruth Oldenziel clearly demonstrates, linking *engineering* to traits considered masculine in the 19th century, such as common-sense and physical coordination, was a key component of the professionalization of the field as a whole. Ruth Oldenziel, *Making Technology Masculine: Men, Women, and Modern Machines in America, 1870-1945,* (Amsterdam: Amsterdam University Press, 1999), 10-12. Where mine engineering departs from the norm of the engineering profession is in this emphasis on the *romance* of mining. That working on a mine was an adventure, rather than a job, is a belief that mining engineers embraced wholeheartedly, and that colored their subject-position within the nascent corporatization of the mining industry to a remarkable extent. On changes to the industrial system of the United States see David Hounshell, *From the American System to Mass Production: The Development of Manufacturing Technology in the United States*, (Baltimore: Johns Hopkins, 1984), and David Noble, *America by Design: Science, Technology, and the Rise of Corporate Capitalism,* (NY: Knopf, 1977).

overarching concern was distance. It was more difficult to transport equipment in, and bullion out, of southern Arizona or Chihuahua in the 1860s and 1870s than it was to transport silver bullion out of Colorado or Nevada. The distance from rail lines and the expense of building rails into the desert; the lack of locally sourced water and fuel to power pumps, mills, and smelters; the challenge of recruiting American workers to such distant (and frequently climactically inhospitable) locales were tremendous difficulties that slowed or undermined development of many otherwise promising mining opportunities. For mining engineers working in Mexico, an added concern was tariff law. Even if mining could be profitably carried on in Mexico, and bullion could be shipped out with relatively little expense, would all profits be lost in taxes at the U.S. border? If so, would the cost of shipping bullion to London or Paris worthwhile? This was an issue for Daggett and Hague in their work at the Cusihuiriachic Mining Company; although ultimately they abandoned that project for other reasons, U.S. tariff laws were of major concern to the two engineers.

An additional, and for some engineers, overarching difficulty faced in mining through the U.S. – Mexico border region was that of culture. Some mining engineers viewed the opportunity to work in Mexico or the southwestern territories of the U.S. as a tremendous adventure. Such men embraced the foreignness of their surroundings, and were tolerant of, or intrigued by, the linguistic and cultural divisions between themselves and the average mine worker. The ability to speak Spanish was obviously a crucial dividing line between mining engineers who loved the borderlands and those who loathed it, but language skills were rarely a prerequisite for being hired as a mining engineer in the region, and many mining engineers were happy to learn enough Spanish on the job to be able to communicate effectively with their foremen and local dignitaries. Others chose to presume that they did not need to learn anything of local society, and permitted their racial and cultural biases to control their interactions with mine workers.[13] Not all workers at these mines were Mexican or Mexican-American, of course. By the turn of the century Arizona had large populations of European immigrant miners, and towns such as Bisbee, AZ, were known as "white-man's camps," in which only white Anglo-European workers were hired for the more lucrative underground positions.[14] Mexicans, Mexican-Americans, and Chinese employees of mining companies stayed above-ground shoveling ore; doing laundry; and cooking.

The racial and ethnic diversity of the labor force was a defining characteristic of working life in the mining districts surrounding the U.S.-Mexico border. An additional characteristic of working life was the migratory nature of the labor force. There was tremendous turnover among underground workers in mining camps throughout the region.[15] Mining engineers themselves were also extremely transient. Almost by

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[13] Jonathan C. Brown, "Foreign and Native Born Workers in Porfirian Mexico," *American Historical Review* 98:3 (June 1993): 798 - 801; Joseph F Park, *The History of Mexican Labor in Arizona During the Territorial Period,* (MS thesis, Univesity of Arizona, 1961), 40.

[14] Huginnie, "'Strikitos!': Race, Class, and Work in the Arizona Copper Industry, 1870-1920," (New Haven: Ph.D. Dissertation, Yale University, 1991). 44-60; Benton-Cohen, *Borderline Americans*, 81-85.

[15] Juan Gomez-Quiñones, *Mexican American Labor, 1790-1990*, (Albuquerque: UNM Press, 1994), 44; Sarah Deutsch, *No Separate Refuge: Culture, Class, and Gender on an*

definition, their work was peripatetic, taking them from one company to another, and from one mining site to another on a regular basis. Engineers crossed state, territorial, and national lines with alacrity, pursuing the most interesting or most lucrative work they could find.

Another feature of the work of mining engineers that remained relatively constant through the late-19th and early 20th centuries was that mining engineers consistently functioned as the on-the-ground voices of the business interests of mining companies. Field work was the great draw of mining engineering, but it could be uncomfortable, and occasionally dangerous, for mining engineers. In most cases, mines operated far from company headquarters, and mining engineers were themselves unprotected from the results of their edicts – a significant issue as industrialization in mining led to increasingly antagonistic relations between miners and management. Indeed, some scholars have accused mining engineers of using their technical expertise as a weapon in the war of management against labor; while this interpretation goes too far in attributing malevolent intentions to mining engineers, it is important to acknowledge that mining engineers were not, on the whole, overly concerned with the plight of laborers. Indeed, it is striking how infrequently mining engineers refer to labor unrest or to union organizing, even during the incredibly violent labor upheavals of the early 20th century.[16]

Anglo-Hispanic Frontier in the American Southwest, 1880-1940, (New York: Oxford, 1987), 18-20, 88-90.

[16] A. Yvette Hugginie, "A New Hero Comes to Town: The Anglo Mining Engineer and 'Mexican Labor' as Contested Terrain in Southeastern Arizona, 1880-1920," *New Mexico Historical Review* 1994 69(4): 323-344. On southwestern labor history, see James Byrkit,

Although mining engineering identity remained remarkably static through the decades following the U.S.-Mexico War, the quotidian details of life as a working mining engineer changed dramatically. In the mid-nineteenth century, as American interest in borderlands mining operations began, mining engineers were primarily hired as surveyors. Working alone, or with one or two assistants, they were dispatched to likely locations by investors, where they made both surface and subterranean surveys of ore bodies, sketching for their employers rough maps and mining plans. Depending on the financial situation of the mine owner or investors, the mining engineer might remain on sight as a technical expert, but was rarely given the responsibility of full management of the mine. Over the next several decades, this changed. In part, these changes were due to the increasing importance of copper mining in the economies of the border states and territories. Copper mining did not begin in earnest in the borderlands until the mid-1870s, but with the advent of electricity, copper quickly became one of the most important industrial products in the United States. In the Arizona Territory, the impact of the copper industry was particularly profound. From 1880 onwards, the production of copper accounted for approximately 20% of the economic production of the territory; by 1900, this comprised 50% of the copper produced in the United States, and the neighboring Mexican state of Sonora contained several large copper mines in locations such as Cananea and Nacozari.[17] The emphasis on copper shaped mining practices in the

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Forging the Copper Collar: Arizona's Labor-Management War of 1901-1921, (Tucson: University of Arizona Press, 1982).

[17] *Historical Statistics of the United States*, Table DB73-78, Millenial Edition online; Charles K. Hyde, *Copper for America: The United States Copper Industry from Colonial*

border region in part because of the high demand for copper in the United States, but also because of the nature of the copper deposits. Unlike the pure native ore found in the Lake Superior copper district, in Michigan, copper deposits in the Rockies and southwest contained much lower grades of ore. Keeping up with demand required the adoption of new mining practices – it was not possible for a miner to simply follow the vein of ore, if there was no vein of ore to follow. Rather, copper ore and the quartz in which it was embedded had to be removed from the ground together, and then treated extensively before it could be shipped to market. The systems devised by mining engineers to accomplish this task changed the structure of working life in mining camps, in effect turning mining into an industry based on what historian Tim LeCain has labeled “mass destruction” – the use of heavy technology and unskilled labor to dismantle a landscape on a massive scale in the production of metals.[18] These new techniques had a profound effect on the working lives of mining engineers themselves.[19]

Times to the 1990s, (Tucson: University of Arizona Press, 1998), 127; Marvin Bernstein, *The Mexican Mining Industry, 1890-1950*, (Albany: SUNY Press, 1967), 72-73; David T. Day, *Mineral Resources of the United States* [1902], (Washington: Government Printing Office, 1904), 164-166.

[18] LeCain, *Mass Destruction*, 7-11.

[19] Many labor histories relating to mining focus on technological change either implicitly or explicitly as the triggers for the violent industrial actions of the IWW and the WFM of the 1890s and early 1900s. Scholarship that explicitly considered the role of technological change in labor relations include Mark Wyman, *Hard Rock Epic: Western Miners and the Industrial Revolution, 1860-1910*, (Berkeley: University of California

The dissertation is organized in a rough chronology to delineate the tension between the change in engineering practice and the stability of certain aspects of mining engineers' professional identity over the course of more than a half century of dramatic expansion in the mining industry. Mid-nineteenth century mining engineers were members of an elite class of European-educated men from prosperous eastern backgrounds. By the early twentieth century, the establishment of systematic engineering education democratized the profession a substantial amount, and the growth of corporate mining eliminated much of the autonomy characteristic of mine engineering in the early decades. Despite these changes, mining engineers remained wedded to the notion that their profession rewarded its members with professional lives distinguished by self-

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Press, 1989), esp. ch. 4; Ronald Brown, *Hard Rock Miners: The Intermountain West, 1860-1920*, (College Station: Texas A&M University Press, 1979), ch 5; Larry D. Lankton and Jack K. Martin, "Technological Advance, Organizational Structure, and Underground Fatalities in the Upper Michigan Copper Mines, 1860-1929," *Technology and Culture* 28:1 (January 1989): 43-45; Mouat and Hovis, "Mining Engineers"; Huginnie, "'Strikitos!'" Studies of the mining labor force that emphasize social and political issues over technological change include Elizabeth Jameson, *All that Glitters: Class, Conflict, and Community in Cripple Creek*, (Urbana: University of Illinois Press, 1998); David R. Berman, *Radicalism in the Mountain West 1890-1920: Socialists, Populists, Miners, and Wobblies*, (Denver: University Press of Colorado, 2007), Benton-Cohen, *Borderline Americans*; Richard Lingenfelter, *The Hardrock Miners: A History of the Mining Labor Movement in the American West, 1863-1893,* (Berkeley: University of California Press, 1974).

reliance, a professional identity increasingly at odds with the quotidien reality of mine engineering.

In focusing on the professional identity of mining engineers and the scope of their workplace obligations, this dissertation breaks with earlier studies of mining engineers, the most significant of which is Clark Spence's *Mining Engineers and the American West, 1870-1930: The Lace Boot Brigade*, Spence provides a deeply researched group portrait of mining engineers as a privileged social elite who brought their superior training and intellect to the problem of building a modern America. Spence admires his subjects for their sweeping technical vision and their tremendous (in general) business acumen. Yet he does not take the larger context of their work into consideration. *Mining Engineers* never questions that his subjects were changing the world for the better, and it never asks if they were affected by the extraordinary revolution in mining methods that were pioneered around the turn of the century. A central narrative of this dissertation, by contrast, is how the profession of mine engineering developed through the nineteenth century and changed into the twentieth. By locating mining engineers squarely within the class structure of the nineteenth century United States, I consider how mining engineers were able to gravitate between the drawing rooms of New York and San Francisco and the mining camps of Arizona. How did they negotiate their status among their social peers? How was this different (or not) at a mining camp? Mining engineers passed between different social worlds frequently, sometimes within the course of a single day as they moved between the home, office, and mine. How did they create and maintain authority in these different places?

In focusing on the professional identity of mining engineers and the scope of their workplace obligations, this dissertation breaks with earlier studies of mining engineers, the most significant of which is Clark Spence's Mining Engineers and the American West, 1870-1930: The Lace Boot Brigade. In this work, Spence provides a deeply researched group portrait of mining engineers as a privileged social elite who brought their superior training and intellect to the problem of building a modern America. Spence admires his subjects for their sweeping technical vision and their tremendous (in general) business acumen. Yet he does not take the larger context of their work into consideration. Mining Engineers never questions that his subjects were changing the world for the better, and it never asks if they were affected by the extraordinary revolution in mining methods that were pioneered around the turn of the century. A central narrative of this dissertation, by contrast, is how the profession of mine engineering developed through the nineteenth century and changed into the twentieth. By locating mining engineers squarely within the class structure of the nineteenth century United States, I consider how mining engineers were able to gravitate between the drawing rooms of New York and San Francisco and the mining camps of Arizona. How did they negotiate their status among their social peers? How was this different (or not) at a mining camp? Mining engineers passed between different social worlds frequently, sometimes within the course of a single day as they moved between the home, office, and mine. How did they create and maintain authority in these different places?

More recent studies that analyze the impact of mining engineers on the industry and landscape of the North American West take a different approach from that of Spence. Where Spence looked at mining engineers and only at mining engineers, these newer accounts tend to subordinate the history of the profession to considerations of the labor or environmental history of the mining industry. Whether the focus of the study is labor relations or the mining landscape, these newer studies tend to characterize mining engineers as heartless industrialists and the chief orchestrators of the devastation of local ecosystems. Scholars such as A. Yvette Huginnie and Tim LeCain raise concerns about work of mining engineers in the late nineteenth and early twentieth century, calling into question their self-aggrandizing narrative of industrial progress, and asking why the short-term goal of ever-more-efficient resource extraction was privileged over the welfare of workers or the future environmental viability of a mining landscape. Mining engineers were products of a very particularist training, and their reactions to workplace problems, be they fraudulent mining claims or recalcitrant workers, were informed by their training. My dissertation seeks to understand what motivated their drive to rationalize and dissassemble the landscape. Further, I ask how mining engineers themselves deployed different identities – varied notions of masculinity, or class, for instance -- while attempting to accomplish their work. By explicitly integrating considerations of gender, ethnic, and class status into my analysis of mine engineering work, a more nuanced portrait of life in a mining camp can be constructed.

Geographically, this study of mining engineers focuses on those who worked in the many and varied mining districts surrounding the U.S.-Mexico border in Arizona and New Mexico and below. The most compelling reason to study the mining districts of the borderlands area as a discrete unit is that the mining engineers themselves treated the area as a unified locale. This is in part because of the geological coherence of the region. Having worked at one area mine, a mining engineer could reasonably argue that he had solid knowledge of the local ores and he could readily obtain a position at a neighboring mine. In consequence, many engineers who traveled to the region when young often continued working in the region for much of their careers. In addition, the comparative isolation of the borderlands as compared to mining territories in Colorado or California served to designate this transnational space as a distinctive mining region. Such isolation, particularly in the nineteenth century, discouraged frequent travel, and so mining engineers were compelled to take advantage of their sometimes brief stays in the territory by circulating through neighboring mining districts to study local conditions and mining practices. It was rare for a mining engineer who traveled to Sonora not to visit mines in Arizona; engineers who traveled to Arizona were likely to make side trips down into Chihuahua.

By the 1880s political and technological changes served to knit the region more closely together, despite the international boundary line. As president of Mexico, Porfirio Diaz opened Mexico to international investment, and American dollars poured in to Mexico frequently in the form of investment in Mexican mines. Mining engineers passed easily and frequently across the border. Also in the 1880s, copper began to be successfully mined along the southernmost edge of Arizona and the northernmost edge of Sonora. As the market for copper wire boomed with the coming of electricity in the 1890s, the borderlands region took shape in the minds of mining engineers as a coherent geological landscape. As the engineers moved through the region, they brought with them the rationale and capital resources for building the roads and rails that quite literally tied the region together. A geographically bounded study of mining engineers in the southwestern U.S. and Mexico highlights the international reach of the monied interests for whom mining engineers worked, while underscoring the complex work mining engineers did negotiating between home and work, and investor and mine.

Chapter one discusses the work of those mining companies that brought the earliest mining engineers into the region, arguing that American companies wanting to engage in resource extraction in the region were hampered more by logistical difficulties than by their lack of mining expertise, and so when they hired mining engineers, they did so for reasons of class-consciousness and class-solidarity rather than for the specialized knowledge these men could bring to the region. Chapter two discusses the growth of the profession of mine engineering alongside the establishment of domestic engineering academies in the 1860s and 1870s. Chapter three explores new assertions of expertise on the part of mining engineers facing issues of fraud, mine viability, and mine operations. I argue that mining engineers' access to a body of technical knowledge as experts did not supplant previous modes of technical credibility, such as the apprentice system or networks of familial and social relations, but rather made for a 'third way' to assert credibility. Moreover, while access to a body of technical knowledge served to bolster engineers' authority with respect to claims of mine viability and fraud, it was used also to undercut engineers' authority with respect to mine and labor management. Chapter four analyzes the deployment of masculine and western identities by mining engineers in borderlands mines. Chapter five considers the development of mass-mining and the influence of large corporations like Phelps Dodge through the borderlands, which, while fundamentally restructuring the physical landscape of mining, altered the "landscape" of the mine engineering profession in the borderlands as more mining engineers were needed by each company to work in massively sprawling mine sites, and yet each mining engineer had significantly less impact on the work undertaken. Chapter six discusses the role of mining engineers in the so-called "development companies" – in particular the Guggenheim Exploration Company – that operated in the southwest and northern Mexico in the early decades of the twentieth century. These companies, by formalizing what had previously been ad hoc, were instrumental in binding together the mineral-rich landscape of the borderlands into a technocratic machine feeding private American commerce. Throughout this period, the expansion of American capital into the U.S.-Mexico borderlands was inextricably bound up with the emergence and changing role of a new class of technical professional: the mining engineer.

In analyzing the role of mining engineers in this region and at this time I draw upon several discrete strands of scholarship. Regional studies and the new transnational "borderlands" studies have guided me in locating the peregrinations of mining engineers in space. The vast literature on the labor, ethnic and social history of the southwestern borderlands has been another critical resource. The history of mining, mining labor, and mining technology can be usefully juxtaposed to scholarship in the history of technology and the new 'envirotech' literatures. Crucially, in order to place mining engineers within their social and cultural context, I have also drawn on important recent diplomatic histories that link the politics of gender to that of the expanding U.S. sphere of influence in the late 19th and early twentieth centuries. What emerges is a complex group portrait of a critical professional class working amid and enabling the rapid industrial dynamism and social and economic expansion of the United States into the borderlands region. Mining engineers made decisions about the allocation of capital and human resources, reshaping not only a critical industry but also the economic, social, and physical landscape of an entire region into the 20^{th} century.

Chapter One

Early Mining in the Borderlands:

The Limits of "Intelligence and Capital," 1850-1865

"The simple truth is, that the soil of nearly all North America is more or less impregnated with gold… In Arizona and Sonora it is known to abound. In Mexico, it would have been a principal article of export but for the greater plenty of silver."[20] This statement from *Harpers Weekly* in 1858 was not out of step with what was commonly printed about the mineral wealth of western North America in the years following the California Gold Rush. Reports of the fabulous wealth unearthed in California were commonplace to readers of papers in New York or Chicago. Thus when reports of other sites of mining wealth began to circulate – whether of the Comstock Lode in 1859, or Pike's Peak a couple years later – the American public was primed to accept these reports, and speculators and entrepreneurs prepared to take action to reap the benefits of the alleged natural wealth of the continent. American fortune-seekers who traveled to Nevada or Colorado did so in company with thousands of their fellow-men.

But through the 1850s and 1860s, some Americans took a less well-traveled path down to the newly mapped U.S.-Mexico border region. The Arizona Territory, and the states of Sonora and Chihuahua in Mexico, were all known to have several mining districts. As independent prospectors, speculators, and members of joint-stock companies, Americans hastened south to try to capitalize on the promise of the territory. They were not particularly successful, but the experiences of these early American

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[20] *Harpers* vol. 12/11 (1858): 786.

prospectors were of tremendous importance to those who came later. Early prospectors popularized the region as a destination for adventurers, and provided information about what might be needed to establish successful local mining operations.

The Americans who traveled to the borderlands in the 1850s and 1860s were a disparate group. Some came west from the more populous states of the U.S. Others, particularly in the early 1850s, traveled southeast from the gold mining districts of northern California. For many of these erstwhile forty-niners, the Gold Rush had been a time of thwarted dreams. The expense and difficulty of reaching California meant that by the time would-be miners arrived in San Francisco, they had very little money, and even less interest in the tedium of panning for gold. Lacking immediate success, many migrants who had the means to leave did so – Americans, Mexicans, and other foreign nationals, who left in particularly large numbers following the passage of the Foreign Miner's Tax in 1850. This charge of $20 per month for non-Anglo miners to run a placer mining operation led many Sonoran gold seekers, in particular, to head home from the California mines. Some were sidetracked by silver mines in the New Mexico Territory, but many more headed back into Sonora or Chihuahua, embracing the opportunity to return home while trying their luck prospecting in established mining districts near Hermosillo or Alamos. Sonoran natives were joined in their return home by American fortune hunters, drawn by stories of the mineral wealth of Mexico and by the promise of easy travel and the economic integration of Sonora and Arizona.[21] Not all miners in the

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[21]Susan Lee Johnson, *Roaring Camp: The Social World of the California Gold Rush*, (New York: Norton, 2000), 31; John R. Robinson Diary, 57-58, 66, HM 62476, Huntington Library, San Marino, California [hereafter HL]; Miguel Tinker Salas,

gold and silver districts of Sonora, Arizona, and Chihuahua came via California. Contemporary reports counted upwards of 1000 men who left Alamos and Hermosillo, in Sonora, for the territory of the Gadsden Purchase.[22] This strip of land across southern Arizona was acquired by the United States from Mexico in 1854 in hopes that it would prove to be good land for a transcontinental railroad. That there was gold and silver in the mountains near Tubac and Tucson was an added bonus American legislators did not anticipate.

Upon reaching the mining districts in the new borderlands, prospectors found a series of overlapping ethnic, national, and political groups operating throughout the territory. Although the most recent major political disruptions in the area were the annexation of the New Mexico Territory and the Gadsden Purchase by the United States, the relative absence of the U.S. military in the aftermath of the Treaty of Guadalupe Hidalgo meant that relations between the newly American territories and the northern Mexican states were fairly amicable; indeed the border between the U.S. and Mexico was almost fully permeable at this time. It was scarcely marked through the Sonoran and

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"Sonora: The Making of a Border Society, 1880-1910," *Journal of the Southwest*: 435-436. The political integration of Sonora and Arizona was occasionally a topic of discussion in American politics. See for instance Amy Greenberg, *Manifest Manhood and the Antebellum American Empire*, (New York: Cambridge, 1995), ch. 1; Ernest May, *The Southern Dream of a Caribbean Empire*, (Baton Rouge: Louisiana University Press, 1973), esp. ch. 6; John Douglas Pitts Fuller, *The Movement for the Acquisition of All Mexico, 1846-48,* (Baltimore: Johns Hopkins University Press, 1936).

[22] "Silver Mines of Arizona," *Mining Magazine* 2, no. 1 (January 1854).

Chihuahuan deserts, and law-abiding citizens of both countries crossed with ease, while bandits and less-than-principled characters exploited the agreements that prevented American soldiers from chasing them into Mexico, and Mexican authorities from pursuing them into the U.S. The ease of border crossing meant that American prospectors seeking mining opportunities were as likely to head south of border as to stay to the north. Whether in the U.S. or northern Mexico, they found that federal authorities had little to do with local affairs—a condition greatly exacerbated in U.S. territory by the advent of the Civil War in 1860—and prospectors discovered that they were at the mercy of more local concerns.

The two nation-states were not the only political entities with which gold- and silver- seekers had to contend. The new borderlands were also home to several native tribes, including some who maintained generally peaceable relations with Sonoran and American authorities, such as the Akimel O'odham (known to contemporary Americans as the Pima), who occupied the Gila River basin north of Tucson; the Tohono O'odham (known to contemporary Americans as the Papago), who traveled through a broad swathe of land on either side of the Santa Cruz River, encompassing the old presidios of Tucson, Tubac, and Tumacacori and crossing the new international boundary line; and, farther south, the Yaqui. The presence of these and other native tribes did not prevent Americans from sometimes referring to the area along the border between present-day Arizona and Sonora as Apachería or Apache-land, in reference to the people with the strongest military presence in the region. Most Mexican and American citizens were ignorant of the existence of multiple Apache tribes, and, indeed, many white travelers to the borderlands made a habit of calling any native person who made them slightly nervous "Apache."[23] Travelers' reports from Arizona and Sonora, in particular, focus on the military threat of the Apache, and to the extent that the United States maintained a military presence in and around Tucson in the 1850s it was to combat Apache claims on new American territory and property.

Local political conditions in mining camps in the borderlands region were further complicated by endemic civil unrest throughout the state of Sonora in the 1850s and 1860s. Occasional Apache raids were only the start of the problem for Sonoran miners. The actions of American filibusters, private U.S. citizens who marched armies of mercenaries into the state in a bid to claim it for the United States via conquest, made native Sonorans cautious of the *yanqui* newcomers, although most prospectors who settled into mining communities near the new international boundary line had little interest in the actions of the filibusters except as they disrupted work on mining projects.[24] In addition to invasions by American soldiers of fortune, during the 1850s and 1860s Sonora also endured a more successful foreign occupation, this one by French forces. As the French had some interest in the supposed wealth of the silver mines of Sonora, the state experienced an extended occupation. The governor of Sonora, meanwhile, fled north of the border into Arizona while French forces, allied with the

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[23] The territorial maps provided in Karl Jacoby, *Shadows at Dawn: A Borderlands Massacre and the Violence of History*, (New York: Penguin, 2008) provide a wonderful visual guide to the complicated political negotiations between the O'odham, the Apache, and the two national entities.

[24] Rudolph F. Acuña, "Ignacio Pesquiera: Sonoran Caudillo," *Arizona and the West* 12:2 (Summer 1970): 148; Greenberg, *Manifest Manhood*, 31.

Yaqui and Mayo tribes, assaulted the population. This uneasy state of affairs did not settle down until the late 1860s, when a weakened French army was finally pushed out of Sonora.[25]

In the midst of all this political and military turmoil, prospectors and miners still flocked into a region renowned for the wealth of its mines. Following the tradition of California mining, many of these miners were independent prospectors. During the California Gold Rush, placer mining, in which a miner caught flakes of gold or silver in a wash pan as they flowed downstream from a higher location (the elusive "mother lode") was the norm. Placer mining requires almost no capital outlay besides a pan and a sieve; one man working alone is as likely to find a nugget of value as are a group of men working with a marginally more complex trough or sluicing system. In the arid Southwest, however, there were few active placer mines in the 1850s.[26]

Many of the larger ore deposits in the borderlands were silver rather than gold, and much of this silver ore was found embedded in quartz rather than washed down into streams, and so the riverine mining experience of many California gold seekers did not help them much once they reached the mining districts of Chihuahua, Sonora or present-

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[25] Stuart Voss, *On the Periphery of Nineteenth-Century Mexico: Sonora and Sinaloa, 1810-1877*, (Tucson: University of Arizona Press, 1982).

[26] In the early 19th century a handful of placers were worked in the Ortiz and San Pedro Mountains, just north of Albuquerque, by Mexican miners. Productive placers were also worked near present-day Silver City by white Americans, beginning in the 1860s. Rodman Wilson Paul, exp. ed., *Mining Frontiers of the Far West: 1848-1880,* ed. Elliot West (Albuquerque: University of New Mexico Press, 2001), 156.

day Arizona. Those newcomers who mastered different mining techniques, however, were vocal in their endorsement of the local mineral wealth. One mining engineer, pleased by the encouraging assays his silver samples from Batopilas received in San Francisco, remarked that "the more I have become acquainted with the California mining, the better I am satisfied with the value of the Mexican."[27] Rich gold and silver manifested in the region in narrow veins of almost pure ore, making it relatively simple to extract with a pickaxe and a shovel. Although Americans used words such as "inexpert," "minor," and "desultory" to describe ongoing mining projects that they saw, local practices included a great deal of active mining, following the practices the Spanish had brought with them to North America in the sixteenth century. Mining was not the largest industry in the borderlands, but it occupied an important place in the local economy, with many people working occasional claims, or hiring out as skilled labor at the larger mines. Such mines rarely used the wood timbering practices that were common at underground mines in the United States and Europe; rather, ore was left *in situ* as pillars to prevent the roof of the mine collapsing. Smelting and processing techniques first used by the Spanish and still widely practiced were labor- but not capital-intensive, and enabled small-time producers to work even refractory ores (those that manifested in concert with other minerals rather than as pure veins) with some small success. If a prospector hit a good strike, local knowledge of how to build an *arrastra* or implement the *patio* method was readily available and inexpensive to acquire, if a person were so inclined.[28] There were

[27] John R. Robinson Diary, HM 62476, HL.

[28] After being excavated, mid and low-grade ore needed further treatment before it could be smelted. At its most basic, an arrastra consisted of a circular clay base, overlaid with

ample experienced Mexican and "friendly" natives, members of the Papago, Ópata, and Yaqui tribes, who could be hired to work in a promising mine.[29] Some Americans, however, were uninterested in gaining from local experience. As newcomer John Denton Hall fumed, "it was impossible… to give satisfaction" to such men. "Many a poor devil of a Mexican miner, on giving a correct assay... and report of a mine, has been belied and abused as an ignoramus... from the simple fact that he has not satisfied by lying, the hope of his much more ignorant employer."[30]

Sonora

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was a slightly acidic surface of stones onto which roasted ores were dropped. A team of mules then dragged a heavy weight around the circle as a slow trickle of water dripped onto the crushing surface, mashing the ores into a slurry. The slurry dropped through the stone sieve and was retrieved from the clay base for further processing. Otis Young, *Western Mining: An Informal Account of Precious-Metals Prospecting, Placering, Lode Mining, and Milling on the American Frontier from Spanish Times to 1893*, (Norman: University of Oklahoma Press, 1970), 65-70; Rossiter Raymond, *Statistics of mines and mining in the states and territories ...,* Volume 869, (Washington, D.C.: GPO, 1870), 3

[29] Miguel Tinker Salas, *In the Shadow of the Eagles: Sonora and the Transformation of the Border During the Porfiriato*, (Berkeley: University of California Press, 1997), 11, 82-83; Paul and West, *Mining Frontiers*, 156.

[30]John Denton Hall, *Travels and Adventures in Sonora: Containing a Description of Its Mining and Agricultural Resources, and Narrative of a Residence of Fifteen Years,* (Chicago: J.M.W. Jones Stationery and Printing Company, 1881), 135.

The career of John Denton Hall exemplifies in many ways the experiences of the new settlers in the border territories. An Englishman who met with "indifferent success" in the gold fields of California, Hall accepted the invitation of a Mexican friend he met in California to try his luck mining silver in Sonora.[31] For the next fifteen years, Hall engaged in a series of unsuccessful mining operations, both in Sonora and in southern Arizona. Hall's memoir, *Travels and Adventures in Sonora*, offers a notably detailed depiction of the experience of mining silver in the borderlands in the mid-nineteenth century for a certain kind of white foreigner. Like many Americans who traveled from California to Sonora, Hall had no connections to New York investment money, and was constantly struggling to raise capital. Unlike many other white men who traveled to the region, Hall became remarkably attached to the region during his residency, experiencing the borderlands as an interesting, if not always comfortable, place to live his life, rather than simply as an exotic background for an adventurous youth. In short, he seemed to like it there.[32]

Hall was loquacious on the subject of Sonora's mineral wealth. Indeed, he announced in the preface to his memoir his intention to make it clear that the mines of Sonora and Arizona were "safe investments for legitimate mining," a truth Hall feared was lost on the American public due to the machinations of "unprincipled speculators." Unfortunately for Hall's stated purpose, the narrative that follows is notable for the indifferent success it chronicles. Hall detailed not only his own failures, but those of other

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[31] Hall, *Travels and Adventures*, 9-10.

[32] On the problems of mining in Arizona and the New Mexico Territory prior to the 1880s see Paul and West, *Mining Frontiers*, 155, 157-158.

investors as well. In the spring of 1852, for instance, Hall began working at a gold mine at El Cajon de Brisca; by “June 5th, 1852” he related, “we were to all intents and purposes dead broke.” Later that summer, Hall and his enigmatically named American friend, Mr. C., did some small-time “gold digging” nearby. Reading between the lines, it is evident that what the two men did was camp out and live hand to mouth off what game they could shoot. Tiring of this life, Hall and Mr. C. began working with a Mexican-owned silver mining company at the Santa Teresa de Jesus mines, just north of the mineral district of Cucurpe, and about fifty miles from the U.S.-Mexico border south of Tucson. “We were dubious as to the success of the speculation” Hall explained, “but there was something so enticing about silver mining, that we accepted the offers made [to] us.”[33] Indeed, Hall returned to gold mining only two more times in the next fifteen years, for ventures in which, needless to say, he did not turn a profit.

Following the failure of the Santa Teresa mining effort, Hall and Mr. C. decide to strike out on their own again, independently working a mine close to Cucurpe. When this enterprise also failed, Hall apprenticed himself to the new amalgamator at the Santa Teresa mines, continuing to work in the district until 1855, when the company stopped working and depopulated the mines. Hall next contracted to work the recently abandoned mines with some workers supplied by the company; this mining attempt was also cut short by a wave of violence, this time the civil war in Sonora. Hall’s workers were drafted to fight for the government, and consequently left the mine. Frustrated by the disruption of his speculations, Hall shifted his attention northward to Arizona, where he entered into an unwritten contract with a man who claimed ties to investment money in

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[33] Hall, *Travels and Adventures*, preface, 93-95,103, 109.

New York. This project too failed miserably, and Hall returned to mining in Sonora. Once again, Hall was disappointed; as he put it, "hopes apparently so well-founded have all vanished like smoke before the wind."[34]

In *Travels and Adventures in Sonora*, Hall described seventeen different mining operations in Sonora and Arizona, active between 1850 and 1866, which were owned whole or in part by foreign investors, the vast majority of whom were American. During this period, many Americans were enticed south of the border by the loose legal strictures on mining, and the willingness of eastern investors to be persuaded that Mexican mines were far superior to the proven wealth of the mines of California. One contemporary of Hall's estimated that in the year 1860-61, as many as twelve fully financed American companies began mining operations in Sonora alone.[35] Of those operations in Sonora or Arizona with which Hall himself was familiar, only three resulted in other than abject failure: the Babicanora mines, operated as of 1864 by a French corporation; Sylvester Mowry's Patagonia mine in Arizona, at which operations were suspended at the start of the U.S. Civil War; and Hall's own small success with a mine located near the Santa Teresa, circa 1863.[36]

John Denton Hall was a small-time operator, and his travails were probably unknown to people outside his immediate circle. But the arc of his career in Sonora and Arizona, from independent prospector, to prospecting with other people's money, to

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[34] Ibid., 120-121, 232.

[35] John R. Robinson Diary, 58, HM 62476, HL.

[36] Hall, *Travels and Adventures*, 158, 140-42, 104; [Herman Ehrenberg], "The Old Babicanora Silver Mine of Sonora," *Weekly Arizonian* (Tubac) 28 April 1859.

working for larger mining companies is emblematic of the general trend in the borderlands hard rock mining industry in the years before the U.S. Civil War. The directors and investors in regional mining companies were acutely aware of the difficulties posed by working in a region so distant from the economic center of American society, but they and other observers sought to blame their failures on those aspects of their industry more mutable than location. Sylvester Mowry, for instance, blamed the workers, stating baldly, "the Mexican [miner] is poor, without energy, and too lazy to trust to help himself."[37] Hall, who fancied himself a mining expert, saw a different problem. He believed that "the great difficulty in working mines in Sonora and Arizona to advantage, is the scarcity of scientific, practical miners; for this reason, parties are diffident of investing in mines, fearful of losing both mine and money."[38] Although Hall's own story was one of failure, he clearly hoped that his experiences would inspire investors with knowledge of mining and more financial resources to come into the region to work in the mines. He was not the only person to think that the problems investors had mining in the borderlands were due to a lack of "scientific, practical miners." The *New-York Daily Times* agreed, declaring in 1852 that "there are very rich silver mines in this country [Mexico and New Mexico], but neither capital, enterprise, nor knowledge, to work them."[39]

The Arizona Territory

[37] Sylvester Mowry, *Arizona and Sonora: The Geography, History, and Resources of the Silver Region of North America* 3rd ed. (New York: Harper and Bros., 1866),45.

[38] Hall, *Travels and Adventures*, 150.

[39] "New-Mexico," *The New York Daily Times*, May 11, 1852.

Assembling both knowledge and capital at a mine site in the borderlands proved quite difficult in the 1850s and 1860s. Hall, for instance, was largely an auto-didact, and once he learned how to work the ores in the region, he was never able to find real success with the small amount of capital to which he had access. A handful of other operators, however, were able to raise fairly substantial sums of cash, and to bring into the area bona-fide mining professionals – engineers – to consult on and manage various mining operations. Many of these larger businesses were founded as joint-stock companies, overseen, sometimes loosely and sometimes tightly, by boards of trustees or investors located east of the Mississippi. Beginning in the 1830s, industries requiring massive up-front capital investment, such as railroads, and later, mines, were almost exclusively financed in the United States by sales of stock; that John Hall did not have the connections, and therefore the access, to these sources of finance was a chief reason he was unable to capitalize on the opportunities he had in Sonora. The advantage of the joint-stock system for company managers was the relative ease with which large sums of money could be raised. Using stocks to finance southwestern mines also brought the mineral wealth of the territory to the attention of financiers, whose interest in the borderlands through the late nineteenth century would become necessary as mining entrepreneurs became railroad boosters seeking the large cash influx necessary to build the regional infrastructure.[40] Although stock was often sold in a manner similar to today, with a public offering when a company was sold or incorporated, it was sometimes sold piecemeal, as when the owners of the Gila Copper Mine decided in 1857 to sell a few

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[40] William G. Robbins, *Colony and Empire: The Capitalist Transformation of the American West,* (Lawrence: Kansas University Press, 1994), 31.

shares in their company to raise quick cash so they could ship already-extracted ore out of Arizona.[41] Such ease in raising capital, however, came with the price of nominal accountability to those shareholders for the success or failure of a company's operation.[42] With stockholders' money, mining companies hoped to purchase the most advanced mining and smelting technology available, as well as the experienced workers who could successfully operate such equipment. Advertising the skill and credentials of staff mining engineers became a crucial tool for managers and owners seeking to raise money.

The Heintzelman Mine

The Sonora Exploring & Mining Company, overseen by a board of trustees in Cincinnati, was one of the most well-capitalized mining companies in the borderlands region in the 1850s. Initially capitalized at over $2,000,000, a remarkably large sum at the time, it seemingly had all the advantages that observers thought a successful borderlands mining company needed: money, a property with substantial silver ore holdings, and some of the top mining engineers working in North America.[43] Yet the inability of even this well-advised and well-financed company to pay dividends indicates the hollowness of the standard analysis of mining, as expressed by Hall and others, that success required simply money and knowledge. As one mining journal succinctly summed up the belief: "[Mining] requires of those who pursue it a special education and

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[41] "Gila Copper Mine," *Mining Magazine* 8, no. 5 (May 1857).

[42] Stanley Buder, *Capitalizing on Change: A Social History of American Business,* (Chapel Hill: University of North Carolina Press, 2009), 108-113.

[43] [List of Mining Companies in Arizona, and their capitalization], *Mining Magazine,* Second Series 1:1 (November 1859).

experience, or the labor devoted to it may be fruitless… it is the offspring of intelligence and capital."[44] As the history of the Sonora Exploring and Mining Company demonstrates, this formulation, while logical, is not complete.

The Sonora Engineering and Mining Company. was founded by Charles Poston, a regional booster responsible for lobbying Congress to separate the Arizona Territory from New Mexico, along with a business partner, Major Samuel Peter Heintzelman. Heintzelman, a veteran of the U.S.-Mexico War, had stayed in the region after the Treaty of Guadalupe Hidalgo, establishing an Army post at the junction of the Gila and Colorado Rivers in 1850.[45] Like many military men stationed on the frontier, Heintzelman spent some of his spare time surveying the landscape for speculative mining prospects. In 1856, in partnership with Poston, he purchased a silver mining claim near Tubac in the Gadsden Purchase territory, the eponymously named Heintzelman Mine, and the two established the company to exploit the claim. Despite its name, the Sonora did little exploration and mined only in the Santa Rita Mountains north of the Mexican border. When raising capital for their venture, Heintzelman and Poston placed great emphasis on the *security* of the Sonora Exploring and Mining Company's property, assuring investors that the "mere presence" of four companies of dragoons in the nearby town of Tucson, and, of course, of Heintzelman himself, would prevent Apache raids at

[44] "Mining: It's Embarrassments and its Results," *Mining Magazine*, 2, no. 6 (June 1854).

[45] Diane M.T. North, *Samuel Peter Heintzelman and the Sonora Exploring and Mining Company,* (Tucson: University of Arizona Press, 1980), 3.

the mine.[46] Indeed, the first annual report, likely penned by Poston himself, told stockholders that the company had sent "an armed party [to the Gadsden Purchase] of sufficient strength to protect itself against the Indian tribes."[47] This statement is in keeping with a trope of eastern American writing about mining in Mexico or the new southwestern territories, in which the armaments carried by the exploring party were described in as much detail as the supposed value of the mines.[48] The Sonora Engineering and Mining Companyaggressively asserted the security of its property, no doubt hoping that this would direct stockholder's attention to the subject matter of most interest to all concerned: mining.

Poston and Heintzelman's strategy in this regard proved moderately successful. From the start, however, they were plagued by other difficulties. The company had trouble getting the necessary credit from freighting companies in Sonora to transport heavy machinery from the nearest ports in western Sonora, and this meant that they had to try to bring expensive and heavy mining machinery to Tubac overland from San Francisco or points in the eastern U.S. Although his Cincinnati investors appreciated the apparent security of investing in a company managed by a major in the U.S. Army,

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[46]On Heintzelman's background see North, *Samuel Peter Heintzelman*, 7-21; [Sonora Exploring and Mining Company], *Sonora... 1856*, 7.

[47][Sonora Exploring and Mining Co.], *Sonora – and the Value of its Silver Mines; Report of the Sonora Exploring and Mining Co., made to the Stockholders December 1856,* (Cincinnati: Railroad Record Print, 1856), 5.

[48] "Silver Mines in Sonora," *Mining Magazine*, 3, nos. 5&6 (November and December 1854).

Heintzelman proved to be a terrible executive. He was far more interested in his military career than in the day-to-day life at the mine, disliked the climate in southern Arizona, and appointed his monumentally ineffective brother-in-law, Solon H. Lathrop, as manager of the mine.[49]

Despite shortcomings in the managerial department, one area in which the Sonora Exploring and Mining Company distinguished itself was in the hiring of mining engineers, the majority of whom had trained at Freiberg, in Saxony. Unusually for the region, the Heintzelman Mine often had on staff more than one mining engineer, and as a contemporary observer noted, the company made an effort to hire a "real class of

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[49]The choice of military men as managers often backfired. An agent for Samuel Colt, who took over the Sonora Exploring and Mining Co. in late 1859, observed of Heintzelman that "the habits of thought and manner characteristic of military men, render him rather unfit for the management of men on a frontier. I find that a spirit of dissatisfaction is generally prevailing among all classes at the mine..." Robert Jarvis to Samuel Colt, 6 December 1858, C-47, Box 19, Uncat. MSS.918, Jarvis-Robinson family papers (addition), Beinecke Library, Yale University [hereafter J-R Papers]; North, *Samuel Peter Heintzelman,* 41; [Sonora Exploring and Mining Company], *Third Annual Report of the Sonora Exploring and Mining Co., Made to the Stockholders, March 1859,* (New York: W. Minns and Co., 1859), 3, 16; Robert Jarvis to Samuel Colt, 8 September 1858, [Santa Rita Silver Mining Company], Box 19, J-R Papers; [Santa Rita Silver Mining Company], *Second Annual Report of the Santa Rita Silver Mining Company, made to the stockholders, March 19, 1860,* (Cincinnati: Railroad Record Print, 1860), 4.

people."[50] This is a testament to the relative solvency of the operation, which gave the Sonora Engineering and Mining Companythe ability to hire expensive experts whose skills could be bragged about in annual reports and trade publications. As stated in one of the company's earliest public announcements of its plans, the annual production of the mine was projected to be almost half a million dollars, a "view... borne out by the agent of the Company and *scientific gentlemen* on the expedition [my emphasis]."[51]

In the 1850s and 1860s, mining engineers working in the Arizona or New Mexico Territories, or in Mexican states, were only rarely hired to manage mining properties. The Sonora Engineering and Mining Companyfollowed this pattern. Over a seven-year period, 1856-1863, the company employed mining engineers Guido Küstel, Charles Schuchard, Frederick Brunckow, and Herman Ehrenberg as metallurgists, prospectors, on-site engineers, and technical advisors; none served as a supervisor or manager, although all were central to the company's ability to advertise its operations. Küstel, for instance, who wrote books on ore dressing and the processing of gold and silver ores and eventually became one of the best-known engineers in the western United States, came to Arizona from a position at a smelting firm in San Francisco, lured by the richness of the

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[50] Samuel Colt, cited in Diane North, "'A Real Class of People' in Arizona: A biographical analysis of the Sonora Exploring and Mining Company, 1856-1863," *Arizona and the West* 26:3 (Autumn 1984), 261.

[51] "Sonora Exploring and Mining Co. – First Annual Report," *Mining Magazine* 8, no. 4 (April 1857).

ore in the Santa Ritas.[52] His reports on the value of the Heintzelman mine were cited by mining professionals and regional boosters alike.[53] Hiring Küstel sent a clear message to investors that the company was able to attract educated mining men to its ores, and served to proclaim the seriousness of the endeavor to anyone who might question it. Mining engineer Herman Ehrenberg was also touted by company directors to the stockholders as a particularly valuable asset. In addition to articles and citations in mining journals, Ehrenberg was a frequent contributor on mining matters in the local paper, the *Weekly Arizonian*, and the paper returned the favor by praising his talents to the sky. Although far from an objective reporter of matters of local interest — the *Weekly Arizonian* was owned and operated by the Santa Rita Mining and Milling Company, a subsidiary of the Sonora Exploring and Mining Company — the high opinion of Ehrenberg expressed in the editorial pages was seconded by interested easterners, one of whom described Ehrenberg as "a gentleman of education and

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[52] Guido Küstel, *Roasting of Gold and Silver Ore, and the Extraction of Their Respective Metals, without Quicksilver,* (San Francisco: Dewey & Co., 1870); Küstel, *A Treatise on Concentration of All Kinds of Ores,* (San Francisco: Mining and Scientific Press, 1868); Küstel, *Nevada and California Processes of Silver and Gold Extraction,* (San Francisco: Frank D. Carlton, 1863).

[53] "Silver and Copper Mining in Arizona," *Mining Magazine*, Second series 1, no. 1(November 1859).

intelligence and thoroughly informed upon all points connected with these distant countries [Arizona and Sonora]."[54]

Yet despite the wealth of intellectual capital at the Heintzelman Mine, the mine struggled to turn a profit. Guido Küstel reported in 1857 that he was able to extract $148 of silver per ton of ore. While not an insignificant payout, this was not nearly enough to cover the costs of operation. When it opened, the Heintzelman mine used an adobe oven to heat ore prior to treatment, and treated the ore using the patio process, a traditional Mexican system for separating silver ore from quartz. The oven was a simple blast oven, operated by a single man powering a bellows.[55] Although a supremely effective technology for a small-scale local mining operation, the patio process could not produce enough silver to pay the cost of shipping that silver to markets in New York or San Francisco. To be profitable, the Heintzelman needed to operate on a more ambitious scale, producing relatively large quantities of high-quality silver. The investment the company made in mining engineers was naturally intended to enable this to happen. Although mining engineers were comparatively expensive employees, the amount of

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[54] H[erman] Ehrenberg, "Valuable Statistics," *Weekly Arizonian* (Tubac), 14 April 1859; H[erman] Ehrenberg, "A Valuable Table," *Weekly Arizonian* (Tubac), 21 April 1859; H[erman] Ehrenberg, "Table of Distances," and "Table for Converting...," *Weekly Arizonian* (Tubac), 28 April 1859; Robert Jarvis to Samuel Colt, 7 July 1859, C-47, Box 19, J-R Papers.

[55] "Silver and Copper in Arizona," *Mining Magazine*, Second Series 1, no. 1 (November 1859).

money that could be made by selling high-grade silver was expected to be far more than the cost of one or two engineers.

Guido Küstel initially took responsibility for upgrading the treatment processes used by the Sonora Exploring and Mining Company. Shortly after beginning operations, he instituted the barrel process of amalgamation for on-site reduction of ore. Processing silver ore – separating the silver from the mined ore and shaping it into a form that could be readily transported – is complicated. As Küstel explained, "the concentration of silver ores is generally a delicate process, being subject to heavy loss, which cannot be avoided."[56] Barrel amalgamation, also known as the "Freiberg method," after the German institute where it was developed, was a process for treating silver ores by mixing them with salt, and using silver's affinity for the chlorine in salt to separate it from what nineteeth century mining manuals called "baser materials." In barrel amalgamation, half a ton of roasted, pulverized ore was placed in a barrel, along with a large quantity of water and iron. The barrel was then rotated at a high speed on a perpendicular axis. This continued until the "paste" in the barrel reached a consistency similar to heavy cream. At that point, quicksilver (mercury) was added to the barrel, and the rotating continued for another twelve hours, after which time the barrel was topped off with water and the rotation slowed down, so that the amalgam falls to the bottom of the barrel. As a final step, the amalgam was reheated to remove the quicksilver, and the remaining silver concentrate shaped into blocks for transport.[57]

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[56] Guido Küstel, *A Treatise on the Concentration of All Kinds of Ores*, [213].

[57] John Shertzer Hittell, *Mining in the Pacific States of North America,* (San Francisco: H.H. Bancroft and Co., 1861), 172 – 173.

Initially, Küstel used a team of mules to power the rotation of the barrels. This was not very successful. The trade publication *Mining Magazine* reported that the mules provided insufficient "regularity of motion" for successful amalgamation; in addition, there was "much injury and loss occasioned by stopping to rest or change the animals."[58] The engineers at the Heintzelman wanted to bring in steam-powered equipment to solve the production issues with the mules, but the nearest port, Guaymas, was fifteen hundred miles away, and the directors feared the route was not secure. The other option was to ship the amalgamators overland. At 50,000 lbs. apiece, the cost to bring two amalgamators overland would be $15,000.[59] Despite the impracticability of this cost for a mine producing approximately $500 of ore per week, the decision was made to buy the equipment, on the calculation that the long-term viability of the mine required such capital investment.

Yet despite all the calculated risks the various mining engineers suggested to Heintzelman, Lathrop, and their successor, industrialist Samuel Colt, the Heintzelman Mine failed to live up to its promise. Indeed, the engineers, rather than increasing the output of the mine, seem to have served instead as convenient scapegoats for more general managerial problems. Heintzelman, for instance, publicly reprimanded one of his mining engineers for lacking knowledge of metallurgy. He further accused the engineer of wasting money through lenient dealings with Mexican laborers and of not

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[58] "Silver and Copper in Arizona," *Mining Magazine*, Second Series 1, no. 1 (November 1859).

[59] H[erman] Ehrenberg to William P. Blake, ed., *Mining Magazine*, Second Series (January 1860).

understanding barrel amalgamation, a process about which Heintzelman himself assuredly knew almost nothing.[60] Given Heintzelman's general ignorance of mining processes, it is difficult to give much credence to the major's attacks on the mining engineers on his payroll, especially as Heintzelman's final ill-conceived action as president of the company was to send a shipment of silver overland to San Francisco for smelting, where from "some imperfection in the furnaces, or some other cause, [the yield] was 47 per cent. less than the assay. This scarcely paid the expense of sending the ore so far, and was the source of much embarrassment to the Company[.]"[61] Such poor decision making was not unusual at the Sonora E&M Co., where valuable shipments of equipment were perpetually getting lost or stalled in a tangle of bad business practices and personal vendettas.

Notably, however, the mining engineers who worked for the company were prolific publicists of their work, publishing a multitude of articles devoted to their metallurgical practices and the geology of Arizona in trade publications such as New York's *Mining Magazine,* as well as in local, company-owned newspapers such as the *Weekly Arizonian.* Positive reports on the wealth of the mine continued to be issued through the end of the 1850s, although such reports were almost always accompanied by an explanation of the logistical difficulties to be overcome in the service of bringing

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[60] [Sonora Exploring and Mining Company], *Sonora... 1856*, 43; [Sonora Exploring and Mining Company], *Third Annual Report...*, 20.

[61][Sonora Exploring and Mining Company], *Third Annual Report,* 7.

modern mining and metallurgical practice to the Heintzelman Mine.[62] The Sonora Engineering and Mining Companylacked neither investment capital nor intellectual capital in the form of mining experts, but suffered rather from poor management and the perhaps-foreseeable difficulty of trying to mine a quartz district that was several hundred miles from the nearest water or rail route. In addition, bad luck and bad timing plagued the enterprise, as the federal government withdrew troops from Arizona at the start of the Civil War in 1861 and investors concurrently pulled out of mining enterprises for the duration of the conflict.

The Santa Rita Mining and Milling Company

Neighboring the Heintzelman Mine was a subsidiary of the Sonora Exploring and Mining Company, financed by the same group of Cincinnati-based capitalists: the Santa Rita Mining and Milling Company. Like the Sonora Engineering and Mining Company, the Santa Rita Company made an effort to hire university-trained mining engineers, although without the same capital resources to draw upon, it only succeeded in hiring one, in 1860: a young man named Raphael Pumpelly. Like Guido Küstel, Pumpelly was a graduate of the Freiberg Academy, in Saxony.[63] And like the Sonora Exploring and Mining Company, the Santa Rita Mining and Milling Company possessed both “intelligence” – in the form of Pumpelly – and “capital,” albeit not as much as the parent company. For a company operating in the multi-cultural environment of the borderlands, Pumpelly was a good hire. Although he did not speak Spanish, he was fluent in French,

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[62]“Silver and Copper Mining in Arizona,” *Mining Magazine*, Second series 1, no. 1 (November 1859).

[63]*Weekly Arizonian* (Tubac): 3 March - 7 July 1859.

and his employers may have hoped that he would be able to muddle through the language barrier to communicate with Mexican laborers, as proved to be the case. As a recent Freiberg graduate who was also proficient in German, the language in which much of the cutting-edge research in mining methodology was published, Pumpelly was acquainted with the most up-to-date scholarship on mining. He was also connected to a wide network of professional mining engineers who could provide the young engineer with the benefit of their experience if he so required.[64]

Yet although the directors made the calculation to hire a Freiberg-trained expert, Pumpelly did not have more success than Ehrenberg, Küstel et al at the Sonora Exploring and Mining Company. Pumpelly's task in Arizona was to help the Santa Rita Mining and Milling Company open some new mines, and to establish a modern smelter in the Santa Rita Valley. In a region which, in Pumpelly's own words, was "credited by Mexican tradition" to possess silver deposits of unthinkable wealth, his job was to make such rumors into reality.[65] As noted by William Wrightson, the general manager of the Santa Rita Mining and Milling Company, "it is one thing to have ore – however good it may be, and quite another thing to extract the silver out of it."[66]

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[64]Arizona Diary 1861, Box 1, Raphael and Eliza Shepard Pumpelly Papers, Part I, Huntington Library, San Marino [hereafter Pumpelly Papers I].

[6565]Raphael Pumpelly, *Across America and Asia: Notes of a Five Years Journey around the World, and of Residence in Arizona, Japan,[and China,* 2nd ed., revised (New York: Leypoldt and Holt, 1870), 15.

[66] [Santa Rita Silver Mining Co.], *Second Annual Report…* ,17.

Almost from the start, Pumpelly's attempts to institute modern mining methods in Arizona were plagued with difficulties. When he first headed to Arizona in 1860, the Santa Rita was already deeply in debt, acquired in part from the company's sponsorship of the *Weekly Arizonian.*[67] He was not impressed by the landscape or climate – this native of Owego, New York considered the locality of Tubac to be "a veritable hell."[68] Most problematic for Pumpelly, he realized shortly after his arrival that "the capital of our company was not proportionate to the results expected to be achieved."[69] In spite of his misgivings, Pumpelly spent considerable time mapping the Santa Rita's holdings, which he considered to be impressive and intrinsically rich. Indeed, Pumpelly traded on his time in Arizona later in his life, giving public lectures on the ores of Arizona and publishing a well-received memoir of his time at the Santa Rita, as well as a couple of short travelogues for publications such as *Putnam's* in the 1860s.[70] During the first weeks of Pumpelly's time in Arizona, he surveyed the company's property, visited neighboring mining sites, and experimented with various means of heating the company

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[67]*Weekly Arizonian* (Tubac, AT), 21 July 1859; [Santa Rita Silver Mining Co.], *Second Annual Report...,* 6.

[68][Santa Rita Silver Mining Co.], *Second Annual Report...,* 2.

[69]Ibid., 13, 12.

[70]Arizona Diary 1861, Box 1, Pumpelly Papers I; [Raphael Pumpelly], "A Mining Adventure in New Mexico: A Real Experience," *Putnam's Magazine* 4:22 (October 1869): 494-502.

furnace, which did not correspond to any furnace Pumpelly had previously encountered and for which he was the sole responsible party.[71]

Despite being one of the most credentialed young mining engineers in the United States at the time, Pumpelly was unable to raise the fortunes of the Santa Rita Mining and Milling Company. Unlike at the Heintzelman Mine, where the technical experts were simultaneously publicly lauded for their skill and privately blamed for the company's failure to turn a profit, the directors of the Santa Rita Mining and Milling Company expressed more primal fears about the problems facing their business, going so far as to tell their investors that the area surrounding Tubac was a “country which is worse than a frontier, which is, in reality, the heart of a wilderness, with laborers who speak a different language from our own.”[72] During his tenure in the borderlands, Pumpelly was by his own account preoccupied with his personal safety when he was not frustrated by the lack of resources at his disposal. He believed, possibly correctly, that the Santa Rita mine was the site of more Apache raids than any other place in the country, and considered the attempt to operate a modern mining company under those conditions to be almost criminally insane. Pumpelly’s existential concern became particularly acute about six months after his arrival when Mr. Grosvenor, Pumpelly’s friend and the superintendent at the Santa Rita mine, was killed less than a quarter mile from their shared quarters.

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[71] Pumpelly, *Across America and Asia*, 15.

[72][Santa Rita Silver Mining Company], *Second Annual Report...*, 6. This portion of the report was signed by the President of the Company, George Mendenhall, and was most likely from reports and letters written by Pumpelly, Charles Poston, and/or William Wrightson.

Neither Pumpelly nor the bookkeeper, also an American, knew if Grosvenor had been killed by Apaches in retaliation for an American raid on a local encampment the previous week, or by their Mexican employees, in retribution for the Santa Rita Mining and Milling Company's failure to make payroll. Following Grosvenor's death, Pumpelly abandoned any pretense of working as a mining engineer, and busied himself working as debt collector and accountant, attempting to extract the Santa Rita Mining and Milling Company from Arizona with as little financial loss as possible. He and his American colleagues moved to Tubac from the mine on June 15th 1861, and Pumpelly left Arizona a few months afterwards, in company with Charles Poston and a man Pumpelly described only as as a "known murderer" named Williams.[73]

Pumpelly's experience at the Santa Rita was slightly different from that of Ehrenberg or Küstel at the Heintzelman, yet it offers a similar lesson about the relative value of mining engineers in the borderlands during the 1850s and 1860s. John Denton Hall and others may have pointed to the need for capital and expertise in building a successful mine, but the stockholder companies near Tubac were also in desperate need of a more stable political climate and a cheap and safe means to transport their product to market. Pumpelly, for instance, was unable either to establish systematic extraction methods, or to process successfully any quantity of ore. Yet he nonetheless proved very useful to his employers, albeit in ways they could not have anticipated. For instance, after the death of Grosvenor, when it was clear that the company would not be able to

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[73]Pumpelly, *Across America and Asia,* 15-17, 19, 52-55; Arizona Diary 1861, Box 1, Pumpelly Papers I; Receipt April 1861, Folder Correspondence B-W, Box 2, Raphael and Eliza Shepard Pumpelly Papers, Part II, Huntington Library, San Marino.

continue operations, Pumpelly oversaw six weeks of smelting at the Santa Rita, during which period he and his largely Mexican workforce were surrounded, and occasionally shot at by a force of Apache warriors. After the smelting was complete, Pumpelly took it upon himself to personally separate the silver from the lead *planchas*, a process which took him approximately sixty hours of nonstop labor. Given that the workers at the Santa Rita had stayed with Pumpelly at risk of their own lives for several weeks, he could probably have trusted them to perform this final task. Given the strength of the ethnic hostility felt by white Americans towards Mexican men, however, Pumpelly's employers were undoubtedly thankful for what they would have considered his exemplary caution.[74]

Raphael Pumpelly's experience demonstrates that despite the need for technical men in the border region in the 1860s, noted by John Denton Hall among others, in the absence of military security or significant capital resources, mining engineers were at this time less valuable as experts.[75] Company directors clearly hoped that mining engineers would bring specialized knowledge into the region, elevating a mining prospect to the status of a worthy investment. The Santa Rita Mining and Milling Company, for instance, noted in its first annual report that, "the unexpected difficulties which have... surrounded the Sonora Exploring and Mining Company... have created some distrust in the success of mining in Arizona." They then noted that they sought the opinion of Frederick Brunckow of the Sonora Exploring and Mining Company, "a gentleman well known as an eminent

[74] Pumpelly, *Across America and Asia*, 26.

[75] Hall, *Travels and Adventures*, 150; "Mines and Mining," *Weekly Arizonian* (Tubac), 16 June 1859.

mining engineer" as to where they ought to sink their own mining shaft.[76] The implication is clear that whatever the troubles of the Sonora E&M Co., they were not caused by the inadequacies of its technical professionals. It is equally clear that being able to cite a "well-known" mining engineer was an important tool in raising investment capital.

In a certain sense, mining engineers during this time were most valuable to their employers as tools of the stock market, trotted out for the sake of investors, and cast aside, or blamed, when windfall profits failed to materialize. Raphael Pumpelly was hired in part to combat the distrust that eastern investors felt towards western mining ventures; although the company could afford to pay for his services as a surveyor and metallurgist, the Santa Rita company could not afford to implement Pumpelly's engineering plans, nor could they afford, on a more basic level, the necessary security to protect their property or employees from death and dismemberment. The engineers of the Sonora Exploring and Mining Company published many articles about the process of mining silver in the Santa Rita Mountains, and confidence in their abilities led one of the most important industrialists of the mid-nineteenth century, firearms manufacturer Samuel Colt, ultimately to purchase the mine. But the mine nonetheless failed to turn a profit, limited by a dearth of local infrastructure, and similar capital poverty as at the neighboring Santa Rita mine. Although company directors hoped that mining engineers would be able to solve the kinds of problems that plagued small-time operators such as Hall, profitably mining the U.S.-Mexico borderlands proved to be extremely difficult in the years prior to the U.S. Civil War, and impossible once hostilities broke out in the east.

[76] [Santa Rita Silver Mining Company], *Second Annual Report...*, 4.

That said, the experiences of these early mining engineers were not without value. Metallurgists such as Küstel gained experience working southwestern ores, and published widely read papers on their properties and attributes. Potential investors in San Francisco and New York heard stories about the great wealth of the ores mined at Alamos, Tubac, or Santa Teresa, and these stories primed the investment market in later decades. Patterns of behavior were established during these years to which generations of future mining engineers remained committed. Lured by the challenge of working difficult ores in far-away places, mining engineers such as Küstel, Ehrenberg, or Pumpelly headed into the borderlands, each hoping he would bring the necessary intelligence to work the ore, and trusting that his employers would be willing to invest the necessary capital to extract it. To this ambitiously noble pursuit of excellence in knowledge, mining engineers coupled the frisson of travel to an unknown (to them) and scantily mapped territory claimed and inhabited by people quite foreign to the lives of university-educated men from New York or Washington, D.C. As the profession of mine engineering grew and changed, the experiences of these early American mining engineers came to occupy a larger-than-life place within their profession as the ensuing generations of mining engineers took up the adventurous mantle of their forebears for themselves.

Chapter Two

Instituting Expertise in the Borderlands: Mining Education in the United States

Herman Ehrenberg, mining engineer for the Sonora Exploring and Mining Company, observed in 1859 that "the grand interest of the country being mining, this should be fostered by all means... [and] scientific and practical men, well acquainted with the manipulation and metallurgical treatment of ores, are indispensable."[77] This statement was not so much a compelling insight as it was a sober assessment of the realities of borderlands mining. Ehrenberg, along with the handful of other mining engineers who worked through the borderlands region in the 1850s and 1860s, was a German-trained engineer. As such, he was a member of a distinct minority. The majority of the miners, prospectors, and assorted speculators who traveled to the region from the eastern United States at the time were, at best, self-taught mining men. University-trained experts such as Ehrenberg were few and far between in the United States in general, and were particularly uncommon in the borderlands. Although the southwestern United States experienced a couple of booms, such as that of Tombstone, notable for their pure, easily extracted ore, much of the mineral ore in the borderlands was of a lower grade, and required significant processing before it could be conveyed to market. Because of this, mines that operated without good technical advice had little chance of success. Mine owners, investors, and operators were very aware of the need for technical workers, but in the 1850s and 1860s, the shortage of such people was noted

[77] [Herman Ehrenberg], "The Apache Treaty," Tubac (AZ) *Arizonian*, 2 June 1859.

even by members of Congress. Senator William Stewart of Nevada, for instance, noted that "the number of truly scientific and practical men who have been engaged in the examination and working of our mines is extremely limited."[78]

Between the 1860s and the 1890s, however, the number of university-educated mining engineers increased significantly in the United States. In concert with other white-collar workers, most notably doctors, lawyers, and civil and mechanical engineers, mining engineers shared in the late-nineteenth century drive for the standardization of professional expertise.[79] While fraternal and trade organizations played a role in the professionalization of mining engineering, they did not assume the "gatekeeper" role of groups such as the American Medical Association or the American Society of Civil Engineers. Rather, the development of a domestic system of dedicated mine-engineering education was of paramount importance in changing the professional role of mining engineers between the 1860s and 1900. In turn, the professionalization and growth of the field of mining engineering had a dramatic impact on the mining industry in the

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[78][William Stewart], "Speech of Hon. William M. Stewart, of Nevada, on The Bill to Establish a National School of Mines; delivered in the Senate of the United States, January 16, 1868" (Washington: F&J Rives and Geo. A. Bailey, 1868), 11.

[79]On the rise of a professional class in the United States see Alfred Chandler, *The Visible Hand: The Managerial Revolution in American Business,* (Cambridge: Belknap Press, 1977); David Noble, *America by Design: Science, Technology, and the Rise of Corporate Capitalism,* (New York: Knopf, 1977); and Robert H. Wiebe, *The Search For Order, 1877-1920,* (New York: Hill and Wang, 1967), especially chapter 5.

borderlands region, providing regional mining engineers with not only a growing network of professional colleagues to call upon for assistance, but also with tools for asserting their authority that were either not available to, or not useful for, engineers in Ehrenberg's generation.

Michel Foucault posited that knowledge and power work together to establish institutions which by their nature are oppressive, and therefore knowledge claims – technical, scientific, or otherwise – presupposed a attempt to assert authority over a social system.[80] To claim technical expertise, as mining engineers do, is therefore to claim the authority to override social, political, or economic considerations in the service of a higher cause – that of a supposedly objective technical truth. Yet in the establishment of professional mine engineering, the relationship between the claim of technical expertise and the assertion of authority was not always so straightforward. Some of the earliest mining engineers to work in the southwest and in northern Mexico found their academic credentials actively working against their ability to assert their authority. Later on, some discovered that a mining engineer's need for academic and technical credentials, although seemingly paramount, was actually secondary to his need to demonstrate hands-on, local knowledge as he established his plans as a technical advisor and manager on-site at the mine. This tension between professional credentialing and the necessity of demonstrating a strong practical knowledge of mining techniques and local circumstances became a driving force in structuring a U.S.- based system of mining engineering education between the 1860s and the early 1900s.

[80] Michel Foucault, *Discipline and Punish*: *The Birth of the Prison*, trans. Alan Sheridan (New York: Vintage, 1995), 208-210; 216-228.

<u>The Freiberg Network</u>

Most mining engineers who worked in North America in the 1860s and 1870s were trained in Germany, for the most part at the Königliche Sächsische Bergakademie (Royal Saxon Academy of Mines) in Freiberg, Germany, the foremost mining institution in Europe. Raphael Pumpelly, who worked for the Santa Rita Mining and Milling Company in Tubac; James D. Hague, a major investor in southwestern and Mexican hard-rock mines; Guido Küstel, metallurgist and mining engineer for the Sonora Exploring and Mining Company, also in Tubac; all three Janin brothers – Louis, who spent a few months in Tubac as Küstel's assistant, Henry, and their brother Alexis – and Rossiter Raymond, long-time editor of the *Engineering and Mining Journal*, were only the most important of the first generation of German-trained American engineers who spent a significant portion of their careers in the western United States and Mexico.[81] More often than not, graduates of Freiberg maintained life-long connections to each other, corresponding about both personal and professional matters. Such friendships ensured that mining engineers in the new territories of the western United States remained part of a small network of educated and unusually cosmopolitan men. This network helped men in obvious ways, by enabling an easy flow of information about work opportunities and new mining methods, while taxing the Freiberg graduates with a

[81]Clark Spence, *Mining Engineers in the American West: The Lace Boot Brigade,* (New Haven: Yale University Press, 1970), 25; and J. Ross Browne, *Adventures in the Apache Country: A Tour through Arizona and Sonora, with Notes on the Silver Regions of Nevada,* (New York: Harper & Brothers, 1871; repr., New York: Promontory Press, 1974), 217.

certain social responsibility toward one another. In the early 1880s, for example, a Freiberg graduate named Price took a job out west and was “broken down through softening of the brain or some other form of intellectual ruin.” Two of Price’s former classmates who cared for him through his breakdown took up a subscription among Freiberg alumni to send the unfortunate man back to his family in England. Louis Janin and James Hague, two successful Freiberg alumni from a previous generation, neither of whom was a particular friend of Price’s, together contributed more than a third of the expense of Price’s trip home.[82]

At Freiberg, students split their time between classroom and “practical” studies in the field, a unique approach in mining education before 1864. Graduates of the Academy began their careers knowing the latest metallurgical techniques and theories of ore genesis. As with any credentialing process, the network of working professionals to which Freiberg provided access was as important as the education obtained by students at the Freiberg Academy. A Freiberg education certainly bestowed several advantages besides the purely academic on a mining engineer wanting a career in North America. Ambitious officials at marginally profitable companies hired trained mining engineers, hoping that their academic backgrounds would enable them to turn a profit under exceedingly difficult conditions. As we have seen already, this strategy was not successful at borderlands mines in the 1850s and 1860s. Yet German-trained mining

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[82] James D. Hague to Mr. Booream, 20 February 1883, and James D. Hague to Henry Janin, 29 October 1883, folder L-10, James D. Hague Collection [hereafter JDH], Huntington Library, San Marino [hereafter HL]. This episode was fictionalized by Wallace Stegner in *Angle of Repose,* (Garden City: Doubleday, 1971).

engineers coninued to command high salaries in western mines. Their presence lent a veneer of respectability and authority to speculative ventures, which in turn indicated the socio-technical authority of their status as educated technical workers.[83] Not only was the supposedly esoteric expertise of a Freiberg-trained mining engineer valued by investors, but among educated Americans, German universities were considered to be the best in the world.[84] A young mining engineer who held a certificate or a degree from Freiberg was considered in certain circles to be the superior of an engineer trained at other European institutions, such as the Royal School of Mines in London, or the École des Mines in Paris. A Freiberg graduate wanting a career in North America was in the happy position of possessing a level of education that could soothe the anxious investor who wanted to be sure he was hiring the "best" mining engineer available, while also having the kind of practical education that would be useful in wrangling with mine workers out in the field.

Mining Engineers at the Frontier

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[83][Sonora Exploring and Mining Co.], "Fourth Annual Report," (New York: W. Minns and Co., 1860), 5, 14; [Santa Rita Silver Mining Co.], "2nd Annual Report," (Cincinnati: n.p., 1860), 10; and J.W. Ruggles to Board of Trustees, Guazapares Mining Co., 14 April 1865, BC 2071, Henry D. Bacon collection [hereafter HDB], HL.

[84]Roger Geiger, *To Advance Knowledge: The Growth of American Research Universities,* (New York: Oxford University Press, 1986); and Peter Meiksin and Chris Smith, introduction to Meiksin and Smith, eds., *Engineering Labor: Technical Workers in Comparative Perspective,* (London: Verso, 1996), 4.

Although "practically" trained mining engineers with German degrees such as Pumpelly and Küstel were hired on the basis of this coincidence between their training and credentials, they were not always greeted with open arms when they arrived at a mining site. Speculators, mine operators who fancied themselves (and sometimes were) very knowledgeable about mining processes and local conditions, and the apprentice-trained skilled workers who staffed midcentury mines were often very suspicious of the university-educated men brought in from outside to fix, upgrade, or re-organize a mine. Much of this suspicion stemmed from the inequities of class distinction: a Freiberg education was not easy or inexpensive to obtain, and possessing German training signaled a life of privilege available to few Americans at the time. In the mid-nineteenth century, only the children of the elite could afford to spend three or four years living in Europe to attend a mining school. Still fewer possessed the requisite language skills to study in Germany. Indeed, stories abound of Americans who cheated or got lucky on their language exams and then discovered they could not follow a technical lecture in German.[85] Despite the challenges inherent to attending university in Germany, prior to the 1890s, it was not uncommon for budding mine engineers to spend two or three years at an American university, such as Harvard or Yale, and then to "finish up" with a certificate from Freiberg. These early American mining engineers were almost

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[85]Spence, *Mining Engineers*, 27; and William Randolph Balch, *Mines, Miners, and Mining Interests of the United States in 1882,* (Philadelphia: Mining Industrial Publishing Bureau, 1882), 345.

exclusively the products of extremely privileged backgrounds.[86] Yet these mining engineers were in a sense independent operators without the full support of a professional class. They lacked institutional support within the mining industry, or automatic recognition of their education from their colleagues. Each engineer had to negotiate his status onsite, by demonstrating either his worth or an appropriate humility before the local knowledge of others at the mine.

The social privilege of mining engineers was thus a double-edged sword in the southwestern borderlands, where technical knowledge was measured not by degrees or by scientific authority but by the ability of an engineer to build profits for his employer. Although many people doubtless agreed with Senator William Stewart of Nevada that "an education at Freiberg is a guarantee not only to position and influence, but to the regard and confidence of the humblest miner," investors and managers also frequently complained through the 1860s of the lack of technical skills possessed by their university-trained mining engineers.[87] Capt. J.W. Ruggles, for instance, mine manager at the Guazapares Mine in Chihuahua, fired his engineer due to that engineer's "dead, flat failure" to make the mine profitable. The engineer in question acknowledged that he

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[86]Spence, *Mining Engineers*, 25; and John Hays Hammond, *The Autobiography of John Hays Hammond*, vol. 1, (New York: Farrar & Rinehart, 1935), 66.

[87][Stewart], "Speech," 11. For typical complaints re: untalented engineers and managers, see folders BC 2071, BC 2035, BC 1974, HDB; and Robert Jarvis to Samuel Colt, 26 May 1859, folder C-47, box 19, Jarvis Robinson family papers (addition), Beineke Rare Book and Manuscript Library, Yale University, New Haven.

"might have been roasting his ores too long; or that he might have been using too little salt." Neighboring mine operators and American agents in Chihuahua, meanwhile, agreed that the engineer "was not sufficiently acquainted with [the variety of ore at the mine]... by which means he ruined the whole concern," but they cast no aspersions on the engineer's general technical competence.[88] Ruggles, however, insisted he would have none of "this or that, or the other trifling excuse in extenuation of what appears to me [the engineer's] ignorance of the business."[89] Rather, it was in Ruggles' interest to place the blame for the failures at Guazapares on the shoulders of the mining engineer, rather than on external forces, or on himself for hiring a man who was not acquainted with the local ores. In this instance, all observers, including the engineer himself, agreed that the engineer lacked practical knowledge that would help at the mine, but the vehemence of Ruggles' attack on his engineer underscores a problem that vexed mining engineers, particularly in the early days when there were very few in the region. Even if this engineer had roasted and treated the Guazapares ores properly, that alone was no guarantee that the company would turn a profit. Absent a profitable balance sheet, how could a mining engineer prove his value?

In practice, possessing a German mining degree did not immediately endear a mining engineer to his local contacts in Arizona or Sonora, a circumstance which

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[88]J.W. Ruggles to Pres, Sec'y Board of Trustees Guazapares Mining Co., 14 April 1865, BC 2071, HDB, HL; William Jennings to John Heard, 23 May 1865, BC 2036, HDB.

[89]J.W. Ruggles to Board of Trustees, Guazapares Mining Co., 14 April 1865, BC 2071, HDB, HL.

compounded the difficulties faced by engineers attempting to prove themselves in the field. As a young engineer, for instance, John Hays Hammond, a mining graduate of both Sheffield Scientific School and Freiberg, was told outright by an acquaintance that he could not have a letter of recommendation since "engineers educated in the theory of mining had not been successful" in southwestern mining projects. Hammond, who later became one of the wealthiest and most influential mining engineers in the United States, learned from his mistake. He obtained his first mining position, as an assayer for George Hearst, by, he claimed, foreswearing the value of his engineering education altogether.[90] Hammond may have played down his education on Hearst's account, but although Hearst may have publicly proclaimed his mistrust of mining engineers, he owed the long-term success of his mines on the Comstock and in Deadwood to the innovations of mining engineers, including those of Freiberg-educated Guido Küstel and both Louis and Henry Janin.[91]

The value of a university degree in the eyes of working miners was also undermined by the strength of the apprenticeship system which thrived under the large population of Cornish immigrants who dominated the workforce in mid-century western and Mexican mines. These miners traditionally worked in teams that bid on contracts for labor, rather than by negotiating a daily or monthly wage. Men advanced in pay grade and responsibility with seniority; under the Cornish system, a manager was always a

[90]Hammond, *Autobiography*, 83-85.

[91] A.D. Hodges, "Amalgamation at the Comstock Lode, Nevada," *Transactions AIME* XIX (1890); *Mining and Scientific Press* (21 May 1910).

miner who had worked up through the ranks, rather than a college-trained engineer.[92] The social value of a college degree was not worth as much as local knowledge acquired in the field at a mining camp.

The growth of an American educational system

Given the shortage of substantive technical and managerial competence in the borderlands, the difficulty of acquiring an education at Freiberg, and the suspicion with which that education was greeted, a movement grew after the U.S. Civil War to establish a national mining institution in the United States. Editorials in such disparate papers as the *Arizona Miner* and the *San Francisco Bulletin* argued forcefully that it was in the national interest of the United States to establish an American school of mines on the model of Freiberg or the Royal School of Mines in London.[93] In 1868 Senator Stewart of Nevada went so far as to introduce a bill in Congress to establish a National School of Mines, to be located close to the major hard-rock mining regions of Colorado, Arizona, and Nevada. The arguments in favor of an American school of mines included the nationalistic assertion that "we send our young men to the schools... in Europe, to learn

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[92]Spence, *Mining Engineers,* chapter 3, passim. Larry Lankton, *Cradle to Grave: Life, Work, and Death at the Lake Superior Copper Mines,* (New York: Oxford University Press, 1991), 58, 60-61, 65.

[93]Prescott (AZ) *Arizona Miner*, "The Proposed Mining College," 14 March 1866; and "Opinions of the Press and of Eminent Public Men on the Importance of our Mineral Resources and the Advantages to be Derived from the Establishment of a National School of Mines," (Washington, D.C., Wm. H. Moore, 1868), 12.

that which they could much better learn at home, if we had institutions equally thorough and comprehensive." The observation that "the production of ore has decreased, as the amount of waste generated by mining has increased," and that the industry ought to focus on producing profits from low-grade ore were also cited as evidence for the critical need for a national school of mines.[94] Two common objections raised to Stewart's proposal included a fear that establishing a Board of Mining to oversee technical standards would suffocate individual entrepreneurial investment, and the belief that taxpayers should not support the mining industry, since individuals, not the community, benefitted from the industry.[95] The bill was withdrawn before the Senate could vote on it, but not before Stewart could give an impassioned defense of the mining industry and mineral wealth of North America, insisting that American-trained-Americans could do better mining work than could men trained at "the great school at Freiberg."[96]

Lawrence and Sheffield

In the absence of an American School of Mines, the domestic options for training engineers were really limited in the 1850s and 1860s, which is one reason Stewart's proposal generated so much attention in mining districts despite its lack of traction in the

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[94]"Considerations in Reference to the Establishment of a National School of Mines as a Means of Increasing the Product of Gold and Silver Bullion," (Washington: Intelligencer Printing House, 1867), 5; "Opinions of the Press...", 4; and [Stewart], "Speech," passim.

[95]Prescott (AZ) *Arizona Miner*, "The Proposed Mining College," 24 March 1866; [Stewart], "Speech," passim.; and "Opinions of the Press...", passim.

[96] Wm. Stewart, *Congressional Globe,* 556-561; January 16, 1868, 40th Congress.

Senate. Prior to the Civil War, there were only a few institutions in the United States that trained engineers or provided a technical or scientific education. Rensselaer Polytechnic Institute, founded in 1823, and the Polytechnic Institute of Pennsylvania, founded in 1857, both trained civil engineers, but neither produced a significant number of graduates who worked in the mining industry.[97] Other schools that eventually had significant mining programs, such as the California School of Mines at Berkeley and the Massachusetts Institute of Technology, had very few mining graduates before the twentieth century. The domestic schools that provided the greatest number of mining graduates during these early decades were the privately-operated Lawrence Scientific School in Cambridge, Massachusetts, and the Sheffield Scientific School in New Haven, Connecticut. Of these schools, Sheffield eventually became the more prominent training ground for mining men, while Lawrence eliminated its mining program in 1879—but during the 1850s and 1860s they were more similar than they were different.[98] Not only were the programs of study similar, but mining students at each had similar experiences, as students and faculty alike wrestled with being affiliated with the least prestigious of the scientific fields: mining.

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[97]Noble, *America By Design*, 22; Spence, *Mining Engineers*, 37.

[98] In the early 20th century, Lawrence and Sheffield were both absorbed by their neighboring institutions of, respectively, Harvard University and Yale University. Samuel Eliot Morison, *The Tercentennial History of Harvard College and University, 1636-1936 v.1, The Development of Harvard University Since the inauguration of President Eliot 1869-1929,* (Cambridge: Harvard University Press, 1930), 415.

From the outset, both Sheffield, established in the early 1850s, and Lawrence, established half a decade earlier, granted degrees in civil and mechanical engineering. Dedicated mining programs were established a few years later, although it is noteworthy that in the mid-19th century the mining program did not differ significantly from the other courses in engineering. To modern eyes, all of these courses were astonishingly broad-based, with students taking more classes in fields such as botany, languages, rhetoric, and history than in mathematics or topography and mapping. Despite the similarity in the programs, most Sheff or Lawrence graduates who worked in the mining industry in the 1850s and 1860s studied geology or chemistry as undergraduates. Whether this was because the field of mine engineering was not particularly well established, or because the mining curriculum was looked down upon by other students is unclear.

While the mining students at these scientific academies were thought to be pursuing the least scholastic of the fields of study, all students at both Lawrence and Sheffield were considered the academic inferiors of their neighbors at Harvard and Yale. In later years, many students who enrolled in Lawrence after a couple of years at Harvard College had weak academic records, and mining students were among the weakest of them all, suggesting that in the early years of dedicated mining education the brightest students interested in the industry chose not to study mining because it was seen by their scientific peers to be an inferior academic pursuit.[99] In some ways, such evident disdain for the mining curriculum probably served graduates of Lawrence quite well in the field; if U.S.-educated educated mining engineers were greeted with suspicion by mine

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[99]Records of Students in the Lawrence Scientific School, 1888-1911, Harvard University Archives, Cambridge, Massachussetts.

managers and workers, it could be that it helped an engineer establish his technical authority to be able to claim the credential as a geologist rather than as a mining engineer. Regardless, the principle difference between the curriculum at Lawrence and the curriculum at Freiberg remained the absence of a "practical" mining component in the U.S. schools.

In New Haven, faculty and students alike devoted more time to asserting the importance of dedicated training for engineers than did their peers at Lawrence. Eventually such effort resulted in Sheffield becoming a top engineering institution while the prestige of Lawrence flagged among those in the mining business. But initially demanding respect was an uphill battle, for faculty and students alike. Entrance examinations were instituted as early as 1861, with mixed results. As one historian of Yale University explained, the entrance exams were useful as they

> dissipated the danger that this school [Sheffield] would become a refuge for a certain class of students whose presence, while it added to the number of those receiving instruction, diminished the effective working of the instruction given.

The trouble was that attempting to keep weak students out of Sheffield meant that the school lost revenue, and so the faculty also made provisions for admitting numerous "special" students who failed to pass the entrance exams. The result was that many students "who cared for only a nominal connection with the college in order to save themselves from being held responsible for their vigorous way of doing nothing at all" were admitted to the school in spite of the relatively hard entrance exams. Sheffield courses thus had a very high attrition rate, and when students from Yale College across the street mocked "Sheff" students for being lackadaisical intellects who drank too much and were generally so dissolute they were "past praying for," students at Sheff knew there was some truth to the characterization.[100] The combination of academic and social stigma experienced by Sheffield undergrads during the nineteenth century may have caused many of them to be reflexively defensive about their choice of (or need for) a career in mining. It almost certainly prepared them to foreswear their academic credentials in the manner of Sheffield alumnus John Hays Hammond.

The Morrill Land Grant

Proponents of an American-based system of engineering education hoped that by broadening the educational options for prospective mining engineers beyond the rarified bastions of Cambridge and New Haven, the passage of the Morrill Land-Grant Act in 1862 would revolutionize the domestic mining industry. The Morrill Act granted states a certain acreage of land to sell; the size of the land-grant was determined from the 1860 census. Proceeds from the sale of this land were designated to endow public "land-grant" universities devoted to teaching the principles of agriculture and the "mechanic arts." The phrase "mechanic arts" was not clearly defined in the legislation, however, and most of the funds thus raised established institutions with relatively large agricultural programs and comparatively small faculties for engineering and the applied sciences. In a small number of cases, however, the Morrill Act did indeed advance the cause of engineering

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[100] Loomis Havermayer, *Sheff Days and Ways: Undergraduate Activities in the Sheffield Scientific School, Yale University, 1847-1945*.

education.[101] Schools established by funds from the Morrill Act included the Massachusetts Institute of Technology and the Missouri School of Mines at Rolla, both of which eventually trained large numbers of mining engineers. The Morrill Act had some odd and unintended consequences, however. For instance, rather than establishing an agricultural college, legislators in Connecticut diverted the semi-annual interest payments of the Morrill Act into the operating fund of the otherwise privately-funded Sheffield Scientific School, and the mining curriculum was a significant piece of their argument that this was an appropriate use of funds.[102]

In the early years, the land-grant system was somewhat ad hoc. Many institutions only employed one or two engineering instructors, and the courses offered were contingent upon the knowledge of those instructors. Yet over time, the land-grant colleges developed what one historian of engineering education has called a "land-grant style." This "style" resonated with the particular job requirements for mining engineers very well, with an emphasis on the relationship between practical and theoretical knowledge, and with a significant proportion of class time devoted to field or laboratory

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[101]James Gregory McGivern, *The First Hundred Years of Engineering Education in the United States (1807-1907),* (Spokane: Gonzaga University Press, 1960), 93.

[102] Lounsbury, "Sheffield Scientific," 7-9; 20. The actions of the CT legislature were inspired by the example of New York State, which used its (much more substantial) land-grant money as a matching grant to persuade Ezra Cornell to establish Cornell University.

work.[103] Although the Morrill Act did not do for engineering education what proponents of a national mining academy hoped – it did not create a network of mining colleges – it did provide funding for a style of education that was closer to the education of Freiberg-trained engineers than to the theoretical miners who came out of other European institutions or from Lawrence or Sheffield in the 1850s and 1860s. The land-grant colleges, by providing a public source of funding for training engineers, contributed to the overwhelming emphasis on *practice* that came to dominate American engineering education by the end of the nineteenth century.

Of more immediate importance to the mining industry, however, the Morrill Act dramatically and immediately increased the number of institutions providing engineering education in the U.S. In 1860, there were seven engineering colleges in the United States. By 1872, there were seventy.[104] Fewer than three hundred men received engineering degrees in the U.S. during the two decades preceding the Civil War. Over the next ten years, that number quadrupled. Ten percent of those new engineering graduates – approximately 120 men over the course of a decade – were mining engineers

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[103] Bruce Seely, "Reinventing the Wheel: The Continuous Development of Engineering Education in the Twentieth Century," in Alan Marcus, ed., *Engineering in a Land-Grant Context: The Past, Present, and Future of an Idea,* (West Lafayette: Purdue University Press, 2005), 164-165).

[104]McGivern, *The First Hundred Years*, 88.

with specialized degrees.[105] Despite the relatively small number of men who possessed mining degrees in the 1870s and early 1880s, as engineering education became progressively more available, investors and financiers began to expect that anyone who called himself a mining engineer would have a college degree. In the long run, these American engineering colleges changed the demographics of the profession of mine engineering. By the turn of the century, more than ten thousand students were enrolled in engineering colleges, and while the private institutions remained the most prestigious schools for mining, the preponderance of "land-grant" colleges made it possible for many more men to take at least *some* college courses, and, indeed, the vast majority of mining graduates in 1900 came from the land-grant system. [106]

The Columbia School of Mines

Over the long-term the establishment of the Morrill Act revolutionized the engineering profession within the United States, but in the short-term, the most significant challenge to the dominance of Freiberg alumni in the nineteenth century

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[105]Ibid., 73-74, 90. The numbers of pre-Civil War engineers are based on the graduation statistics from the earliest engineering colleges in the U.S.: Rensselaer Polytechnic Institute; University of Michigan, Dartmouth College; Sheffield Scientific School; Lawrence Scientific School; and Union College. No women received degrees in mine engineering in the 1860s.

[106]Edwin Layton, *The Revolt of the Engineers: Social Responsibility and the American Engineering Profession*, (Cleveland: Case Western, 1971), 4; Bruce Seely, "Reinventing the Wheel,"163.

mining industry was the opening of another private mining institute in 1864, the Columbia School of Mines in New York City. While all courses on mine engineering offered extensive classes in geology, chemistry, and surveying, in addition to the usual engineering requirements of algebra, trigonometry, calculus, physics, and German, the feature that made Columbia stand out with respect to other technical schools in the United States was the Summer School of Practical Mining.[107] This program differed from the practically-oriented "land-grant system" of education in that the practicum was the central curricular feature, around which all other aspects of the mining curriculum at Columbia were based. Consciously modeled on the practical curriculum at Freiberg, the School of Mines required all third-year mining students to spend the summer as apprentices in a working mine, mostly in the copper mines at Lake Superior, Michigan.[108] Neither Lawrence nor Sheffield offered a comparable "hands-on" experience. Some of Columbia's early success undoubtedly stemmed from the belief, common in the North American mining community, that "our schools are not practical enough, [and] that practical miners do not find the graduates capable of doing what they profess."[109] Columbia had strict entrance requirements, and also provided relatively good opportunities for scholarship students, making it a top choice for upwardly mobile prospective engineers. The relative success of Columbia in usurping the dominant position of the European academies, principally Freiberg, as the premier institution for

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[107]Balch, *Mines*, 271-343.

[108]Balch, *Mines*, 297.

[109]Ibid., 344.

budding mining engineers also owes a debt more generally to the direction of American scientific study in the late nineteenth century. Historians of science have puzzled over the predominance in U.S. science of experimental and observational scientists over theoretical and mathematic thinkers prior to 1900, a situation that seems to point to the relative backwardness of American science.[110] Mining, a field of study that privileges fieldwork and the application of theoretical knowledge for immediate and concrete financial gain, was perfectly positioned to take advantage of this perceived weakness in the American model.

The Columbia summer school was designed explicitly to bring the social and the technical aspects of mine engineering together, to give the university students the practical experience that would legitimize them in the eyes of grizzled old miners. In practice, it served to underscore the class distinction between mining engineers and working miners, but also to give the engineering students the tools they would need to negotiate their status on-site at a mining camp. Growing up in Toledo, Ohio, William Field Staunton was so impressed by his neighbor's son, a mining engineer named John A. Church who worked at the time in Tombstone, Arizona, that he decided to follow in Church's footsteps to the Columbia School of Mines.[111] Staunton, who eventually

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[110] John W. Servos, "Mathematics and the Physical Sciences in America, 1880-1930," *Isis* 77:4 (December 1986): 611-613.

[111] William Field Staunton, "Memoirs of William Field Staunton: The First Fifty Years, 1860-1910," p.21, box 1, William Field Staunton papers, AZ 152 [hereafter WFS], University of Arizona Library Special Collections, Tucson, Arizona [hereafter UASC].

became the president of the Congress Mine, one of the largest gold mines in Arizona, recalled to the end of his life the social stigma he felt as a student in New York. Although the son of a successful railroad engineer, as a student he judged himself a cash-strapped and unsophisticated midwesterner compared to his classmates. Staunton's term of enrollment in the Summer School of Practical Mining, however, demonstrates the impact that a Columbia education had on the relationship between even a middle-class Midwestern boy and the "practical" miners whom he would direct throughout his career. In the summer of 1881, Staunton's Columbia class worked at a copper and iron mine in the Keweenaw Peninsula in Michigan. When he first arrived, Staunton made an error typical of first-time miners, and forgot to extinguish the candle in his hat before it guttered. As the candle flickered out, it melted the resin that attached it to the front of his cap, and the wax, resin, and end of the wick all stuck to Staunton's forehead. His friends had to shave his hair off to remove the mess, leaving a readily recognizable symbol of Staunton's inexperience for all to see.[112] A rube in New York, Staunton also found himself to be a tenderfoot underground, although he was able to parlay that early naïvete into a story that showed him to be capable of modesty and able to play by the rules of the underground workers.

Staunton's troubles at the summer school did not end with a shaved head. Later in the summer, more comfortable with life underground, he heard that some of the miners preferred to leave the mine by climbing directly up an 800-foot ladder, rather than by walking out through the tunnel. Staunton reasoned that this shorter climb would be a faster, and therefore better, way to exit the tunnel, and followed a group of miners up the

[112]Staunton, "Memoirs," p.25, box 1, WFS, UASC.

ladder towards the surface. Unaccustomed to such physical labor, Staunton soon exhausted himself, and, losing sight of the miners he followed, clambered hand over hand in the pitch dark after his candle burned out. He recalled:

> At last... I saw a faint glimmer, like a fire-fly, seemingly miles below me in the shaft. The light grew, and then I could hear the steps of men on the ladders coming up. On few occasions in my life have I felt a more joyful sense of relief. They found me, perched like a squirrel, at the top of a ladder which had projected farther past one of the landings than the others, and which I had passed in the dark. The miners seemed to find the situation hugely amusing, a feeling I did not share at the moment.[113]

The absurdity of Staunton's situation is apparent. The underground workers clearly understood that the young "college boys" would one day be the supervisors and managers of works just like their own. What a pleasure to find a young engineer-in-training perched "like a squirrel" on a ladder, unable either to keep his candle lit or to find the mine exit without recourse to the miner's local knowledge.

Staunton also gained significantly from telling this story. His rookie mistakes were a shorthand for explaining that he had already made mistakes in underground mining, and was unlikely to make those mistakes again. He could therefore approach the field as an experienced hand rather than as a green college boy. The *Engineering and Mining Journal* once explained that "'the principal advantage gained by this manual work [in the Columbia Summer School] was the braking [sic] of the ice between the student and the miner, placing them in pleasant relations and on common ground, the student for

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[113]Ibid., 27.

the time becoming, to all intents and purposes, the miner's 'butty,' and to be treated and instructed as such."[114]

Although it seems unlikely that the class divide between the principally foreign-born, apprentice-trained miners and the predominantly east coast, university-educated mining engineers could really be bridged, Staunton's stories indicate that he really *was* treated as a miner's "butty," and that he called on this experience to legitimize his authority for the rest of his career. Columbia graduates thus began their careers with a real advantage over their other colleagues: while a graduate of Sheffield, for instance, would have to find a way to work underground for a couple of summers to gain Staunton's experience – a project few, if any, Sheff men undertook on their own – a graduate of Columbia was understood by his peers and potential employers to have a worker's insight into underground work. Columbia graduates themselves began their professional careers with a visceral notion of how tenuous their claims to authority would be underground. Although even a young engineer might have plenty of theoretical knowledge of how to mine and what to mine, he would still have to negotiate with the miners to make the work happen.

Even Columbia's famous practicum was not actually the same as an apprenticeship experience. Many people in the industry — engineers and owners alike — felt that there was simply no substitute for extensive underground experience, and this inexperience was shorthand in the industry for criticizing engineering work as sloppy or poorly conceived. An anonymous engineer's report on the Santa Elena mining property

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[114]*Engineering and Mining Journal* 30 no. 9 (11 August 1877), cited in Balch, *Mines*, 297.

in Sonora, for instance, lamented the work done by Eben Olcott, who was employed to manage the property in 1881 shortly after he graduated from Columbia. "Olcott carried out [his work] in a most elaborate and costly manner" the report stated. "Properly speaking, [Olcott produced] no cut, it was simply an enormous out-crop of quartz that was carried out." In other words, Olcott failed to engineer the mine; rather, he grabbed a chunk of surface rock and called it mining. Even more egregious, by the account of the report's author, Olcott chose the wrong process for milling ore extracted by a previous manager and allegedly lost 60% of the ore's value.[115] This failure, the report's author implied, was a direct result of Olcott's lack of practical knowledge of mining, and his reliance on book-learning over common-sense. If Olcott did indeed commit these errors (and there is no way to verify the claim either way), they were costly mistakes, both in terms of revenue lost to the mine owners, and, presumably, in labor expended to remedy the mistakes. Olcott went on to have a remarkably successful career, as a partner in a highly successful mining consulting firm based out of New York and a well-known expert on southwestern, Mexican, and Latin American mining projects, serving at one point as the president of the American Institute of Mining Engineers. This professional success stemmed in no small measure from the combination of Olcott's well-respected Columbia degree, and to the many mining projects in Mexico he managed as a young man, including the Santa Elena.[116] Yet as a young engineer, the Columbia degree could

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[115]"The Santa Elena Gold Mine," 5 November 1894, folder P-117, JDH, HL.

[116]Eben E. Olcott to Arthur Macy, 2 December 1885, BV Olcott, New-York Historical Society; Eben E. Olcott to John Brooks, 19 November 1885; BV Olcott, N-YHS;

not fully overcome the suspicion on the part of other engineers that every questionable decision Olcott made was the result of an over-reliance on theoretical "knowledge" of mining over practical experience. Olcott's situation points to a curious aspect of the Columbia model of field education. Although it was instituted to further the *mining* knowledge of students, the summer school was actually most effective in alerting young mining engineers to the fact that they would have to negotiate their status at the mine — that it would not be self-evident to the workers that a mining degree makes a man an engineer.

Overall, however, the success of the Columbia system was apparent to people in the industry, and by 1880 other institutions followed suit. The Massachusetts Institute of Technology, for instance, installed a "mining lab" on its campus in Cambridge, and the California School of Mines instituted a requirement that mining students use their summer vacations to visit area mines and metallurgical works. Until the late 1890s,

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"Report on Certain Claims near Alamos, Sonora," 2 January 1907, Olcott, Corning and Peele, No. 3, BV Olcott, N-YHS.

however, more engineering graduates of Columbia worked in the mining industry and in the related field of metallurgy than did graduates of any other American university.[117]

Impact of Educational Changes on the Profession

One of the most noteworthy features of the history of engineering education in the U.S. in general, and of mine engineering education in particular, is its evolution from a broad-based classical education with a heavy emphasis on languages and mathematics into a specialized course of study in physics and chemistry. In the early 1870s, every student at Sheffield, for instance, took a three-year course in either mechanical or civil engineering; those students who wished for a degree in mining took a fourth year of metallurgy. Regardless of major, each student was required to study two full years of both German and French, as well as three years of drawing, geometry, physics, differential and integral calculus, and some courses in botany, English composition, and geography, as well as specialized courses in mechanics and stone cutting (for civil engineers), and steam engines (for mechanical engineers). All students were also required to study several semesters of elocution, although some faculty believed this

[117]Balch, *Mines*, 283, 307, 310, 318, 342-43; Spence, *Mining Engineers*, 40. A survey of graduates of the Columbia School of Mines, conducted over the winter of 1881-1882, found that nearly seventy-seven percent of Columbia's graduates were employed in the mining industry in some capacity: as engineers, metallurgists, or assayers. *School of Mines Quarterly* 3, no. 3 (March 1882): 242. The California School of Mines at Berkeley assumed a dominant position in U.S. mine- engineering education after 1900.

should be an optional requirement.[118] Sheffield actually eliminated many of the language requirements in the 1880s, a move that in retrospect made the curriculum at "Sheff" more modern than that at other private scientific institutions. By the 1890s the faculty was again concerned that the entrance requirements for Sheffield were too low and began to demand that students read either French or German upon entrance, as well as Latin well enough to read Caesar in the original.[119] By 1901, the stricter entrance requirements remained in place, but almost all of the "frills" in earlier Sheffield course requirements had been eliminated for mining engineers, including botany and elocution, and replaced by the more professionally relevant study of thermodynamics, mineralogy, crystallography, hydraulics, chemistry, and machine design. While calculus remained in the curriculum, geometry, algebra, and trigonometry were relegated to the entrance requirements and advanced study of these fields was no longer mandated. These changes were intended "to enable the men to have a course leading to more practical results in their professional work." By 1906, Sheffield had instituted an optional course in Spanish,

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[118] "Programme of the Sheffield Scientific School of Yale College for the College Year 1873-1874," (New Haven: Tuttle and Morehouse, 1873); [Governing Board Minutes] 12 January 1874, folder 55, box 6, Sheffield Scientific School, Yale University, Records (RU 819), Manuscripts and Archives, Yale University Library, New Haven, Connecticut. [hereafter RU 819].

[119] "Programmed of the Sheffield Scientific School of Yale College for the College Year 1880-81," (New Haven: Tuttle, Morehouse and Taylor, 1881); Governing Board Minutes, May 9, 1892 and May 30, 1892, folder 55, box 6, RU 819.

a far more useful language than French or German for the many Sheffield graduates who worked at mine sites in the southwestern United States and throughout Latin America.[120]

To some degree, this shift in educational focus is reflective of changing mining methods. Nonselective mining methods of the twentieth century were heavily dependent on engineers' understanding the chemical attributes of an ore; the physical manifestation of an ore-body was of secondary importance, as the quantity of rock removed from the ground was so great. The great changes in the coursework of prospective mining engineers, however, also serve to underscore the ways in which the working role of mining engineers changed through the first decades of the profession. In the 1850s and 1860s, mining engineers were classically trained advisors, whose knowledge of geology and chemistry was far superior to that of most practically-trained miners. A half century later, mine engineering education had changed such that they could more readily serve as critical technical experts, advisors and managers.

By 1900, mine engineering professionals were wholly invested in the American university system, while remaining committed, in principle if not in practice, to the idea that a "practical," or apprenticeship-centered, education was in some sense superior to a "theoretical," or university-centered, education. As engineer George Packard expressed in a letter to the editor of the *Mining and Scientific Press* in 1907, "there has never been such a demand for the college graduate as there is today." Indeed, Packard continued, it

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[120] Governing Board Minutes, March 11, 1901, May 22, 1905, and February 5, 1906, all folder 56, box 6, RU 819.

"unfortunately is not necessary for the present graduate 'to start at the bottom.' It would be much better for him if it were."[121]

In 1907 Packard was nearing the end of his career, but the ambivalence he expressed concerning the replacement of practical mine work with college credit was not simply generational. Rather, mining engineers as a group persistently expressed discomfort with the perception that they were among the elite, and noted with concern that the best place to learn mine engineering was not in the classroom, but underground.[122] As late as the 1930s, the alumni bulletin for the Colorado School of Mines ran an article discussing the concern of School of Mines graduates that they would be accused of "looking for a 'white-collar job'" because they were "afraid to soil [their] hands in manual labor."[123] The publication naturally concluded that "no one can accuse the young alumni of the Colorado School of Mines of such an attitude," yet the fact that this fear could be stated so baldly is an indication of how troubling the profession continued to find the idea that a university-trained engineer was less "practical" than a working stiff down in the mine.

The introduction of a widespread technical education for mining engineers did more than create a more uniform class of mining professionals; it also effected a mining

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[121]George Packard, "Mining Schools and Their Graduates," *Mining and Scientific Press* 95 (10 August 1907): 173-174.

[122]*Engineering and Mining Journal* 36, no. 10 (8 September 1883): 142.

[123]"Not Afraid of Work," *Colorado School of Mines Magazine* 21, no.11 (November 1931): 8.

engineer's advancement throughout his career. As it became easier to get a technical education, career prospects dwindled for men who lacked university certification. Halfway through 1913, the *Bulletin* of the American Institute of Mining Engineers began to publish the work histories of men nominated for membership. While these listings include only a small sample of mining professionals, the individuals listed were among the most professionally active, and can be taken to be indicative of the demographics of the profession as a whole. The vast majority of the nominees attended engineering institutes, and held graduate (E.M.) and/or undergraduate degrees in mining. Only a handful of the nominees had not attended university; of these, most were between the ages of 35 and 55, with two or three decades of experience as superintendents or overseers before being nominated for membership in AIME.[124] Through the 1870s or 1880s, a man who was known to have good "practical" skills could readily find employment as an expert, and the ages of the men nominated in 1913 indicates that they probably began working in mining in the late 1880s or early 1890s. The nominees with college degrees were significantly younger, most under thirty with no more than eight years work experience; more often, these young men were working at only their second or third professional position, and had been out of college for fewer than four years.

By the twentieth century, possession of a mining degree was presumed to be the decisive factor in hiring decisions, even when hiring managers declared education (or the lack thereof) to be irrelevant. In 1902, for instance, Courtenay DeKalb, a Columbia-trained mining engineer in charge of operations at the Fernando Mining Company, was

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[124] "Candidates for Membership," *Bulletin American Institute of Mining Engineers*, No. 78-81 (June-September 1913).

pressured by the owner of the company, Colonel Livermore, to hire his son, Tom. When DeKalb expressed his reluctance to take Tom on as assistant engineer, the Colonel assumed that DeKalb's reluctance stemmed from the fact that young Livermore "ha[d] not received a technical training in the schools." DeKalb objected to this characterization, and protested that he did not care whether Tom had a college degree or not. The Colonel continued to demand that DeKalb nonetheless hire his son; DeKalb continued to refuse, asserting that Tom was unreliable and knew nothing about geology. Had Tom Livermore completed coursework in mining, he would have studied geology, thus mitigating at least one of DeKalb's reservations. Had Tom completed a college degree, he might also have demonstrated some reliability, or at the very least the ability to complete a task once he began it. Despite DeKalb's protestations that he did really not care whether Tom Livermore had a college degree or not, Col. Livermore was clearly correct to think that his son's lack of a degree materially damaged his professional chances.[125]

In less than a generation, in concert with the opening up of the educational landscape for mining engineers, and the increasing specialization of mine engineering coursework, the employment field for mining engineers changed dramatically. By the 1890s, engineers who themselves graduated from college in the late 1870s or the early 1880s, barely a decade after the Columbia School of Mines was established, were already

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[125]Colonel Livermore to Courtenay DeKalb, 16 September 1902; Courtenay DeKalb to Tom Livermore, 19 October 1902; Tom Livermore to Courtenay DeKalb, 10 November 1902, all folder 92, box 9, Courtenay DeKalb Papers, MS 1176, Arizona Historical Society.

making excuses to their superiors on behalf of informally-trained co-workers whom they wanted to promote. When William Field Staunton resigned from his position as superintendent of a group of mines in Tombstone, Arizona, he recommended a man without a university background, Bert Macia, whom he described as "a very good practical man," as his successor.[126] Sounding both defensive and paternalistic, Staunton explained to his superiors that "[Macia] has the advantage of being a practical miner and the promotion would undoubtedly stimulate him to do his best." Furthermore, Staunton asserted, "I believe in promotion from the ranks where the man has good stuff in him even though some of the embellishments may be absent."[127]

What Staunton coyly referred to as "embellishments," were nothing of the sort. Rather, he was indicating to his superiors that he understood that a person who did the work of a mining engineer – which, in 1908 when Staunton resigned from Tombstone, included supervisory positions such as the one he was leaving – ought to possess a degree from an engineering institution. By the twentieth century, institutional affiliation could stand in for practical, "ground-up" knowledge, even in borderlands mines, some of the least institutionalized and most anti-establishment mining districts in North America a mere four decades earlier.

In the 1850s and 1860s, hard-rock mining in the North American West and throughout northern Mexico was carried out primarily by independent prospectors,

[126]Staunton, "Memoir," p. 226, box 1, WFS, UASC.

[127]William F. Staunton to Henry Robinson, 26 December 1908, folder 1, box 4, WFS, UASC.

apprentice-trained miners, and auto-didactic speculators. University-trained engineers came up through a system dominated by the German mining academy at Freiberg, although they were, for the most part, Anglo-Americans from the northeastern United States. After the U.S. Civil War, the Columbia School of Mines led the way in establishing a new mining curriculum in the United States that was a hybrid of theoretical and practical training, modeled on the system at Freiberg. The success of the Columbia model, in combination with the establishment of several new dedicated engineering institutions in the 1860s and 1870s, caused the faculty at engineering colleges more generally to take mining seriously as a field of study independent from civil or mechanical engineering. Narrowing curricular focus in mining programs through the late nineteenth century coincided with a tremendous increase in the number of students educated at the newly established engineering and technical colleges. At the same time, the mining industry came to need workers who could extract ever-lower grades of ore, and who therefore had advanced training in metallurgy and chemistry. By the turn of the twentieth century, university-educated mining engineers were critical workers in the mining industry; no longer outside consultants, mining engineers were, rather, integral to the operation of a mining venture.

Chapter Three

Expertise Enacted

As increasing numbers of mining engineers earned the E.M. degree from the mining institutes created in the United States in the latter half of the nineteenth century, the importance of mining engineers within the mineral industry grew. By the late 1870s, a mining engineer was attached at one time or another to almost every mining project in the western United States. This had the effect of engaging mining engineers in both rhetorical and substantive battles concerning the use and meaning of their professed scientific and technical expertise. The ability of mining engineers to reassure investors that a given mining prospect was not fraudulent, to assess speculative risk, and to participate in managerial decisions regarding mine operations became increasingly important for their own professional success as well as for the success of the mining operations to which they were attached. Meanwhile, the terms of such assurances also changed. While in 1863 booster Sylvester Mowry could claim that the "character of the men.... [was] a certain assurance of large returns" on a mining investment in Arizona, ten years later such an assertion was no longer the only valence of credibility.[128] Rather, investors judged engineers by the quality of their plans for a mine, their managerial abilities, and their use of technical knowledge to expose fraudulent mines, to investigate the financial irregularities that flourished in the mining industry, and to provide definitive responses to myriad arguments about the value and prospects of particular pieces of

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[128] Sylvester Mowry, *Arizona and Sonora: The Geography, History, and Resources of the Silver Region of North America,* 3rd ed. (New York: Harper and Bros., 1866), viii.

mining property. Mining engineers' assertions of the integrity of their technical knowledge, along with more established connections to the apprentice system and to family and social networks, became critical in the late nineteenth century, as engineers positioned themselves both within the mining community, and within the changing professional mores of their field. New references to a mining engineer's "body of technical knowledge" did not usurp previously established modes of determining a mining engineer's worth. Rather, connection with a group of technical experts offered a third way for a mining engineer to protect his reputation and argue for the validity of his claims, particularly in cases where fraud or illegal activity was suspected on the ground. In trying to impose their managerial plans at a mine, however, mining engineers could find that asserting their technical expertise sometimes worked against them. This chapter will look at episodes in the professional histories of mining engineers to demonstrate the changing ways in which expertise was rhetorically defined during an era of professionalization and modernization. Placing these episodes within the broader context of both the regional circumstances in the U.S.-Mexico borderlands and the on-the-ground work of mining engineers highlights the utility and complex nature of these new assertions of technical expertise.

The social network within which mining engineers defined their technical knowledge was composed of a web of familial ties. Many of the first mining engineers to attend university in the United States were the sons of apprentice-trained mining engineers, or of men otherwise engaged in leadership roles in underground work in mining —foremen, superintendents, and crew chiefs. Thus, as in many trades, mine engineering tended to be a family affair. Charles Hoffmann, who was trained at Freiberg and moved to California in the 1850s, had four sons, all of whom followed in his footsteps as mining engineers; Joseph Collins, a mining man from Cornwall sometimes referred to as "the grandfather of technology," likewise had four sons who were successful mining engineers.

The family of T.A. Rickard, the influential editor of the *Engineering and Mining Journal* (1902-1905), and manager and editor of *Mining and Scientific Press* and the *Mining Magazine* (1905 through the 1920s), offers one of the best examples of this patrimony. Rickard was the great-grandson of a Cornish mine captain, the son and grandson of accredited mining engineers, and had four uncles and brothers who also worked in mine engineering, primarily in North America.[129] Being a part of such an established mining dynasty carried significant benefits. After Rickard, whose mining degree was from Britain's Royal School of Mines, over-valued a mine and lost thousands of dollars of his employer's money, he found a place for himself in the profession as a writer and editor on ethical and legal matters concerning mining engineers.[130] Rickard's deep knowledge of, and comfort within, the mining world doubtless gave him the confidence to give voice to some unpopular positions, and to argue with some of the most well-established of his peers. In the early twentieth century, Rickard used his platform as editor of the *Engineering and Mining Journal* to lobby for standardized professional ethics and to bring to mine engineering education into the Progressive framework

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[129] Clark Spence, *Mining Engineers,* 12; T.A. Rickard, *Interviews with Mining Engineers* (San Francisco: Mining and Scientific Press, 1922), 521-522, 536-538.

[130] Spence, *Mining Engineers*, 12-13; 99.

embraced by mechanical and chemical engineers.[131] If the standards Rickard publicly embraced were established, he himself would have likely come up short — he owed his ongoing professional career to his guild-based fraternal connections, rather than to his successful deployment of technical knowledge. Yet Rickard positioned himself as a new kind of mining engineer against an "old guard" of which he was, through family connections and generational affiliation, a member.[132] Mining engineers could benefit from their family connections in more standard ways, as well. The sons of Charles Hoffman, all of whom graduated from university in the 1890s and early 1900s started their careers as assistants to big-name mining engineers through their father's connections within the industry. Most notably, one of Ross Hoffman's first professional positions was as a junior engineer for the Guggenheim Exploration Company, headed up at the time by John Hays Hammond, a family friend. Despite the liberalizing force of the new engineering institutions, and their role in bringing more men, of more varied backgrounds, into the profession, the ties of family, friendship, and school loyalty proved an enduring force within the community of university-educated mining engineers, complicating professional loyalties while providing their members with important avenues of professional support.

One of the most established of the family dynasties in western mining was that of the Janin brothers. Unlike many of their mining engineering peers, who tended to be either of German, English descent, or (as T.A. Rickard expressed it) of "old New England

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[131] Layton, *Revolt of the Engineers*, 29-35.

[132] Ibid.; David Noble, *America by Design: Science, Technology, and the Rise of Corporate Capitalism*, (New York: Knopf, 1977), 39.

stock," the Janins were a French family that settled in New Orleans in the early 1800s.[133] Three of the six Janin brothers were mining engineers, educated in Europe at the École des Mines and the Freiberg Academy in the 1850s. A Janin was present at virtually every major mineral strike in the west following the Gold Rush.[134] Louis Janin, the eldest, served as an assistant, and possibly the only university-trained engineer, in the Butterworth exploring party in Arizona in the 1850s; in 1864, he was the metallurgist at one of the largest mines on the Comstock Lode, where he instituted the so-called "Freiberg Process" of barrel amalgamation to extract silver ore.[135] Alexis Janin worked with his brother Louis at the roasters on the Comstock, and after Louis tired of amalgamation and returned to mine inspections, Alexis continued to refine the smelting procedure, gaining a reputation as "a metallurgist of exceptional genius."[136] At the start of his career in the 1860s, Henry Janin principally worked in gold mining in California.

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133 Rossiter W. Raymond, [Biographical sketch of Henry Janin], Bulletin AIME, no. 53 (1911): xxxiii.

134 Raymond, [Biographical sketch of Henry Janin], xxxiii, xviii-xxx.

135 See chapter 1 for a discussion of the Freiberg process. A.D. Hodges, "Amalgamation at the Comstock Lode, Nevada," <u>Transactions AIME</u>, 19 (1890): 195; Henry Francis Collins, The Metallurgy of Lead and Silver, Vol. II., (London: Charles Griffin, 1900) 117; <u>Mining and Scientific Press</u>, 21 May 1910; Rossiter W. Raymond, [Louis Janin Biography], <u>Transactions AIME</u>, 49 (1914): 831-836; J. Ross Browne, *Adventures in the Apache Country...* , 217.

136 Raymond, [Biographical sketch of Henry Janin], xxxiii; Spence, *Mining Engineers*, 237.

He had the reputation of being the very best American mining consultant. In addition to conducting significant explorations at the behest of other investors, Henry Janin himself was an early owner of the Homestake Mine in the Black Hills of South Dakota. He sold most of his shares to George Hearst, but retained a stake in the largest and most profitable gold mine in North America. In the next generation, Louis Janin's two sons, Louis, Jr., and Charles Henry Janin, also worked as mining engineers.[137] The trajectory of their careers was shaped by the way their father's generations asserted and enacted the different modes of mine engineering expertise, both among their professional peers and on the ground at the mine.

Surveys and Inspections

Through the late nineteenth century, a primary aspect of mining in which the growing cohort of technically-trained university-educated mining engineers participated was the crucial work of surveying and inspection of mining sites. During a typical mine inspection, a mining engineer scrutinized the full extent of a property, to determine the value of the ore deposits, or, in the case of an operational mine, the value of the property, including extant technology, as a whole. Before the advent of the automobile, a mining engineer walked or rode on horse or mule-back over the entire property. As described by one student of mine engineering, a mine inspection needed to

> include all the operations necessary to determine the relative positions of any two points underground; to establish the position of points

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[137] Raymond, [Biographical sketch of Henry Janin], xxxi.

> underground with respect to given points on the surface... and also those [actions] necessary to its future prosecution.[138]

In other words, mining engineers had to find and record each outcropping, waterway, or elevation change, and to accurately depict the latitude and longitude of neighboring claims in order to map the direction, depth, and breadth of the ore body. If the mine was on a new site that had never been worked, the engineer would also drill holes to take samples of the earth at regular intervals in order to discover the direction and extent of the ore body, as well as the composition of the ore itself.[139] These samples were usually sent to an assay office. Many engineers got their professional start in assay offices, and many men who remained in assay offices for their entire careers were college classmates of mining engineers who had majored in metallurgy and chemistry rather than in engineering per se, reinforcing the significance of social connections and university affiliations amongst mining engineers.[140] When an engineer was called on to inspect a mine operation that had already been worked, he was expected to go over the entire

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[138]Charles F. Hoffman notebook, [n.d.], Folder 10, Box 1, Ross B. Hoffman Collection, MS 3163 [hereafter MS 3163], American Heritage Center, Laramie, WY [hereafter AHC].

[139]Clark Spence, *Mining Engineers and the American West: The Lace-Boot Brigade, 1849-1933* (New Haven: Yale Press, 1970),96-99.

[140]Crampton, *Deep Enough*, 59-70; Staunton, 37.

underground works, to map both the tunnels and the ore body, and take samples from each ore face most recently worked.[141]

Fraud was a recurring problem during this period. There are many points in any examination of a mine at which a sample could be contaminated or, in industry terms, "salted." It was virtually impossible for an engineer or his assistant to remain with all of the samples all the time to ensure that an outside party did not tamper with them. Oftentimes the samples were stored in the mine office or with the engineer's personal belongings until it was time to send them to the assayer. Engineers who inspected mines owned by a person or consortium other than his own employer were sometimes accompanied throughout the inspection by the agent or representative of the owners. An engineer usually interpreted such close attention as an attempt on the part of owners to keep him from seeing something that would either dramatically raise or lower the

[141]Spence, *Mining Engineers*, 96-99. A most precise description of a survey of a mine in Argentina can be found in Charles Hoffmann to F. Perugia, Esq, 1899, Folder 28, Box 2, MS 3163, AHC. There are numerous examples in the archival sources of the details mining engineers looked for when making reports, see: Arthur Laing to James Douglas, 18 July 1881, Folder 29, Box 3; James Douglas Papers, MS 1031 [hereafter MS 1031], Arizona Historical Society, Tucson, AZ [hereafter AHS]; James D. Hague to Santa Eulalia Mining Co., 20 May 1885, L-9, JDH, HL. On contractual agreements to examine mines, see [Agreement between James D. Hague and Perkins, Livingston, &Co.], 8 July 1879, and [Agreement between James D. Hague and Phelps, Dodge, and Co.], K-5; Ellsworth Daggett to James D. Hague, 3, August 1884, M-13, JDH, HL; [unknown] to George J. Hoffmann, 13 March 1900, Folder 29, Box 2, MS 3163, AHC.

valuation of the mine, but it was just as likely that the owners simply wanted to establish for themselves the integrity of an engineer's work.

Such close monitoring of an engineer's inspection, however, rarely lasted long. The process of inspecting a mine was arduous and uncomfortable, and typically involved walking or riding for fourteen or more hours each day for two to three weeks. Indeed, the ability to withstand tremendous bodily strain during these inspections was a significant aspect of a mining engineer's working life, and a man who could not maintain the marathon task of a mine inspection, or who "broke down" on the job, had little hope of recovering his career.[142] In remote areas such as the borderlands region, inspecting a mine meant spending weeks outside in punishing hot weather, without adequate access to water or familiar foods. Mining engineers in the nineteenth century often had to climb in and out of mines themselves. Only the largest and most well-established hard-rock mines had rail cars or joists to bring miners below ground. In the United States, this meant walking down miles of tunnels or climbing up and down long ladders; in Mexico, it could mean climbing up and down so-called "chicken poles" — notched logs that Mexican miners who worked in soft-soled shoes or bare feet could navigate with ease, but that evaded the grip of Americans' hard-soled boots.[143] Even the most enthusiastic owner's agent wearied of following in an engineer's footsteps, and mining engineers typically completed their inspections alone or accompanied only by their own assistant. Working

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[142] Louis Janin, Jr., for instance, suffered a breakdown while still in his early twenties and never recovered his career, despite his education and family connections.

[143] John Hays Hammond, *The Autobiography of John Hays Hammond* , vol 1. (New York: Farrar & Rinehart, 1935), 166.

as an assistant was an important part of an engineer's career trajectory during the late nineteenth century as the system of engineering education developed and became established. These assistants were generally young engineers or students from technical colleges, and had considerable responsibility. On large mine inspections in particular, the mining engineer and his assistant might split up to hasten the sampling process, leaving both men liable for ensuring the purity of their samples. For a solitary man engaged in mapping and sampling a mine site, tampering with the assay samples was simple; and although mining engineers themselves had a lot to lose from salting samples, they could not trust anyone, including in some cases their own assistants, to refrain from doctoring the assays.[144] Although being a mining engineer meant doing many different kinds of work, surveys and inspections were among the most visible, as inspection reports were used to raise initial investment funding, and then used as baseline analyses in any work moving forward. Under the best circumstances, mining engineers were aware of the value of their reports, and scrupulous about checking their data.

A Western Diamond Field?

The nature of the profession, however, was that mining engineers did not always have the luxury of doing their work "by the book." Henry Janin had a reputation for being "as cool as a cucumber, with a temper that could not be ruffled by… any breeze." His conservative reports on mine prospects placed him among the most trusted men

[144] Spence, *Mining Engineers*, 112.

working in western mining in the nineteenth century United States.[145] As a result of this high professional esteem, Henry was approached in 1872 by two grizzled prospectors, Philip Arnold and John Slack, who wanted to prove to potential investors that they had found a field of diamonds in the mountains of North America. Chief among the financiers were two Civil War generals, as well as the mining speculators William C. Ralston, the head of the Bank of California, and Asbury Harpending, all of whom were apparently in agreement that if the conservative Henry Janin believed the mining claim to be real, it must be real.

Arnold and Slack kept the location of their find secret, although metropolitan newspapers in Chicago, San Francisco, and New York reported that it was in the Arizona Territory, the only North American region deemed "exotic" and unknown enough to be hiding such riches. The news that Henry Janin was heading into the wilderness to see the alleged field of diamonds sparked a miniature diamond rush in northern Arizona, as

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[145] *Pacific Coast Annual Mining Review and Stock Ledger, containing detailed official reports of the principal gold and silver mines... for the year 1879* Part II (New York: Mining Review Pub. Co., 1879), 50; Raymond, [Biographical sketch of Henry Janin], xxxii; T.A. Rickard, *A History of American Mining* (New York: Mcgraw Hill, 1932), 393. Henry Janin did not lose his esteemed place in the profession in the wake of the Diamond scandal, but the incident was invoked on occasion by Janin's closest colleagues when disagreements arose. Louis Janin to James D. Hague, 26 October 1885, M-15, James D. Hague Papers [hereafter JDH], Huntington Library, San Marino [hereafter, HL].

speculators stormed the desert hoping to find gemstones for themselves.[146] The location of the mine was kept a secret even from Janin himself, and Arnold and Slack did nothing to disabuse the notion that the mine was in Arizona. Along with Harpending and Ralston, who insisted on joining the expedition, Henry was blindfolded for the duration of a long train ride out of San Francisco, and then for a subsequent journey on horseback. When their blindfolds were finally removed, the men found themselves on a vast, high mesa. Due to the arduousness of the journey and the need for absolute secrecy, Henry traveled without an assistant. He was therefore the sole mining expert in the field when Arnold and Slack showed him their initial "discovery" of a raw diamond and a half dozen rubies. The three men walked around the site a few times, digging shallow holes at locations where the ground looked "different." At many of these sites, they uncovered still more gemstones —usually a diamond with a few rubies; sometimes only the rubies; sometimes sapphires. By Henry's own account, he performed nothing resembling a standard survey of a mining site, and he allowed himself to be led through the site by

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[146]Asbury Harpending, *The Great Diamond Hoax and Other Stirring Incidents in the Life of Asbury Harpending,* ([New York]: James H. Barry, Co, 1913), 191-236; in "MUST the New Diamond Fields," 1872, the *San Francisco Sentinel* reported that the find was in "Pimas" Indian territory on the border between the U.S. and Mexico; the *Chicago Tribune* and *New York Sun* likewise repeated the belief that the diamond mine was in Arizona. See for instance "The Arizona Diamonds," *Chicago Tribune*, 9 August 1872 and "The Diamond Excitement, in All Probability, a Great Swindle," *Chicago Tribune*, 19 August 1872; Hubert Howe Bancroft, *History of Arizona and New Mexico, 1530-1888* (San Francisco: A.L. Bancroft, 1889), 591-592.

interested parties rather than making the kind of methodical assessment he was trained to make and on which his reputation rested.

Henry Janin later described his "stay at the diamond fields […as] so short, and there was so much to be done in the way of locating, surveying and securing the property, water rights and title lands that it left me much less time than I desired in which to prospect and sample this tract of ground."[147] Upon returning to San Francisco —another multi-day, blindfolded expedition —Henry supposedly sent the gemstones to jewelry dealer Charles Tiffany in New York for valuation and wrote a preliminary report extolling the virtues of the site.[148] In addition to the report, he contacted some friends and family to inform them of his belief that diamonds had been discovered in North America.[149]

Many geologists, including the young Clarence King, recently appointed director of the United States Geological Survey of the Fortieth Parallel, did not believe it possible that there could be diamonds in the Rocky Mountains of North America. The science of ore formation, and of the geological processes that created gems, were poorly understood in the 1870s, but King was suspicious of the claim that diamonds could be found in the western U.S. The 40th Parallel Survey had just mapped the Great Basin and the land

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[147]Henry Janin to Samuel Barlow, 26 June 1872, Folder 3, Box 81, S.L.M. Barlow Papers [hereafter SLMB], HL.

[148][editorial], "The Diamond Swindle," *Engineering and Mining Journal* 10 December 1872, 377.

[149]Henry Mayers Hyndman, *The Record of an Adventurous Life* (New York: MacMillan, 1911), 182.

encompassing the proposed transcontinental railway route. Although the survey had not dipped down into the presumptive location of the gemstones, in northern Arizona, King's work indicated that the geologic conditions for a diamond field simply did not exist in or around the Rockies. Should King be proven wrong, his own scientific expertise, which was backed at great expense by the U.S. government, would be called into question.[150] He had reason to investigate the diamond claim for himself.

Coincidentally, two of Clarence King's assistants saw Henry Janin on the train in company with grimy and weathered men whom they suspected were diamond prospectors. Armed with information as to the general area Henry Janin and the prospectors had been investigating, King and a couple of his associates from the survey took a highly secret trip to Ft. Bridger, Wyoming, where they hypothesized the diamond hunters had boarded the train. From there, King and his assistants rode south for about 150 miles until, somewhat fortuitously, they came upon the campsite recently vacated by Henry Janin and company: a high mesa with plenty of recently disrupted soil. In short order, King found several diamonds, sapphires, and rubies; closer inspection, however, showed clear evidence of tampering. Most damning, he found gemstones only in those places on the claim where the ground was disturbed. Sampling dry, hard land that was clearly untouched by human hand did not yield any gemstones. Satisfied that the gems he exposed were fraudulently planted, King returned to San Francisco, where he immediately informed Henry Janin of his findings, and also of the location of the mesa, in northern Colorado rather than in Arizona. The two men returned for a joint

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[150] Martha A. Sandweiss, *Passing Strange: A Gilded Age Tale of Love and Deception across the Color Line*, (New York: Penguin, 2009), 66.

exploration of the site, and together published a formal report stating that there was no multi-million-dollar diamond field in North America.[151] The investors attempted to recover the money they had already paid to Arnold and Slack, but Slack had disappeared, and Arnold returned home to Kentucky. The governor of Kentucky was opposed on principal to extraditing Kentuckians into the hands of Yankees, or of prosecuting his citizens for crimes committed beyond state lines. Arnold was killed in a brawl a few years later; he died the wealthiest man in his county.

In the aftermath of the diamond hoax, many professional mining engineers pointed out that Henry Janin, who was trained at Yale University and the Freiberg Academy in the 1850s, and whose mining experience was principally in ore extraction in the western United States and Latin America, had never actually seen a diamond field. Yet Arnold and Slack's ability to pull off the hoax rested on how well Henry understood, *in theory,* what he ought to find when looking for diamonds, and on their success in structuring Henry's visit to the site in such a way that he was unable to actually put his theoretical knowledge to work on the ground. Another critical aspect of Janin's role in the "diamond muddle" was his supreme confidence. His preliminary report stated that he "considered this a wonderfully rich discovery, and one that will prove extremely profitable," and it was reported that when King first approached him to express his doubts as to the legitimacy of the field, Henry Janin brushed off his concerns, attempting

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[151]A.J. Liebling, "The American Golconda," *The New Yorker* 16 November 1940; Sandweiss, *Passing Strange*, 68; [Henry Janin report], *Engineering and Mining Journal* 10 December 1872. King also published reports of the scandal in the popular press, see the *Chicago Tribune* 5 December 1872, and the *New York Times*, 5 December 1872.

instead to persuade King to buy shares in the company.[152] He wrote those words despite the fact that by his own account he had not performed his duties as a mining engineer and he did not perform a proper survey. He had not surveyed the ground properly to determine the geological structure; he had not planned or taken samples from the ground at defined intervals; he only spent a single day on-site — this was not a thorough or coherent inspection.

The role of Henry Janin's expectations must be taken into consideration along with his confident (or arrogant) belief that he could recognize a diamond mine. As an experienced, educated mining engineer, he certainly *should* be able to identify the geology of a diamond field. Yet all of Henry Janin's experience — all of his on-the-ground expertise — was with heavy-metals mining. He had only *read* about how diamonds present in nature, and never seen them for himself. Prior to his brief journey to the alleged diamond field, Henry had seen and heard reports on the value of the diamonds Arnold and Slack had brought to San Francisco when they announced their find. The most prominent jewelers in town inspected these diamonds and reportedly gave them exceedingly high valuations. For centuries, most of the diamonds in the world were mined in India, but during the 1870s, the worldwide mining community was in thrall to

[152]Covington Janin, "Requiem for Henry Janin, 1838-1911: Years of Gold and Diamonds[,] Silver and Music[,] Days of Heartbreak," [San Francisco: ca. 1973], #433068, HL, frontispiece; Spence, *Mining Engineers*, 114; *Pacific Coast Annual Mining Review...*, 50; Henry Janin to S.L.M. Barlow, 26 June 1872, Folder 3, Box 81, SLMB, HL; Aaron Sachs, *The Humboldt Current: Nineteenth-Century Exploration and the Roots of American Environmentalism,* (New York: Viking, 2006), 256.

the extraordinary diamonds the British were mining in Africa. If a new diamond field could be found in Africa, many Americans reasoned, why not in the continental United States as well? The atmosphere of great expectations that surrounded Arnold and Slack's claim, coupled with Henry Janin's theoretical understanding of how diamonds present in nature prepared the engineer to believe that what he saw was a field of diamonds. Henry Janin unwittingly demonstrated that a little knowledge is a dangerous thing.

Despite the fact that his inaccurate report resulted in the embarrassment of prominent figures in American finance, and almost created an economically devastating "diamond bubble," Henry Janin himself was never suspected by his peers in the mine engineering community of being a criminal.[153] Other engineers understood that Janin was not given the opportunity to practice his trade properly on the alleged diamond mesa; he was thus considered a patsy, rather than a man who had intentionally defrauded those who trusted him. Janin only survived as an engineer because of his decades-long reputation as a cautious mining engineer; a less-seasoned man could have been professionally destroyed by an error of this magnitude. Henry Janin merely removed himself from the region, relocating his professional office to London and avoiding performing mine inspections in western North America for much of his remaining career.

The diamond episode thus underscores two features of the state of mining in the 1870s —the importance of *reputation* to a mining engineer's professional career, and

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[153][editorial] "The Diamond Swindle" *Engineering &Mining Journal* 10 December 1872, 377. On Henry Janin's continued high reputation within the mine engineering community, see for instance *Arizona Daily Star* (Tucson), 18 July 1879, vol 3 no. 1; *Arizona Daily Star* (Tucson), 29 July 1879, vol. 3, no. 2.

how reliant the mining industry, even as early as the 1870s, was on the judgment of engineers to value mines. In the 1860s, companies with investments in locales that were difficult to reach found it useful to hire experts to reassure their investors that everything was above board. By the 1870s, dishonest mine profiteers sought out a trusted expert in order to run a scam, and Henry Janin was hardly the only engineer to attach his reputation and expertise to such illegitimate projects. Millions of dollars could depend upon an engineer's estimate of the extent of an ore body and the cost of extraction. In consequence, when a company suspected deception at a mine site, mining engineers were usually near the top of the list of suspects. Henry Janin, however, was never accused of being criminally dishonest, largely because of his decision to publicly retract his statements by publishing a report on the fraudulent diamond site with Clarence King. Ultimately, King's endorsement of Janin was as important as Janin's personal reputation as a "conservative" engineer or his status as a member of the well-connected Janin clan.

Henry Janin's experience with the diamond mine illustrates the risk inherent to a mining engineer's claim to be a technical expert. Although investing in a mine was self-evidently a risky proposition, as professional men, mining engineers did not want to be thought of as risk-takers, positioning themselves rather as strategic advisors.[154] As Louis Janin explained, "[mining engineers] must be cautious in conclusions but bold in

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[154]In the latter half of the nineteenth century, young men embarked on professional careers to guarantee solidity and financial stability for themselves and their families. E. Anthony Rotundo, *American Manhood: Transformations in American Masculinity from the Revolution to the Modern Era* (New York: Basic Books, 1993), 168-169.

executing; an expert is cold nosed."[155] Mining was a speculative industry, and one reason mining engineers were hired was to increase the odds that an investment would succeed. The highest praise a mining engineer could receive, as Janin implied, was that he was cautious and conservative. Mining engineers' status as educated professional men rested upon their deployment of technical expertise, the most obvious manifestation of which, in the late nineteenth century, was the geological and mechanical knowledge mining engineers learned at university. Obvious risk-taking suggested that such hard to come by expertise was worthless.[156] Yet the nature of the mining industry meant the possibility always existed that despite his best efforts a consulting engineer would make a mistake. After all, engineers understood that it was

> "on the strength of the recognized integrity, ability, and successful experience of the engineer that capital is invested in mining enterprises. The success or failure of such enterprise determines the career and future value of the engineer. He risks his reputation when he submits a report to his client."[157]

Therefore, mining engineers themselves had a rhetorical challenge when constructing their reports. Sounding authoritative while also acknowledging that expertise had limits

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155 Louis Janin to J. Blythe, 19 October 1887, L2, Louis Janin Papers [hereafter LJ], Huntington Library, San Marino [hereafter HL].

156 Gunther Peck, "Manly Gambles: The Politics of Risk on the Comstock Lode, 1860-1880," *Journal of Social History* 26:4 (Summer 1993): 701, 704.

157 John Hays Hammond, *The Autobiography of John Hays Hammond* (New York: Farrar and Reinhart, 1935), 148.

was a difficult prospect. Mining engineers made frequent use of terms such as "cautious;" "conservative;" and "careful" in writing their reports, even when the conclusions thus qualified were clearly absurd, as when an engineer concluded that the ore reserves at the Mulatos Mine in Sonora were "by careful calculation, simply inexhaustible."[158] More often, caution was asserted so as to highlight weaknesses in the engineer's own work. In a report on a mining property in Yuma County, Arizona, for instance, mining engineer John Church reiterated his point so that it would be perfectly clear: "No careful survey of these claims has ever been made... A careful survey is a necessity before any purchase can be made." Church had inspected the mine in question, but did not perform a full survey. In the cover letter accompanying his highly qualified report, Church noted that there was a reported $450,000 net profit to be made from the ore in sight, and that he thought that it might be worth paying as much as $800,000 "b/c what's not in sight may be equally valuable."[159]

The dual nature of mining engineers — that they were always possible conduits for mining scams as well as the best investigators of possible dishonesty — posed a problem for the profession. In the wake of the diamond scandal, for instance, an editorial in the *Engineering and Mining Journal* asserted that in the early days of the scheme

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[158]E.A. Brandon, "Mulatos Mineral Zone and Land Grant, Mexico," n.d., P-89, James D. Hague Collection [hereafter JDH], HL.

[159]John A. Church, "Condensed Copy: Report on la Fortuna Mine Yuma County, Arizona," P-70, JDH, HL; John A. Church to H.L. Higginson, 19 December 1896, P-70, JDH, HL.

"Henry Janin's name was all that secured for this enterprise the public confidence."[160] The insertion of mining engineers into the center of the diamond case was self-serving of the editors of the *Journal*, who took every opportunity to extol the quality of the mine-engineering community as a whole, but drawing attention to their central significance came with a price, as it suggested to the public that mining engineers might be responsible for the failure, as well as the success, of mining operations.

Establishing the Credibility of the Profession

A simple but effective way for engineers to reassure investors of their trustworthiness was to use a third party to vouch for the quality and probity of a mining engineer. Such vouchers came in different forms, such as a letter of introduction from a well-known engineer or financier or a statement signed by the upstanding residents of a given locale. John Anderson, for instance, a "pioneer" and mining engineer who worked in Arizona beginning in 1881, carried a document signed by the citizens of Rohnisville, Humboldt County, California, his previous residence, which certified "that Anderson is a machinist and engineer."[161] Prior to 1900 it was particularly common for letters in support of an engineer to be appended to a mine report, suggesting that a mining engineer's claims to technical expertise had to be vouched for by non-technical people. A report put out by the Loma de Plata mining company included a signed and notarized

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[160] [editorial] "The Diamond Swindle" *Engineering and Mining Journal*, 10 December 1872, 377.

[161] "Certificate of John Anderson as Engineer," 1881, Folder 8, Box 1, MS 19, John B. Anderson Papers, AHS.

affidavit in support of the company's engineers from a local Sonoran miner, who was known locally to have milled and smelted an extremely valuable ore body estimated at $640 per ton; a pair of mining men who were acquainted with the purchasers of the mine that adjoined the Loma de Plata, and a presumably-knowledgeable third party, D. L. Guernsey, whose "personal inspection of the Loma de Platta [sic] left him favorably impressed" by both the value of the property and its technical management. None of these affidavits were from mining experts who were known outside the region, but each was presented in the report as a prominent mining man in the Altar district of Sonora. A potential investor could, in principle, seek out these attesters to verify their statements.[162] Likewise, the Aztec Syndicate published a report on the mines of the Santa Rita Mountains, citing two articles from local newspapers as well as the work of engineer Raphael Pumpelly to support its own engineer's assertion that the mines contained valuable ore.[163] As the experiences of Henry Janin demonstrate, however, when mining

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[162]"Prospectus of the Loma de Platta [sic]... Situated in the Altar District, State of Sonora, Republic of Mexico," (Atlantic, IA: Telegraph Steam Printing House, 1880), Appendix.

[163]"Reports on the Mines of the Aztec Mining District, Santa Rita Mountains, Arizona Territory, October 1877," (San Francisco: Cubery & Company, 1877), 7, 8, 13-15. Other examples of companies using this tactic to buttress claims made in their prospecti can be found in the "Prospectus of the Gunsight Consolidated Silver Mining Co. of Arizona. Incorporated May 1881," (Philadelphia: [unknown publisher], [1877]) and *Gold and Silver Mining in Sonora, Mexico: Proposed Purchase of the San Juan del Rio Mines and Lands, Belonging to The Cincinnati and Sonora Mining Association*, (Cincinnati: Wrightson & Co., 1867).

engineers were brought in to survey a mining property, the words of *other* technical experts, such as Clarence King or John Hays Hammond, who were presumably completely impartial, were of much greater importance in supporting or undermining the technical assertions of the initial mining engineers than were the affidavits of inexpert locals.

Unlike laboring miners, who lost income, food, and lodging overnight when a mine closed without warning, consulting mining engineers had some control over the level of risk they took on at any particular mining claim.[164] As they needed to promote themselves as highly educated, skilled advisors in a context of economic uncertainty, they utilized distinct rhetorical strategies when addressing capitalists and financiers about mining issues. For consultants, the financial instability of the mining industry was most frequently manifested in their need to find the correct level of endorsement for a marginal mining property. Although the mistakes made by mining engineers opened the profession up to the ridicule of the general public and the mistrust of both working miners and mine owners, many successful mining engineers were skilled in the rhetoric of qualification, a talent that is particularly apparent in mining reports written in the years after mining was well-established as a regional industry.[165] For instance, after receiving

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[164]Peck, “Manly Gambles,” 703-705; 714.

[165]Spence, *Mining Engineers*, 79, and chapter 2, passim. For examples see W.E. Dodge to James Douglas, 5 September 1881, folder 30, box 3, JD, AHS; William Church to James Douglas, 13 June 1888, folder 4, box 12, Lewis Douglas Papers [hereafter LD], University of Arizona Special Collections, Tucson [hereafter UA]; James Tully to William Defty, 19 April 1901, folder 8, box 3, William E. Defty Papers, UA.

assays that were lower than anticipated on samples he took during a survey of the Copper Chief mine in Arizona, engineer Harry Titcomb wrote to his employer that "as the property stands at present it would not be at all attractive under the terms you outlined."[166] Titcomb thus offered a bleak assessment of the value of the property, without thoroughly discouraging the purchase of the mine. Should an investor choose to purchase the mine, Titcomb could cover his tracks by noting that he thought the Copper Chief was a poor investment. Should the Copper Chief make money, Titcomb could note with satisfaction that he recognized the mine's potential. In a similar vein, a mining engineer cautioned in his report on a property near Alamos, in Sonora, that the ownership of the property was uncertain, and that labor seemed quite expensive for the quality of the copper ore available. Furthermore, with regard to a second mine on the property, the engineer noted that the current manager was unable to speak Spanish or to communicate directly with the miners, and therefore "the importance of the enterprise centers on conditions of management, future technical policy and participation."[167]

Carefully qualified reports could be seen to be the work of mining engineers intent on protecting themselves from professional embarrassment or worse, but such reports were valuable to investors, as they could serve as the basis for renegotiating the purchase price of a mining property. Disagreements between mine owners and potential purchasers over the value of a given property were at the heart of many mining

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[166] Harry A Titcomb to A.C. Beatty, 12 June 1905, folder 4, box 2, Harry A. Titcomb Papers [hereafter HAT], American Heritage Center, Laramie, WY [hereafter AHC].

[167] [unknown author], "Report on certain claims near Alamos, Sonora....," 2 January 1907, Olcott, Corning and Peele No. 3, BV Olcott, New-York Historical Society, New York.

negotiations; mining engineers were responsible for providing advice to potential investors on how much to offer for a particular mine. Even in negotiating properties that were tremendously rich, a potential purchaser could make an offer on a property well below the asking price for the land, and if the owner could not produce enough evidence to demonstrate the inaccuracy of the report, but was still determined to sell, that owner might have to accept a much lower bid than anticipated.

A disagreement of this kind played a role in one of the most important mining purchases of the nineteenth century, the 1881 purchase of the Copper Queen mine near Bisbee, Arizona, by Phelps, Dodge, and Company. Despite the belief of the on-site managers of the mine that there was a large body of ore deep underground, the fact that shallower assays pulled up inferior grades of ore led a Boston-based company to offer a low bid on the mine. The existence of this bid, made as Phelps, Dodge was getting paperwork together to make an offer, caused company leader William Dodge considerable concern, and he called on the mining engineers James Douglas and Eben Olcott to find evidence in the field to help him to counteract the Boston company's claim so that Phelps, Dodge could responsibly make a higher bid and secure the rights to the mine.[168] Despite the work of Douglas and Olcott, Phelps, Dodge did not purchase the mine in 1881, instead buying up land adjoining the Copper Queen. The work done by

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[168]W.E. Dodge to James Douglas, 5 September 1881; Eben E. Olcott to W.E. Dodge and Daniel James, 20 September 1881; Eben E. Olcott to W.E. Dodge and Daniel James, 21 September 1881; Arthur Laing to James Douglas, 22 September 1881; W.E. Dodge to James Douglas, 29 September 1881; W.E. Dodge to James Douglas, 30 November 1881, all folder 30, box 3, JD, AHS.

these mining engineers was not in vain, however. Phelps, Dodge successfully bought the Copper Queen in 1885, largely on the strength of earlier surveys by Douglas and Olcott.[169]

Another way that consulting engineers managed the expectations of their principles was by using their initial reports to suggest that all a mine needed to be successful was better on-site management. Engineer James D. Hague reported to the owners of the Cusihuiriachic Mining Company in 1885 that “the whole thing needs clever management, and the mine especially wants to be taken in hand by an experienced man.”[170] Although endorsing the mine, Hague simultaneously distanced himself from any production that might result. If the mine failed, he could explain that it needed an extremely efficient manager and if the company chose to hire an incompetent man, he, Hague, could not be held responsible. Advocating for good management gave a mining engineer considerable latitude for expressing his enthusiasm about a mine. Engineers less circumspect than Hague also used this tactic, such as the man who gushed, “with the proper management, this mine will pay larger dividends and continue to do so for a longer period of years than any gold mine now in history.”[171] Without the qualification

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[169]Robert Glass Cleland, *A History of Phelps Dodge*, *1834-1950*, (New York: Knopf, 1952), 87, 99. The establishment of Phelps Dodge in Arizona and northern Sonora is discussed in greater detail in chapter 5.

[170]James D. Hague to Pres. & Trustees, Cusihuiriachic Mining Co., 25 May 1885, L-9, and James D. Hague to Ellsworth Daggett, 7 Dec 1885, L-9, JD.

[171]E. A. Brandon, “Mulatos Mineral Zone and Land Grant, Mexico” [n.d.], P-89, JDH, HL.

that the mine needed good management, such unequivocal support for a mine could cause an engineer's professional colleagues to mistrust him, and in the worst-case scenario, destroy a mining engineer's consulting career (as happened to T.A. Rickard, editor of the *Engineering and Mining Journal*).

Engineers with established consulting practices did much of their work visiting and reporting on already operational properties. Although engineers who were managers and supervisors relished the opportunity to talk to their professional peers, they were also concerned that visiting experts would steal information about the technology or techniques they were using, or would publish information that was detrimental to the financial well-being of a company, causing investors to scale back or pull out entirely. Because of this, managers tended to be cagey around consultants and suspicious of their visits. William Field Staunton recalled of his time as manager of the Silverbell copper mine in southern Arizona, "we had been reasonably free from experts for some time, but.... for some reason or another they began to come again."[172] The cautious relationship between engineers-as-managers, and engineers-as-consultants, is evident in Staunton's words. Staunton himself was educated at the Columbia School of Mines, and as a leader in the local mining industry, he frequently made independent mine visits as a consultant himself, yet he clearly experienced the visits of other experts as a burden to be endured. As consultants, engineers were aware of the awkwardness of their position. Of a mine visit in 1881, James Douglas noted, "The Longfellow Co. [in Globe, AZ] is jealous of admitting visitors…. They relaxed their rule in my favor, but of course I had to follow

[172][William F. Staunton Memoir], 161, William F. Staunton Papers [hereafter WFS], UA.

wherever led, and my observations were necessarily superficial."[173] The awkwardness of the manager/consultant relationship points to its effectiveness in ensuring critical standards and practices throughout a regional mining industry.

Besides personal affidavits and rhetorical gymnastics, other more standardized attempts were made by mining engineers to assure the public of the probity of the profession. Some engineers thought that the existence of a professional code of ethics would be the best means to gain the public trust. These engineers hoped that the American Institute of Mining Engineers (AIME), founded in 1873, could serve as a "gatekeeping" organization for mining engineers, much as the American Medical Association did for doctors or the American Society of Civil Engineers did for civil engineers. AIME welcomed members "practically engaged in mining, metallurgy, or metallurgical engineering," and initially had rigorous educational guidelines for membership, ensuring that each member engineer was well known to his colleagues.[174] The small membership of the AIME in the early years served as the most effective guarantor on the honesty of mining engineers. By joining the AIME, mining engineers agreed to be governed by collegial codes of conduct, spelled out in the AIME charter and informally enforced by the community.[175] The self-policing nature of the early years of AIME, like that of many nineteenth-century professional organizations, was decidedly

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[173]James Douglas, [Notes on Frank Church Property], May 1881, folder 92, box 5, JD, AHS.

[174]AIME *Transactions* vol. 1 (1873).

[175]Edwin Layton, *The Revolt of the Engineers: Social Responsibility and the American Engineering Profession*, (Cleveland: Case Western, 1971), 4, 6.

premodern, harkening back to the standards and practices of medieval guildhalls, which were organized specifically to protect the interests of a small group of apprentice-trained craftsmen. Unlike the new professional organizations such as the American Medical Association, however, the AIME had no power to rescind an engineer's membership or to sanction a colleague who strayed from the straight-and-narrow. Although members in AIME were closely vetted by other members, by the end of the nineteenth century many of the educational guidelines for membership were dropped, and anyone affiliated with the mining industry, including investors and businessmen with no formal engineering training, could apply for membership. In addition, AIME could do nothing to prevent nonmembers from working as practical mining engineers. Thus the organization, while serving as an important clearinghouse for the mining industry, fell short as a standard-bearing organization.

These weaknesses in the AIME organization meant that professional ethics were an important and consistent topic of discussion in AIME's own *Transactions*, as well as in the two most prominent mining journals, New York's *Engineering and Mining Journal*, and San Francisco's *Mining and Scientific Press*, well into the twentieth century. Observers, particularly other types of engineers, felt that mining engineers, as represented by AIME, were too responsive to the demands of finance capital.[176] In part

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[176]Layton, *Revolt of the Engineers,* 35. David Noble argues the "mining engineer's did little to promote professionalism" *compared to* their colleagues in mechanical and chemical engineering. His critique echoes conversations in national engineering groups at the turn of the twentieth century, which felt that only trained engineers should be

to counter such accusations, other societies for mining engineers were founded in the early twentieth century, including the Mining and Metallurgical Society of America (MMSA) and the American Mining Congress (AMC). While AIME members focused their energies on "educational and technical" matters, and the AMC worked for "economic and legislative" ends, the MMSA was established in 1908 specifically to strengthen the ethical standards of mine engineering. The charter members of the MMSA actually voted on whether the new organization should take "a positive stand in controlling and improving the ethics of the profession," or work for the "maintenance of a high professional standard among its members and a constant endeavor to check and eliminate dishonesty and fraud in the mining industry."[177] However, as with AIME, the MMSA did not have the power to prevent someone from working as a mining engineer, and therefore its ability to police the ethics of the profession fell short.

The absence of a strict gatekeeping organization for mining engineering was particularly relevant for mining engineers working at mine sites that were somewhat inaccessible, such as those in the new southwestern borderlands and much of Mexico. The difficulty of reaching the mining regions of these territories from New York, Boston, or San Francisco meant these regions were particularly plagued by accusations of mining fraud — what one engineer described as the "kind of fakes [that] do Arizona more harm

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members of engineering organizations. David Noble, *America By Design: Science, Technology, and the Rise of Corporate Capitalism*, (New York: Knopf, 1977), 36.

[177][List of "Charter Members of the Mining and Metallurgical Association"], [1908], M-10, JDH, HL.

than good."[178] Perhaps this is why mining engineers who did spend significant time in these locations were so frequently hired as consultants to check one another's work. By the turn of the twentieth century, the higher volume of American investment in the borderlands, enabled by the new rail lines that eased travel into the region, resulted in an increasing number of investigations of mines of dubious quality. Visiting salted, or possibly salted, mines became more and more a part of consulting engineer's work. In the early twentieth century, both Harold Titcomb and Charles Hoffmann were brought to mines in Mexico as outside experts to determine whether the mines had been salted. The conclusions each engineer drew about the mine he surveyed is very clear; but each was careful to couch his critique with reference to older forms of social interaction, rather than solely within the realm of technical expertise.

Titcomb was hired in May 1910 to check up on a survey submitted by an engineer named Kennedy on a mine near Naica, in Mexico. In the course of a lengthy investigation of Kennedy's work, during which Titcomb and his assistant checked and re-assayed every fourth sample taken by Kennedy, and then conducted their own full survey of the mine, Titcomb decided that "Kennedy was salted badly." Titcomb explained the fraud in detail: the assay results were, in general, too high; each sample left "unguarded" by Kennedy during his investigation returned higher assays than the norm; Kennedy grossly understated the cost of labor at Naica, and overstated the value of erecting a

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[178][Leo] Von Rosenberg to [William Defty], 15 August 1901, Folder 35, Box 3, WED, UASC.

smelter at the mine; Kennedy's estimates of ore "in reserve," or as-yet unseen, were twice as high as Titcomb's.[179]

By Titcomb's estimation, Kennedy was clearly at the very least incompetent, and quite possibly was the person responsible for the salting. By returning higher assays than existed at the mine, he gave the owners the ability to sell more stock in order to purchase new equipment, and thus to make more money themselves, and, eventually, to sell the mine for a higher asking price. With millions of dollars at stake, it was quite possible that the owners consciously hired a mining engineer they could buy off. However, it is notable that Titcomb never explicitly accused Kennedy of dishonesty. Rather, he phrased the problems with Kennedy's investigation in the passive voice: he "was salted badly" and his valuation "was mistaken and too high." Titcomb worked for the Guggenheim Exploration Company; he was a well-respected, highly paid mining engineer of broad experience. That even someone with such stellar credentials hesitated before condemning a fellow mining engineer's work is indicative of the strength of the code of etiquette that governed the profession. The technical expertise of mining engineers was something that they had to be vigilant in guarding, so unless there was something clearly to be gained by proving a colleague wrong, mining engineers were loathe to criticize one another's work. Titcomb's reticence also speaks to the difficulty of proving the culpability of people who engaged in mineral swindles, even in the face of overwhelming evidence that someone had tampered with the assays. The particular exigencies of

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[179]F.R. Weekes, "Report on the Property of the Compañia Minera de Naica," 1, 2; and "HAT's note on Compañia Minera de Naica," Folder 8, Box 3, MS 2220, Harold A. Titcomb Papers [hereafter MS 2220], AHC.

working in the borderlands, and of maintaining good relations amongst the relatively small population could also account for Titcomb's evident discomfort in accusing Kennedy. In the remote locales where Titcomb worked, professional standards were less important than cordial relations with one's neighbors. It is easy to imagine Titcomb deciding that he would rather have a colleague of dubious honesty than a colleague who disliked him.

The experience of Titcomb's colleague, Charles Hoffmann, offers another example of a mining engineer's circumspection in the face of evidently tampered assays. Hoffmann reported to his principles that a Mexican mine he visited on their behalf was salted. The investors, led by mining engineer and financier John Hays Hammond, were contemplating building a water flume at the site, but not in purchasing the mine. A couple of months after submitting his report, Hoffmann received a letter from William Fitzhugh, the owner of the mine. In addition to declaring his astonishment that Hoffmann found the mine to be salted ("you <u>never</u> <u>once</u> <u>intimated</u> to me in the slightest way your suspicion of anything wrong"), what is most noteworthy about Fitzhugh's letter is his tone of anger and betrayal. Fitzhugh was angry because an outside party might assume that he, the local man, was responsible for perpetrating a scam. More critically, he felt betrayed because he felt that, as a gentleman, Hoffmann ought not to have shaken his hand if he believed the mine to be salted.[180] In expressing his outrage, Fitzhugh was not suggesting that Hoffmann betrayed any professional standard, but rather that the mining

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[180]William M. Fitzhugh to Charles F. Hoffmann, 17 July 1903, Folder 32, MS 3163, AHC.

engineer had bypassed the social mores of a gentleman in the interest of furthering his professional goals.

In replying to Fitzhugh, Hoffmann dismissed the idea that he was somehow disloyal to the man, and referenced a distinction between his personal and his professional obligations: "I was not making the examination for you, and although personally friendly to you, it would have been unprofessional in me to inform you of my results." Furthermore, Hoffmann gave two reasons for his own astonishment that Fitzhugh could be so upset with him: "the mines were salted and it was my duty to so report, but I never accused you or anybody else of the salting." Furthermore, Hoffmann pointed out that anyone who knew, as he did, that Fitzhugh did not stand to make any money from his contract with Hammond et. al., understood that there was no reason for Fitzhugh to salt the assays.[181] Hoffmann was a *professional*, and he wanted his relationships to acknowledge that fact first and foremost, along with all it entailed — technical mastery, social status, and membership in a privileged fraternal society. Fitzhugh wanted his relations with mining engineers to follow a different pattern, in which personal connections among social peers were more important than abstract matters such as technical knowledge or professional standards. Hoffman's observation about the distinction between his personal feelings and his professional obligations served as a rebuke to Fitzhugh for taking Hoffman's actions personally, while suggesting that Hoffmann abided by a set of social rules governing relationships that were different from —and more modern than —the rules that Fitzhugh himself referenced. Yet

[181]Charles F. Hoffmann to William M. Fitzhugh, 11 August 1903, Folder 32, Box 2, MS 3163, AHC.

Hoffmann made this point gently, trying not to offend a man who was clearly afraid that he was being accused of salting a mine. A mining engineer's professional knowledge and expertise, which provided employment and an entrée into a privileged society of professional peers, and the social grace needed to maintain a pace in that professional fraternity, were often at cross-purposes. Mining engineers walked a fine line in critiquing one another's work. The question of who was right was not always as clear as Hoffman and Titcomb found it to be.

<u>The Oro Grande —Lies and Lawsuits?</u>

Alexis Janin, for instance, found himself at the center of a mining lawsuit of ambiguous validity. In 1888, the Oro Grande Company, a mining syndicate based out of San Francisco, bought the Mulatos Mine, a gold mine located in the state of Sonora in northern Mexico. Shortly after commencing mining operations, the company decided that the recoverable ore was not of a quality or quantity sufficient to recoup the initial investment. Faced with financial ruin, company directors decided to sue the mine's previous owners, Mexican nationals, for the return of the $800,000 purchase price. In the lawsuit, the Oro Grande Company alleged that it had hired American mining engineer Alexis Janin to survey the Mulatos, and that the company purchased the mine on the strength of Janin's recommendation. The lawsuit further implied that the ore sampled by Alexis Janin during his inspection had been "salted," or doctored, by the Mexican land-owners. While the lawsuit did not claim that Janin orchestrated the allegedly inaccurate assays, the implication was clear that the engineer had either misread the signs of salting out of incompetence, or had quietly ignored evidence of outright fraud. This was the kind of allegation that could destroy Alexis Janin's career, by making him out to be a patsy, or worse.[182]

Naming Alexis Janin in the lawsuit was a red herring, as was much of the content in the suit. Complicating matters, some months after Janin conducted his survey, and shortly before the Oro Grande Company filed its lawsuit, there was a cave-in at the mine, which reportedly "had done such damage as to seriously impair the value of the property... [and] caused the stoppage of all work in the mine." The superintendent's claim that he shipped tens of thousands of dollars of gold out of the Mulatos each month was an outright lie, Janin argued, as the ore was not that valuable to begin with, and the cave-in dislodged and rendered inaccessible much of the richest ore on-site. In Janin's estimation the disaster, rather than salting, was the reason for the company's low yields. Furthermore, his own report, based on an examination that took him seven weeks to complete with three assistants, and which covered the newest and supposedly richest portion of the underground works [much of which was subsequently destroyed by the cave-in], concluded that the likely yield from the gold on the property would be only $2.50 per ton, after deducting costs for labor and transportation. Janin himself spent several weeks corresponding with his acquaintances and with the editors at various engineering journals, explaining that his report "contain[ed] no expression of my firm

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[182] Alexis Janin to unknown recipient, 19 March 1890, folder 16, box 33, Charles Henry Janin Collection [hereafter CHJ], HL. As evidence of the strength of these allegations against Alexis Janin, they were repeated in a slightly altered form in the memoir of the eminent mining engineer, financier, and diplomat John Hays Hammond. Hammond, *Autobiography*, 159-161.

opinion of the cash value of the property, and when I consider the list of assays given complete in my report I am at a loss to understand why any one should have expected them to give a high average yield." Furthermore, he asserted, "I [would not] wish my report altered in any way, it being a perfectly clear statement of facts obtained by the best means put at our disposal."[183]

The putative existence of a "high average yield" was the critical feature of the case as brought by the Oro Grande Company. Alexis Janin firmly believed the Oro Grande Company officers intended to artificially inflate the stock value of their mine by only mining and milling the highest grade of ore at Mulatos and then promoting the mine as a high producer. The cave-in at the mine, Alexis theorized, derailed this scheme, causing the company to cry "salting" to explain why the mine failed to actually turn a profit. By linking Alexis Janin's name with the Oro Grande Company in the lawsuit, company officers hoped to capitalize on his reputation and extensive connections within the professional community of mining engineers, who took a strong interest in such a high-profile lawsuit. Company officers were fortunate, moreover, in that the publicity brought their case to the attention of Mexican president Porfirio Diaz, who offered to refund the company's investment if fraud could be proven. Once Diaz made this proclamation, nothing could be done but to send yet another mining engineer to the

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[183]Alexis Janin to E.G. De Crano, 24 March 1890; Alexis Janin to unknown recipient, 19 March 1890; Alexis Janin, "Report on the Mulatos Mining Property" 30 April 1888, Folder 16, Box 33, CHJ, HL; see also ["M&SP 1890"]; Daniel B. Gillette, Jr., "Report on Mulatos Mine, Sonora, Mexico," [n.d.], Folder 16, Box 33, CHJ, HL; and Louis Janin, Jr., *Engineering and Mining Journal* 1 Feb 1890.

Mulatos to determine if the assays checked by Janin were salted. The engineer chosen for this delicate task, purportedly by Diaz himself, was John Hays Hammond.[184]

Hammond, like the Janins, was educated at Yale and at Freiberg, and enjoyed a high reputation among his professional peers. Unfortunately, the only real record that remains of his trip to the Mulatos is his *Autobiography*, an exciting, if not particularly reliable, narrative of his swashbuckling adventures. It is also unclear who paid Hammond's salary, and as with Henry Janin in the diamond fields, Hammond's employer might have subtly influenced the engineer's interpretation of what he found on-site. In the *Autobiography*, Hammond states that there was no doubt as to the competence of Alexis Janin's survey, but that he, Hammond, quickly determined that the assay samples Janin took were salted, and that the poverty of the mine was evident as soon as the ore was run through the mill. The implication is that Alexis Janin should not have trusted assay samples in determining the value; Janin himself agreed with this methodological assessment, and insisted all along that he had desired to inspect the mine by other means.[185] Hampered by time and money, he chose to take samples and then analyze them to the best of his abilities.

The involvement of Hammond in the Mulatos case, like the involvement of Clarence King in the diamond fraud, brought a third-party engineer into the conflict; unlike the diamond case, however, Hammond's presence served mostly to create a "he said, he said" discrepancy between two technical experts — Alexis Janin, and John Hays

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[184] Hammond, *Autobiography*, 160.

[185] Hammond, *Autobiography*, 160-161; Alexis Janin to E.G. De Crano, 24 March 1890, folder 16, box 33, CHJ.

Hammond — who agreed that the mine had little value, but disagreed over whether Janin's assays had been salted or not. Alexis Janin never admitted that he had been salted, although he did argue that if his assays were tampered with "that of course relieves the experts from any responsibility; for having employed as many assistants as the means at their disposal would permit, and only trustworthy men, nothing more could be demanded of them."[186] The Mulatos scandal was in most respects a typical "salting" issue. The lawsuit suggests that a mining engineer's claim of technical expertise was limited — all the Oro Grande syndicate had to do to deflect suspicion from themselves was to claim that they had been duped, and despite Alexis Janin's concerted arguments, the Oro Grande officers were not pilloried as criminals or stock promoters. Who, after all, could expect ordinary American citizens to stand up against the intrigues of unscrupulous Mexican mining speculators? As with other aspects of this case, even the conclusion is unclear. In his autobiography, Hammond claimed that since salting was proven (by his own inspection), Diaz returned the money to the Oro Grande Company. An undated mining engineer's report from the 1910s states that the Supreme Court of California returned the mine to its Mexican owners, but makes no mention of financial settlement.[187]

The Oro Grande Company lawsuit also indicates the rhetorical utility of a mining engineer's assertions of expertise. Alexis Janin's principle weapon against allegations he considered libelous was to point to his technical work, citing at length and in multiple

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[186] Alexis Janin to E.G. De Crano, 24 March 1890, folder 16, box 33, CHJ.

[187] Hammond, *Autobiography*, 168; Pearl Skelton, "The Mulatos Mine," [n.d.], folder 16, box 33, CHJ, HL.

outlets his sampling technique and providing detailed assessments of his assay results. He could readily assert that his accusers lacked the necessary knowledge to judge his assessment, by claiming, for instance, "I am at a loss to understand why any one should have expected [my samples] to give a high average yield." In addition, he could assert his authority by "call[ing the] attention [of other engineering experts] to the unreliability of this method [sampling] of determining the value of so large a body of ore."[188]

Technical Credibility and Labor Management: Louis Janin and Concepción

Mining engineers had to assert their status as technical professionals in other aspects of their work, not only when called upon to adjudicate or investigate fraud or salting scandals. The case of Louis Janin at the Concepción Mining and Milling Company brings to the fore complicating issues in mining engineers' work with labor and in mine management.

In 1886, Louis Janin was appointed the superintendent for the Concepción Mining and Milling Co., a gold and silver mine operating in a small U.S. enclave in Michoacan, Mexico. The Concepción was owned by a group of investors from St. Louis, Missouri. Initially hired as a consultant to write a report on the mine's potential for the Board of Directors, Louis was prevailed upon to direct the operation of the mine himself, once the company determined it wanted to buy the property. He was able to negotiate several perks into his contract with the Concepción: in addition to taking partial payment in stock options and serving on the Board himself, Janin also arranged to superintend operations from the relative comfort of his business address at the Union Club in San Francisco;

[188] Alexis Janin to E.G. De Crano, 24 March 1890, Folder 16, Box 33, CHJ, HL.

providing, of course, that the company hire his choice of on-site manager. Janin, however, would retain authority for all mining decisions. Thus he occupied a position between a consultant and a manager, responsible at some level for aspects of both jobs.

Louis Janin's skillful report was only partially responsible for enabling him to negotiate such a generous compensation package. His reputation and connections were as valuable to the new company as his technical knowledge. Janin had been working in western North America since the 1860s, having first traveled to the Arizona Territory shortly after the U.S.-Mexico War. In addition to his work on the Comstock Lode, which established his reputation as a clever engineer, by the 1880s Janin had been successfully managing mines in California for years, and from his base in San Francisco had access to much of the eastern capital that was rapidly flowing to the west coast. Through his brother Henry, who was by this time established as a consulting engineer based in London, Janin also had connections to the most important capitalists of the era, including the Rothschilds.

As superintendent, Louis Janin worked from an 11-point "to do" list he evidently compiled during an on-site visit to Concepción in July 1887. This document contains the kind of technical and mechanical suggestions a mining engineer was expected to produce, such as a calculation of the cost of digging the shaft, and plans to "unwater [the] mine" through a complex series of hoists. Janin also indulged in some peevish observations about the construction of tunnels built before he took charge, which he described as having been built "Mexican fashion ... zig-zag, and not level."[189]

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[189]"Work in the Near Future," 1 July 1887, folder 1, box 1, LJ, HL.

Despite the detailed and orderly plans, engineering work at Concepción was easily derailed, and not by technical concerns. In early September 1887, he decided to fire the bookkeeper, a man named Smith, who was having some differences with Janin's hand-picked, on-site mine manager. For six weeks, Janin wrote or received one or two letters or telegrams a day concerning Smith, to the virtual exclusion of all other correspondence with the mine. The trouble with Smith, according to Janin, was that he was incompetent; a poor accountant who behaved disrespectfully towards both the manager and himself. The further trouble with Smith was that after receiving a telegram from Louis Janin terminating his employment, he refused to leave his position, claiming that the engineer and the mine manager had "acted meanly from the start and... not worked in the interest of the co[mpany]."[190] Smith's refusal to step down infuriated Janin, who in turn insisted that he "alone represented the Board, and... [he] must have obedience from every subordinate, without any division of authority."[191]

In thus asserting himself, Louis Janin received no support from the Board of Directors, who were of the opinion that the mining engineer was in charge of the mine works only, and so lacked the authority to remove an office employee. Furthermore, the president of the company explained to Louis, "I have the utmost confidence in Mr. Smith [the bookkeeper], and... am utterly at a loss to understand how he could have acted in a manner to lose the confidence of [both the manager] and yourself."[192]

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[190] D.W. Kline to Louis Janin, 7 September 1887, folder 1, box 1, LJ, HL.

[191] Telegram, Louis Janin to James Blythe, 8 September 1887, folder 1, box 1, LJ, HL.

[192] Telegram, D.W. Kline to Louis Janin, 9 September 1887, and J.W. Blythe to Louis Janin, 10 September 1887, folder 1, box 1, LJ, HL.

Up to this point, the difficulties Janin had with bookkeeper Smith could be described as typical of a mid-level manager powerless to control his subordinates (due to his physical distance from the mine) and undercut by his superiors. But Louis Janin was not working for a large and faceless corporation: he was himself a member of the Board of Directors of Concepción, and he was on very friendly terms with many of the other Board members. He was also the sole technical informant for the Board, which mistrusted the on-site manager. Despite his close relationship to the members of the Board, they were unwilling to hear anything Janin had to say that did not involve engineering, which was one reason he failed to persuade the Board that Smith's work as a bookkeeper was detrimental to the health of the mine. Janin's vision of the scope of an engineer's work was more expansive that that of the Board. He construed his realm of expertise broadly; they construed it narrowly. The Board failed to understand that the mine was embedded within a Mexican community; when the bookkeeper at Concepción skimmed profits off of the top, and took sides in local political affairs, as Louis believed Smith had, such actions affected the workers at the mine, and the work—both technical and otherwise—accomplished.

Without the support of the Board of Directors, there was little Louis Janin could do, either to proceed with his engineering plans or to quiet the increasing discontent of the people he referred to as "Peon's" —the miners and support workers at Concepción. By attempting to fire the bookkeeper, Louis Janin unwittingly placed himself in the center of a complicated local power dispute that escalated on a daily basis. There were reports that a local strongman, allied with Smith, was rallying to the streets crowds of workers shouting "'Death to the Americans.'" Terrified American employees refused to show up for work, and the Mexican miners, for all intents and purposes, went on strike.[193] Louis Janin's correspondence with his on-site manager mine at this point was entirely given over to this labor dispute, and he despaired over what he considered to be the foolishness of Mexican miners who were willing to disobey the directives of a man (himself) who was to a large degree responsible for their employment.

Given the Board's insistence that Janin was a "practical" miner, it is curious that the bulk of the correspondence between the mining engineer and the President of the company concerned labor problems at the mine —those same problems which the Board insisted that, as an expert technician, Louis Janin had no right to oversee. Janin himself considered the labor problems to *be* technical problems, and therefore under his jurisdiction. The President wrote to Louis Janin of his dissatisfaction with the on-site manager: how the manager had not sent proper reports to the Board the previous month; how it was impossible to get information about the progress of draining the mine; how the expenses at the mine seemed to be excessive, especially given "the cheap Mexican labor, and the relatively low price of supplies."[194] The Board, furthermore, mistrusted the Mexican system of contract mining.[195] In a contract system, individuals and groups of miners signed contracts to produce certain lengths of tunnel, with payment based on their estimate of how long such work might take. Unlike an hourly or daily wage, this system

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[193]Amelia Kline to Louis Janin, 14 September 1887, folder 1, box 1, LJ, HL.

[194]James Blythe to Louis Janin, 11 October 1887, folder 1, box 1, LJ, HL.

[195]The Mexican system of contract mining is very similar to that of Cornish miners. See Larry Lankton, *Cradle to Grave: Life, Work, and Death in the Lake Superior Copper Mines,* (New York: Oxford University Press, 1991), 62-63.

removed the miners from the direct supervision of the local manager or mine foreman. If the contract were held by a miner who placed value on the well-being of his workers —a wise move for a contractor, as then he had stronger workers who could accomplish more —it could give miners significant leverage to enact work slowdowns or to renegotiate their wages. If the contract were held by a person with more despotic tendencies, there was no way for an employer to assure that the miners were being treated fairly or receiving their share of the pay. This could lead to significant conflict on-site. In short, contracts were usually an expensive system to manage, and the Board was desperate to introduce a tiered system of wages. However, given the violence of the worker dissatisfaction provoked by the Smith debacle, neither Louis Janin nor the on-site manager was willing to implement a system that might, once again, stop work at the mine.[196]

More than anything, Janin wanted labor relations to be left in the hands of the on-site manager, who reported to Louis Janin directly. Rather than agreeing to this

[196]D.W. Kline to Louis Janin, 19 October 1887, folder 1, box 1, LJ, HL; Otis Young, *Western Mining: An Informal Account of Precious Metals Prospecting, Placering, Lode Mining, and Milling on the American Frontier from Spanish Times to the Present*, (Norman: University of Oklahoma Press, 1970), 191. Note that in copper mines throughout the U.S. west in the early 20th century, engineers liked to implement a contract system, as they felt it inspired workers to more efficient production (Hovis and Mouat, "Miners," 453). At Concepcion, it seems likely that the low grade of the ore, coupled with the expense of transporting it to surface, combined with management's disdain for Mexican workers in wanting to avoid the use of contracts.

suggestion, the President continued to pepper Janin with questions about new equipment and about neighboring properties.[197] He expressed concern about the low grade of the ore that was being excavated, and demanded that neither the manager nor Janin sign any contracts for labor or equipment without first sending those contracts to St. Louis for approval by the Board. This last demand, which Louis Janin did his best to ignore, effectively removed the engineer from oversight of those technical matters he was hired to superintend. Although the Board of the Concepción was responding to a particular problem in a particular mine, this kind of conflict between Board and engineer was not unusual, particularly for men of Louis Janin's generation. Trained at Freiberg by mining engineers who worked in the German context at small-scale mines operated by apprentice-trained miners and superintendents, men such as Louis Janin had to learn how to navigate the different labor conditions of North America on their own, and they learned that labor management was a critical aspect of technical work. Without a competent and well-trained workforce, mining simply could not occur, and by the late nineteenth century, apprentice-trained, experienced miners were in short supply, given the massive increase in the number of mining projects underway in both Mexico and the United States. It may be that previous experience with a Mexican labor force led Louis Janin to decide to employ workers who operated on the contract system rather than as wage laborers, as he may have previously found contractors to be easier to manage.

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[197]James Blythe to Louis Janin, 20 October 1887, folder 1, box 1, LJ, HL; Louis Janin to James Blythe, 2 November 1887, L-2, LJ, HL; James Blythe to Louis Janin, 2 November 1887, folder 1, box 1, LJ, HL.

The labor unrest at the Concepción Mining and Milling Company highlights the incongruous job requirements of late-nineteenth-century mining engineers. Louis Janin was expected to be knowledgeable about mining practice and equipment and to ensure that work proceeded apace. But there was also an implicit understanding that he would be able to interpret local labor politics and practices well enough to prevent discord within the ranks. He obviously failed in this regard. This can be attributed, in part, to his actual physical distance from the mine. San Francisco is several thousand miles from Concepción —a difficult journey of multiple days. Louis Janin's failure can also be blamed on the inherent complexity of the role of mine superintendent. As superintendent and technical expert, a mining engineer was supposed to be a voice of reason — this is why the Board of Directors paid him a rather high salary. Janin clearly considered himself the final arbiter of work on the ground. He conceived of himself as the authoritative voice at the mine; that he was considered by the Board, to be *only* a "technical expert" was galling, emasculating, and ultimately undermined his authority. As Louis Janin wrote to the president of the Board: "I do not claim that I was opposed in Engineering details. —that would have been too much —But every policy suggested has been rejected or so hampered as to become useless."[198] When he was fired, in late October 1887, Janin contemptuously declined the company's request that he remain available for consultation on an as-needed basis, on the grounds that "from the very start

[198] Louis Janin to James Blythe, 2 November 1887, L-2, LJ, HL.

there has been uncalled for opposition and distrust" in the management on the mine [emphasis in the original].[199]

Louis Janin's expertise—his education at Yale University and the Freiberg Academy; his connections among elite businessmen in both New York and California; his record of success in mining projects; the very credentials that made him a successful mining engineer—enabled the Board of Directors to cast aside his suggestions with respect to managing the particular challenges of mining in Mexico, on the grounds that his work *ought to be* theoretical and technical in nature.[200] Following the lead of Smith, who complained that Louis had no authority over the mine, the Board of Directors explained to the engineer that although "it is true we are not miners or experts, but we propose to run this property on strictly business principles" —as if Louis Janin himself were not aware of the need for the Concepción to turn a profit.[201] Here again, the specificity of the conflict between Janin and the Board highlights a more general problem facing mining engineers who asserted the validity of their technical knowledge in combatting complex problems on-site at a mine. By virtue of their training and broad experience at many different mining sites, mining engineers considered themselves to be experts on not simply the technological apparatus needed to extract ore, but on all the mining operations, including the labor force, that supported that apparatus. Company

[199]Louis Janin to James Blythe, 20 October 1887, L-2; James Blythe to Louis Janin, 26 October 1887, folder 1, box 1; Louis Janin to James Blythe, 2 November1887, L-2; James Blythe to Louis Janin, 2 November 1887, folder 1, box 1, LJ, HL.

[200]Rossiter W. Raymond, [Obituary], AIME Transactions 49 (1914): 831-836.

[201]James Blythe to Louis Janin, 5 December 1887, folder 1, box 1, LJ, HL.

owners, by and large, saw separate spheres of expertise: engineering, and personnel management. Mining engineers understood this distinction (as Louis Janin noted, “I do not claim that I was opposed in Engineering details”), but found it flawed. If more than engineering was required to run a mine, and mining engineers were responsible for running the mine, then mining engineers considered that “more” to be within their purview. As at the Concepción, however, engineers often had a hard time making the case that they were knowledgeable about nonengineering matters, or that personnel issues were within their realm of expertise.

Indeed, how was a mining engineer to demonstrate that he had “expertise” in management or personnel matters? Prospective mining engineers did not study management in college — there was no academic field of business training in which they could be schooled until well into the twentieth century. The only way that a mining engineer could demonstrate expertise as a manager was through working in managerial positions. On the basis of his resume, Louis Janin should have had no trouble declaring himself an expert at mining in Mexico. In the 1860s, Louis Janin had been among the earliest mining engineers to travel into the Arizona Territory; he followed up on his tremendous success milling silver in the Comstock Lode with stints as a managing engineer at several mines in Mexico in the 1870s before striking out on his own as a consulting engineer.[202] While Louis Janin understood the impact of labor discord on

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[202]Raymond, [Obituary], 831-836; Browne, *Adventures...,* 271-273; Louis Janin, “Report on the Harshaw Mining Property,” (New York: Spectator Company, 1879); [Louis Janin], “Report of Louis Janin, M.E., on the Harshaw Mining Property...” (San Francisco: Spaulding & Williams, 1879); A.D. Hodges, “Amalgamation at the Comstock Lode,

operations at Concepción more clearly than did the company's Board of Trustees, he just as clearly could not control the relationship between the mining economy and the local political situation. It was widely believed among mining engineers and investors in the nineteenth century that very few Americans had the "skill in handling Mexicans" thought to be required to be a successful labor manager in Mexico.[203] By virtue of his extensive time in Mexico, Louis Janin was perceived to have such skills; yet since the workforce at Concepción was not tranquil, his managerial expertise was readily dismissed by the Board. An expert manager would not have let the situation get so out of control, regardless of the external situation at the mine.

An important aspect of the industry's recognition of the expert, or specialized, technical knowledge of mining engineers is that the acknowledged value of expertise varied depending on the context in which it was asserted. In situations where investors felt nervous about their investments, or where they may have thought themselves to be in

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Nevada," AIME Transactions 19 (1890): 195; [Obituary], *Engineering and Mining Journal* 97:12 (21 March 1915); [Obituary], *Mining and Scientific Press* 108 (14 March 1914).

[203]For examples see: Louis Janin to James Blythe, 11 December 1887, L-2, LJ, HL; Louis Janin to James E. Blythe, 18 February 1888, L-2, LJ, HL; James Blythe, Jos[eph] T. Donovan, and Geo[rge] A. Bannantine to Board of Directors, 12 October 1887, folder 1, box 1, LJ, HL; and R.A. Arnold to L. Janin, 18 March 1888, folder 1, box 1, LJ, HL. See also, [Morris Parker Memoir], 77, folder 1, box 1, MBP, HL, and Robert Jarvis to Samuel Colt, 25 September 1858, and 26 May 1859, C-47, box 19, Jarvis-Robinson Family Papers, Beineke Library, New Haven, CT.

over their heads, such as the diamond mines incident, or in establishing a profitable American export economy in Michoacan, far from the U.S. border, *technical* expertise — and only technical expertise — was highly valued by financial investors. A circumstance more familiar to American investors —for instance, a conflict with a Mexican landowner in Sonora, such as that at the Mulatos in which Alexis Janin was involved — meant investors were more likely to question the technical literacy of an expert, such as Alexis Janin, but also forced investors to entrust yet another technical expert with determining the rights of the situation. That such contradictory attitudes towards engineering expertise were all in play highlights the balancing act in which mining engineers had to engage when asserting their professional status, as they decided whether to emphasize their social status, familial connections, or technical proficiency in a given professional situation. For mining engineers such as the Janin brothers, the fact of their superior knowledge and technical abilities was paramount, but they operated within a small fraternal world of school connections and social status, and had to choose carefully which networks to tap into at different times in their careers. When they were hired for a job, mining engineers considered that their years of training and fieldwork entitled them to high salaries and the respect of both their employers and employees. In the surveillance of fraud, mining engineers found that although university-gained technical expertise was not infallible, it gave them a critical tool for arguing for the validity of their claims and opinions, and had real weight in the eyes of investors, financiers, and other mine workers. In labor management and mining operations, however, mining engineers' claims of technical proficiency could be used against them, and served to undermine their claims to authority in these other realms of mining work.

Technical expertise, the aspect of mine engineering that most set engineers apart from other mine workers, was a double-edged sword in mining engineers' attempts to establish the credibility and authority of the new profession in the business world of mining.

Chapter Four

Westering Easterners:

Mining Engineering Identity

In the 1870s and 1880s, Mary Hallock Foote, the wife of Columbia-educated mining engineer Arthur De Wint Foote, traveled with her itinerant husband to several major mining sites, including Leadville, Colorado, Grass Valley, California, and a mine in Michoacan, Mexico. Although socially well connected, Arthur Foote did not enjoy a particularly successful career as a mining engineer, and for much of the late nineteenth century, his wife supported the family with a career as an author and illustrator for literary magazines such as *Putnam's*, the *Atlantic Monthly*, and the *Century Illustrated Monthly Magazine*. The success Mary Hallock Foote found in the literary world was due to her ability to interpret, for a predominantly northeastern educated audience, the exotic nature of the places her husband worked. In a memoir published after her death, she described her husband's circle of friends as "professional exiles" and "remarkable men, cultivated, traveled, [and] original."[204] While this depiction of her husband as an "exile" probably says more about Hallock Foote's own mixed feelings about living apart from her literary friends in New York than about her husband's attitude towards mining camps and miners, the gulf to which she alludes between the class background of university-

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[204]Mary Hallock Foote, in Rodman W. Paul, ed., *A Victorian Gentlewoman in the Far West: The Reminiscences of Mary Hallock Foote,* (San Marino: Huntington Library, 1972), 133, 130. Arthur D. Foote's friends included Louis and Henry Janin, as well as James D. Hague, who was married to Foote's sister.

educated mining engineers and that of almost everyone else in a mining camp was real.[205] Class affiliation underpinned the professional identity of mining engineers through the late nineteenth century, not only on-the-ground in mining camps but also in the popular perception of mining engineers and in mining engineer's self-presentation in the drawing rooms and board rooms of New York and San Francisco.

Through the early years of the twentieth century, as mining engineers were increasingly drawn from the ranks of college educated men, their class status was clear – they were, after all, the sons, brothers, and classmates of mining investors and capitalists. Historians have long noted that there is a fundamental conflict between engineering professionalism and the business interests that engineers serve. In *The Revolt of the Engineers*, Edwin Layton writes that mining engineers could never truly separate their expertise from their collusion with the company line. In essence, Layton argues, mining engineers were businessmen first, and principled expert advisors second, and this

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[205]The work of Richard H. Peterson, "The Frontier Thesis and Social Mobility on the Mining Frontier," *The Pacific Historical Review* 44:1 (February 1975): 52-67, demonstrates that although men defined as "mining magnates" experienced tremendous social mobility on the mining frontier between 1870-1900; however, these men were exceptional in their communities, which were characterized by a racially and ethnically diverse, economically impoverished, itinerant workforce. Wallace Stegner's Pulitzer Prize-winning novel, *Angle of Repose,* (New York: Doubleday, 1971), loosely based on the lives of Mary Hallock Foote and her husband Arthur D. Foote, offers a lightly fictionalized portrayal of the intermingling of mining engineers and elite New York society in the 1870s.

conflation of roles made mining engineers the most ethically compromised and least professional of the engineering fields.[206] Mining engineers would probably have disputed this claim, and indeed the distinction between businessman and advisor within mine engineering was fuzzy at best. Sometimes the only evidence that a mining engineer did a good job was that a mine turned a profit. In this regard Layton is correct – mining engineers were deeply interested in the fortunes of the companies they worked for, even if they served only as employees and were not actually stockholders or in upper-management. As success for a company meant success for an engineer, however, it is not clear that "good business" for a mining engineer and "principled technical professional" were two separate things. Rather, technical knowledge was at the heart of the professional identity of mining engineers, and they worked hard, as individuals and as a group, to present themselves as competent technical professionals rather than as spokesmen for any given company or for the industry as a whole.[207] For mining engineers working in the borderlands, the distinction between company man and technical man was particularly complicated, as the "company," as such, was not readily present to protect them and enforce their authority in these liminal spaces. The central offices and investors were, in general, located far off-site, usually in centers of capital such as New York or San Francisco. When on-site at a mine even a very junior mining

[206] Edwin Layton, *The Revolt of the Engineers: Social Responsibility and the American Engineering Profession,* (Cleveland: Case Western, 1971), 33, 35.

[207] Although a few well-known mining engineers spent the bulk of their careers working for only one company – James Douglas is the most prominent example – in the 19th century the vast majority of mining engineers changed employers frequently.

engineer was usually among the highest ranking company officials present. Consciousness of their status pervaded the quotidian workplace interactions of mining engineers and, in concert with their status as technical workers, underpinned the professional identity of "the mining engineer." Mining engineers negotiated their bureaucratic status most notably by embracing their self-image as westering frontiersman. This quintessentially American identity both reified their racial status as white men and had a fundamental classlessness that could paper over the obvious status distinction between mining engineers and the mass of mine workers.

By the late 1800s, due to changes within the mining industry and the profession of mine engineering discussed in chapter two, the technical skill of mining engineers was valued by mine promoters throughout the borderlands. With increased U.S. military presence through the southwest after the Civil War, mining operations in Arizona, for instance, were becoming viable in ways they had not been in the 1850s and 1860s. As the odds that a given mining project would be successful improved, the drive on the part of the industry to obtain more capital also increased. Mining engineers remained an important piece of the fund-raising puzzle. Their expertise was still pointed to as providing a reason to invest in a given mine, and mining engineers themselves, whether working as consultants, project engineers, or managers, often reported directly to a mine's investors either in paper or in person.[208] To be professionally successful, mining

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[208]Michael N. Greeley, "The Early Influence of Mining in Arizona" in Greeley and J. Michael Canty, eds., *History of Mining in Arizona, vol. 1* (Tucson: Mining Club of the Southwest Foundation, 1987), 18-22; William Robbins, *Colony and Empire: The Capitalist Transformation of the American West,* (Lawrence: University Press of Kansas,

engineers depended upon their ability to merge their roles as technical experts with other professional duties and obligations -- namely, to reconcile their work as consultants and managers with different class, gender, and self-consciously "western" identities, as they asserted themselves within an industry that required a steady flow of capital. As consultants, mining engineers had to communicate with mine owners, board members, and their agents – those people in the mining industry most associated with finance. As managers, mining engineers were responsible to the capitalists, but principally interacted with mine superintendents, foremen, and miners in the field.[209] In addressing each audience, mining engineers used distinct rhetorical strategies to present themselves as expert technologists who were qualified to assess mining claims and create plans for exploitation. Within their professional community, mining engineers adopted a discourse of identity that drew upon aspects of a distinctly American pioneer narrative to underscore their competence to assess and administer such risk.

1994), 25; Stanley Buder, *Capitalizing on Change: A Social History of American Business,* (Chapel Hill: UNC Press, 2009), 108-109; 123-125.

[209]Mining statistics of any kind are difficult to come by for the 1860s-1880s; by the 1890s, Clark Spence estimates that approximately one-third of university -trained mining engineers were working in managerial positions. Clark Spence, *Mining Engineers and the American West: The Lace Boot Brigade, 1849-1933,* (New Haven: Yale University Press, 1970), 139.

From the 1860s onwards, the drama of working in western territories was a critical aspect of the professional image of mining engineers.[210] Raphael Pumpelly's memoirs exemplify the portrayal of mining engineers as men in the heart of "westering" conflict, although his tendency to portray himself as scared and overwhelmed is unusual for published work. Within a couple of decades, tales of the "Old West" had become one of the defining features of professionals working in this region. One engineer, who grew up in Missouri in a town whose bank was robbed in 1873 by Jesse James, was inspired to study mining by his desire to see the "real" West. Of his first trip to New Mexico and Arizona, in 1888, he noted "from what I read and had been told I expected the boys to wear their guns and spurs while dancing, but instead I found them a jovial lot."[211] An

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[210]On American companies mining in the borderlands in the 1850s and 1860s, see chapter one. Raphael Pumpelly, *Across America and Asia: Notes of a Five Years Journey Around the World, and of Residence in Arizona, Japan, and China,* 2nd ed., rev. (New York: Leypoldt and Holt, 1870), and *My Reminiscences,* (New York: H. Holt &Co., 1918). Other widely read portrayals of mining in Arizona include J. Ross Browne, *Adventures in the Apache Country: A Tour Through Arizona and Sonora, with Notes on the Silver Regions of Nevada,* (New York: Harper & Bro, 1869), and Charles Poston's narrative essays, collected in *Building a State in Apache Land: The Story of Arizona's Founding as told by Arizona's Founder*, ed. John Myers Myers (Tempe: Aztec Press, 1963).

[211]"Life and Travels of a Mining Engineer," folder 2, Joseph E. Obermuller Papers [hereafter JEO], Arizona Historical Society, Tucson [hereafter AHS]. For examples of the discussion of native hostilities, see E.E. Olcott to W. E. Dodge, 20 September 1881

obituary for Louis Janin by his old friend and colleague Rossiter Raymond made a great deal of Janin's early experiences with the Butterworth Expedition in Arizona, explaining that Janin's choice of career was directly related to the allure of the West he felt as a young man. Janin cared little for the domestic political and military dramas of the 1860s, according to Raymond. "[His] thoughts had long been turned to the new, wide, free region further West..., [he was] already enlisted for that war which .... was waged by an army of prospectors and miners, for the physical conquest of a new Empire." Even James Douglas, mining engineer and head of the Phelps Dodge Company which held mining operations throughout the borderlands, told a story about feeling like a tenderfoot when he first visited a bar in Arizona in 1881, and his fear at the time that someone would notice how foreign he found saloon culture.[212]

Mining engineers whose lived experiences of southwestern travel were legitimately "wild" did not necessarily enjoy those times in their careers when their lives were in danger.[213] In later years, however, that did not prevent them from indulging in nostalgia for the "old west," nor did it prevent them from perpetuating those stories when they had the chance. The romance of the wild west remained an important narrative strand in mining engineers' reported memories of their early years in the field. "I heard of Harry's adventures in Arizona [in 1865]," wrote Raphael Pumpelly to his friend Louis

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and W.E. Dodge to James Douglas, 12 October 1881, folder 30, box 3, James Douglas Papers [hereafter JD], AHS.

[212]Rossiter W. Raymond, [Louis Janin Obituary], *AIME Transactions* 49 (1914): 831-836; [Introduction to the West], folder 53, box 4, JD, AHS.

[213] See chapter 1.

Janin, “and recognized the ‘philosopher’ in the coolness of his demand for spectacles, while under fire.”[214] In this account Pumpelly, who was familiar with how genuinely discomfiting western adventures could be, grants Henry Janin one of the most prized attributes of a man of learning, grace under fire. The “adventures” to which Pumpelly alludes occurred in Arizona, suggesting that Janin’s party was besieged, possibly by the same forces that so traumatized Pumpelly. That what Pumpelly finds to admire in the story is Henry Janin’s grace under pressure – his call for something that clearly defined him as an educated man, his glasses, no less -- is indicative of the significance of these events as personal touchstones within the profession. Pumpelly suggests here that even extreme circumstances, a mining engineer thinks carefully, and logically, and demands the proper tools for pursuing his agenda.

The image of the engineer as westering adventurer inspired young mining engineers starting their careers. As one mining engineer cogently recollected, he and his colleagues were “entranced and thrilled with... the glamour and adventure that appeared closely associated with such an occupation.”[215] In letters home, and in columns in local and national magazines, mining engineers portrayed themselves as quintessential American adventurers. Their chosen profession, they argued, “has a life, a speculation, a

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[214] Raphael Pumpelly to Louis Janin, 1865, Raphael and Eliza Pumpelly Papers, II, box 5, Huntington Library.

[215] Fred Bailey, No. 115, Oral History Collection, C. L. Sonnichsen Special Collections Department, University of Texas at El Paso, El Paso [hereafter UTEP].

profit, [and] a vitality... well suited to the American character."[216] At the Colorado School of Mines, wearing a Stetson, the iconic hat of the western frontier, was a privilege reserved for "manly" seniors and the younger students eagerly awaited their chance to break-in their hats.[217] Many mining engineers explicitly related themselves and their working lives to the narrative of American westward movement.[218] This attitude towards mine engineering was summarized in a short essay entitled "The Engineer was Here" appended to a note thanking James Douglas for providing the author, Frank Aley, with transportation to Douglas, Arizona. While clearly a paean to Douglas personally, the qualities Aley attributed to Douglas were general rather than particularist personal quirks. Aley describes Douglas as being both like a "prosperous, intelligent farmer," necessarily attuned to detail and cautious by nature, and also like a railroad engineer, responsible for "pull[ing] the throttle that turns the main shaft" of the Phelps-Dodge train. Of the "wonderful system of commercial progress in Arizona and Sonora… he is the Engineer." In Aley's narrative of development, early mining engineers, including James Douglas, traveled to Arizona and Sonora when the country was wild and "pioneered" the establishment of mining camps and companies. When the companies prospered, mining engineers remained as the civilizing and productive forces in the economy working, in

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[216]Almarin B. Paul, "Gold and Silver Mining," *Pacific Coast Annual Mining Review and Stock Ledger...,* (San Francisco : Francis & Valentine, 1878), 129.

[217] Timothy LeCain, *Mass Destructio: The Men and Giant Mines that Wired America and Scarred the Planet*, (New Brunswick: Rutgers University Press, 2009), 57.

[218]"Life and Travels of a Mining Engineer," folder 2, JEO, AHS; Frank Aley, "The Engineer was Here," folder 77, box 5, JD, AHS.

Aley's words, "persistently, hopefully, and with profound discretion, playing the wonderful game of progression with Dame fortune." However overblown Aley's prose, he clearly links Douglas, and through Douglas, the mine engineering profession, to what historian Frederick Jackson Turner the characteristic "American intellect": "acuteness and inquisitiveness; that practical, inventive turn of mind, quick to find expedients; that masterful grasp of material things… that restless, nervous energy."[219] Aley's many and conflicting analogies of a mining engineer's importance – the engineer as farmer, as driver, as economic mastermind – all relate to a concrete mechanical ability, the mining engineer's "masterful grasp of material things." To Turner, the presumed individualism and intellectual attributes of the frontiersman were significant because they nurtured the growth of democratic institutions. For mining engineers, ingenious creativity in solving practical, technological problems was a key responsibility. This valorization of supposedly practical skills was internalized by mining engineers as an aspect of their own work out west. Indeed, a critical facet of mining engineers' identification with the pioneer spirit was that it served to protect them, in their own eyes at least, from accusations that their university training, designed to give a technical understanding of mining, actually rendered them soft and unable to understand the physical nature of the work.

As part of mining engineers' identification with a pioneering masculinity, they were careful to explain, both to one another and to their friends and families back east, that their work required physical stamina and a certain comfort with discomfort.

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[219] Frederick Jackson Turner, "The Significance of the Frontier in American History," in *The Frontier in American History,* (New York: Holt, 1921), 37.

Nobody, one engineer asserted, should join the profession who lacked "the physique necessary to stand a great deal of hardship in all kinds of climate."[220] To reach the most remote mining camps in the Southwest and Mexico, mining engineers had to ride on horse or mule back for days, sometimes weeks. The work of mapping and surveying a mine could take several months and involved walking miles a day, both above and below ground. As managers, good mining engineers spent several hours a day in the loud, hot, and stuffy world underground, actively supervising the work of miners: ensuring that cuts were made in the proper direction; or setting up and maintaining water pumps to clear the mine shaft. Engineers spoke amongst themselves disparagingly of "'the ladies walks' of the mine" which they had all at one time taken or led. The phrase described those mine tours that avoided all of the dirty or unpleasant places, suitable, therefore, for "ladies," or for those men who needed to be "shielded" from the workings of the mine, such as eastern investors, or (probably more often) technical experts employed by rival mine owners.[221] As women were to be sheltered from making arduous or overly technical visits into the mine; so men who could not handle the rugged world of the mines were to remain in a sphere wholly separated from the real work of mining. The implication is apparent that mining engineers themselves did physically and mentally challenging, thoroughly masculine work.

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[220]T.A. Rickard, *Interviews with Mining Engineers* (San Francisco: Mining and Scientific Press, 1922), 111.

[221][JEH] to H.M. Dieffenbach, Esq, Mexico City, 29 June 1907, folder 53, box 3, Hyslop-Beckmann Collection, UTEP.

The audience for such demonstrations of masculinity was clearly other mining engineers, who needed to be reassured that they belonged in the field, and in their chosen profession, and that they were not "tenderfeet" with no practical knowledge of hardship. As Gail Bederman has noted, the ideology of manhood is comprised of many strands of cultural meaning, and is internally contradictory. Whether born to privilege or merely aspiring to it — early mining engineers were mostly born to privilege, while men who got their start after the late nineteenth century were more likely to pursue the profession out of social ambition — mining engineers shared an interest with other privileged white men in projecting themselves as genteel, respectable, and of strong moral character, traits associated with a Victorian notion of manliness. Yet they also took pride in their physical endurance, and in those experiences that set them apart, and that called upon them to embrace a more modern concept of masculinity, one emphasizing physical strength, risk taking, and virility.[222] In this emphasis on physicality they followed the very public example of Theodore Roosevelt, who valorized the out-of-doors and who held himself up as the very embodiment of the strenuous life.[223] At a time when

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[222] Gail Bederman, *Manliness & Civilization: A Cultural History of Gender and Race in the United States, 1880-1917,* (Chicago: University of Chicago Press, 1995), 7, 10-11, 18-19.

[223] Bederman connects TR's embrace of his identity as a "cowboy-fighter" with the racial imperialism of the westward expansion of the U.S. and Roosevelt's own concern about the decline of the white race. See Bederman, ch. 5 passim. "The Strenuous Life" is the title of a speech Roosevelt gave in 1899 setting out his philosophy that vigourous activity was necessary for the health and well-being of the nation. Although Roosevelt's purpose

professional men chose safe, sedentary, interior livelihoods, mining engineers chose for themselves a physically demanding profession that had them battling the elements more often than not.[224] This is in contrast to their peers in other realms of engineering, who did not tend to work in quite such remote locations as most mining camps or operate under such physical hardship, and in general spent a great deal more time in the drafting room than in the field. As Timothy LeCain has noted, many mining engineers loved outdoor life. They gloried in the beautiful vistas they saw when traveling to and from mining sites, and considered their work to be respectful of the bounty of nature rather than the violent extraction of the same. Indeed, many considered working in the rugged wild to be chief among the benefits of their line of work.[225]

The desire of mining engineers to embrace a more virile concept of manhood was apparent into the twentieth century, when mine investors were more likely to travel out to mining sites to see the prospects for themselves. By this time, travel to remote mining camps was no longer quite as daunting as it had been in earlier decades, although it was still not without challenge. The physical risks that earlier regional mining engineers took

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in the speech was to argue for a vigourous and engaged foreign policy – in particular, in favor of war with Spain and the construction of the Panama Canal – a secondary thrust of the speech was in support of individual action: "the highest form of success [comes]… to the man who does not shrink from dager, from hardship, or from bitter toil, and who out of these wins the splendid ultimate triumph." Theodore Roosevelt, *The Works of Theodore Roosevelt*, (New York: Century, 1901) 3-22.

[224] Rotundo, *American Manhood*, 167-168.

[225] LeCain, *Mass Destruction*, 55-57.

as a matter of course simply to reach mine sites were no longer necessarily a part of the job. Rather, mining engineers now supported their adopted identity as virile outdoorsmen by acerbically distinguishing the discomforts inherent to their work to the comforts embraced by their more sedentary counterparts. Joseph Obermuller's smug recounting of a story about a group of investors he encountered near Nacozari, Sonora in about 1905, who were unprepared for the difficulty of traveling around Mexico and had been obliged travel to the Tigre Mine on mules, offers a good indication of how mining engineers viewed these excursions:

> Anyone that ever rode a freight mule can best understand what these men must have endured, especially as most of them had never been in a saddle – all being business, or one should say office, men not used to hardships.... Some of them were sore in mind and body. Others got a thrill and were inclined to joke, while others resented anything funny.[226]

Obermuller paints a comical picture of a group of bumbling dandies, many of whom had never ridden a horse let alone a mule, tramping through the Sonoran desert. This story also implies that Obermuller himself was no stranger to the discomfort of riding a freight mule – and, by extension, that this surely uncommon occurrence was something that most mining engineers would have experienced at one time or another. Tales of the antics of investors in the field, and the utter lack of physical confidence demonstrated by so-called "office" or "business" workers were a trope of mining engineers' storytelling. Such mockery of investors asserted mining engineer's physical superiority to their employers,

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[226]"Life and Travels of a Mining Engineer," folder 2, JEO, AHS.

and served a parallel purpose to the mockery of mining engineers practiced by working miners – as comfort to men who had little control over the vagaries of their existences, at least as related to the mining industry.[227]

With such a clear sense of themselves as physically tough, mining engineers were particularly sensitive to the charge that they were unable to understand the needs of ordinary miners. Their attempts to manage a labor force were intimately connected to their understanding that they were sophisticated professionals with a distinctive western, and thoroughly masculine, status.[228] In management, mining engineers embraced the suggestion that they were rugged western adventurers working in one of the most physically demanding industries in nineteenth-century America. Mining engineers' imagined identity as frontiersmen had particular resonance in the borderlands region in the later decades of the nineteenth century, ultimately influencing the work of mining engineers as managers and supervisors in the homosocial labor world of the mine.

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[227]Many scholars have pointed to a sense of independence as the crucial identifying attribute of self-consciously "western" men. See Laura McCall, "Introduction," to Matthew Basso, Laura McCall, and Dee Garceau, *Across the Great Divide: Cultures of Manhood in the American West,* (New York: Routledge, 2001), 3. On the mockery of mining engineers by working miners, see chapter two.

[228]Amy Greenberg's concept of "aggressive" antebellum manhood is a better model for "western" masculinity than a more amorphous "beholden to no man" sentiment. Amy S. Greenberg, *Manifest Manhood and the Antebellum American Empire,* (New York: Cambridge University Press, 2005), 13.

The internal contradiction of mining engineers' embrace of the "frontiersman" iconography is apparent. There is an anti-intellectual bias evident when mining engineers presented themselves as frontiersmen, which is in notable contrast to the class background of the vast majority of mining engineers noted by observers such as Mary Hallock Foote. Historian Clark Spence described western mining engineers in the late 1870s and 1880s as "remarkably sophisticated men.... no other group in the West was as well traveled and as well educated."[229] By virtue of their formal education and generally broad experience in the world, mining engineers were members of the cultural elite at the end of the nineteenth century. The erudition of educated mining engineers served them well in the drawing rooms and social clubs of New York or San Francisco, where many maintained permanent offices. But this same technical training, which assured mining engineers of their status as technical experts and provided the social authority for their work also implied a lack of hands-on experience which mining engineers strove to combat.

Agreeing to take control of the day-to-day workings of a mine was a calculated risk, one that could end poorly for both a mining engineer and the mine owner. Experienced mining engineers were well aware that the culture of apprenticeship that dominated western mining labor into the late nineteenth century valued length of service over possible depth of theoretical knowledge. Although the complications of hard-rock mining demanded the managerial and technical expertise of university –trained mining engineers, any mining operation that relied on high-grade ore – which is to say, most

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[229]Spence, *Mining Engineers*, 332; John B. Rae, "Engineers are People," *Technology and Culture* 16:3 (July 1975): 414.

heavy-metals mining prior to the turn of the century – also relied on skilled miners, who knew first-hand when an engineer made a bad decision, because they were responsible for searching for non-existent ore bodies.[230] As one engineer explained, a skilled miner could "find... out very quick whether his superior possesses the required knowledge, or not, and if not, is impudent enough to criticize and ridicule him."[231]

Exacerbating the anxiety many mining engineers felt about exerting their authority over skilled miners in remote mining camps was their deeply conflicted sense of masculine identity.[232] Historian of engineering Ruth Oldenziel discusses the role of class in the dueling notions of manhood that were present in canal-, rail- and bridge-building labor camps of the late nineteenth century. Oldenziel argues that such "labor camps… were largely societies of men, where hard living, hard working, and hard drinking were cherished values, reminding many an aspiring engineer of the kind of proletarian manhood they were determined to avoid at all costs."[233] Aspiring civil and

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[230]Logan Hovis and Jeremy Mouat, "Miners, Engineers, and the Transformation of Work in the Western Mining Industry, 1880-1930," *Technology and Culture* 37:3 (July 1996): 434-435; 440-441.

[231]Spence, *Mining Engineers*, 239; Ottokar Hoffmann to George Crane, Esq., 5 November 1885, K-3, James D. Hague Collection [hereafter JDH], Huntington Library, San Marino, CA [hereafter HL].

[232]A discussion of the tension within the masculine identity of professional men during the Gilded Age can be found in Rotundo, *American Manhood*, esp. ch. 8-9.

[233]Ruth Oldenziel, *Making Technology Masculine: Men, Women, and Modern Machines in America, 1870-1945,* (Amsterdam: Amsterdam University Press, 1999), 55.

mechanical engineers worked cheek-by-jowl on these construction projects with both skilled and unskilled immigrant laborers from around the world. These engineers set themselves apart from the mass of manhood surrounding them through a variety of markers, including, most obviously, their attire. Mining engineers favored wide-brimmed hats, tailored shirts, jackets, and trousers, and tall laced boots. They considered working as a laborer to be a "productive" form of physical exercise, but Oldenziel notes that although aspiring engineers saw in the carousing and raucous society of labor camps a form of working-class manhood that they sought to avoid, they were also drawn to the proclamations of brotherhood and solidarity that formed the backbone of the culture of working men's lives in these places. The disjuncture in these images of masculinity, Oldenziel argues, could only be overcome by seeking a professional career – one that valorized practicality, physical fitness, and the fraternal world of working men – all of which were component parts of the budding profession of engineering.[234]

Mining camps were very much like the work camps Oldenziel describes: male-dominated societies, replete with opportunities for men to prove themselves in contests and competition. Yet unlike the civil and mechanical engineers of whom Oldenziel writes, it is not clear that mining engineers were terribly concerned with setting themselves apart from the performance of manhood as enacted in mining camps, although they were instantly recognizable on-site by their sartorial choices. Mining engineers placed much greater emphasis on the physicality of their work than did civil or mechanical engineers; they were not front-office workers. They used their identification with "pioneering" masculinity not only to counter their own discomfort with the more

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[234] Oldenziel, *Making Technology Masculine*, 57-58.

proletarian masculinity of working miners, but also as a way to understand ordinary miners so as to inform their own labor management tactics.

Mining engineers adopted a discourse of physical valor when interacting with their social peers, but they emphasized other aspects of their professional identity when interacting with working miners, particularly when working as managers and in circumstances with their role was to directly represent the interests of a mining company. For instance, mining engineers agreed that it was important to spend time with miners, not to learn about their work, but to get to know them as men. "The personal equation is everything" one engineer stated, because "when you get a large number of men under one management you obliterate that personal equation and so render the relations unhuman."[235] It is evident that, in general, mining engineers did not socialize with ordinary miners, nor did they, again in general, have much empathy for the plight of the ordinary working man, so this exhortation to get to know miners as individuals should not be taken literally. Rather, it speaks to a desire to keep relations on a human scale, such that mining engineers and workers could interact "man to man." One engineer wrote a treatise for an investor on the skills needed to manage a mine in Mexico; chief among them was the exhortation to "be just towards the common men" in order to "be sure that the employees will work hand in hand with him, as they look at him as their superior… in knowledge."[236] The ability to feel compassion, and to behave with fairness

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[235]Rickard, *Interviews,* 184.

[236] Ottokar Hoffmann to George F. Crane, 5 November 1885, K-3, JDH, HL.

towards other people was a central facet of middle-class manhood in the late nineteenth century, and mining engineers evidently embraced this ideology wholeheartedly.[237]

Such rhetorical focus on the importance of "man to man" interaction between mining engineers was perhaps embraced by mining engineers to convince themselves that their opposition to labor unions was due to disdain for the tactics, rather than the goals, of organized labor. After all, the chief goal of an organization such as the Western Federation of Miners was to improve the health and well-being of miners, a project which directly benefited the work of mining engineers, who were well aware that a contented workforce was better than a dissatisfied one. Contented miners both produced quality mining work and experienced lower than average labor turnover, which could be as high as one-third of the labor force each month in Arizona at the turn of the century.[238] The reasons mining engineers opposed unions are relatively self-evident: chief among a mining engineer's tasks was to improve the efficiency of a mine – in other words, to cut expenses and raise production. By agitating for higher wages, labor unions also undercut one of the primary ways to cut production expenses.[239] Strikes, of course, were a

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[237] Michael Grossberg, "Institutionalizing Masculinity: The Law as a Masculine Profession," in Mark C. Carnes and Clyde Griffen, eds., *Meanings for Manhood: Constructions of Masculnity in Victorian America,* (Chicago: University of Chicago Press, 1990), 144-146.

[238]Huginnie, "'Strikitos,'" 141; Hovis and Mouat, "Miners," note 65, 452.

[239] Larry J. Griffin, Michael E. Wallace and Beth A. Rubin, "Capitalist Resistance to the Organization of Labor Before the New Deal: Why? How? Success?" *American Sociological Review*, 51:2 (April 1986), 149-150.

particularly powerful tool for union organizers, and such industrial actions cut at the heart of the work of mining engineers by destroying carefully calculated estimates of expenses and production. In their opposition to unions, therefore, mining engineers embraced that aspect of their professional identity noted by Edwin Layton – their professional self-interest aligned with the demands of capital.

When the Western Federation of Miners tried to unionize mine workers in the Southwest, for instance, many mining engineers were infuriated, considering that the union created problems rather than solving them. "It was a fairly contented and happy community," William F. Staunton wrote of the Congress mine in Prescott, Arizona, "until the Western Federation of Miners began to try to unionize it." Staunton noted that even in its formal petition to open shop, the Western Federation of Miners (WFM) issued "no complaint whatsoever about wages, working or living conditions, which were specifically stated to be satisfactory," but that shortly afterwards there was a strike necessitating a mine shutdown and pictures of Staunton's foreman were run in the paper under the heading "King Scab in Arizona."[240] Another managing engineer, after experiencing threats on his life and uncovering a plot to dynamite his house, considered his best weapon against the WFM to be what he deemed honest and open communication with the working miners. He instituted a policy not uncommon in Arizona, of only hiring workers who could be eligible for union membership – in other words, only white men – yet never

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[240]William Field Staunton, "Memoirs of William Field Staunton: The First Fifty Years, 1860-1910," p.79, 121-122, box 1, William Field Staunton papers, AZ 152 [hereafter WFS], University of Arizona Library Special Collections, Tucson, Arizona [hereafter UASC].

explicitly forbade them from joining the union, because he believed that by offering them what he called, “a day’s work for a day’s pay” he could undercut their desire to join the WFM. Indeed, the mining engineer’s argument with the union was ostensibly not that it existed, but that it demanded a closed shop, which he considered un-American.[241] However, the evident vitriol that at least some miners felt towards this engineer belies the engineer’s belief in the power of man-to-man interaction.

In addition to the knowledge claims that mining engineers were able to make if they had “practical” experience as a miner, engineers also extolled practical experience as a way to improve an engineer’s sense that he had the ability to speak to miners effectively.[242] L.D. Ricketts explained to an interviewer in the 1920s that

> manual work gives... [a mining engineer] the opportunity to know the viewpoint of the workman; and, if in the future he is called upon to handle men, such an experience is immensely valuable to him. This is merely an opinion, because I have not worked either as a miner or a smelter-hand;

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[241]Courtenay DeKalb to James Douglas, 29 October 1904, folder 6, box 12, AZ 290, Lewis Douglas Papers, UASC.

[242]See chapter two for an extended discussion of “practical” education. Rickard, *Interviews*, 435; George Packard, “Mining Schools and Their Graduates,” *Mining and Scientific Press* 95 (10 August 1907): 173-174; William Ralston Balch, *The Mines, Miners, and Mining Interests of the United States in 1882,* (Philadelphia: The Mining Industrial Publishing House, 1882), 271-344, passim.; [Morris Parker Memoir], 45-46, 54, folder 3, box 1, Papers of Morris B. Parker [hereafter MBP], HL.

> but I have always regretted that I did not have a little experience of the kind, in order that I might be closer to the worker's viewpoint.[243]

When he made those remarks, Ricketts was the superintendent of one of the largest copper mines in the western hemisphere. He was known not only for his tremendous successes building southwestern mines, but also for what might be described as an ostentatious modesty. His appearance was described by peers as "common as an old shirt" and "not much on clothes," affecting rumpled, work-stained attire, scuffed boots, and worn headgear — a dress code greatly at odds with his background as a Princeton Ph.D. and his work as the chief engineer for Phelps Dodge. Despite, or perhaps because of, Ricketts' self-conscious realization that he did not fully understand the physicality of mining, throughout his career he was known for shunning many external markers of his success. In his professional work, this took the form of being well-known to be a generous consultant, always seeking the opinion of others. In the words of the perennial commentator on mining engineers, T.A. Rickard, Ricketts was "not cocksure, but deliberate." In Ricketts' lack of sartorial style can be seen an attempt to blend in with the more proletarian mining workforce rather than a visible exaltation of his status as a mining engineer. Stories abounded in mining communities about people who were confounded by Ricketts' appearance, mistaking him variously for a miner, a vendor, or a

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[243]Rickard, *Interviews*, 435. Further discussion of Ricketts' work in the copper industry can be found in chapter 5.

hobo.[244] Ricketts' personal appearance garnered so much attention precisely because it was at odds with what was normal among the fraternity of mining engineers.

Ricketts' stated regret that he was unable to legitimately empathize with his workers is further evidence that mining engineers had many reasons to embrace the more rugged physicality of miners at the expense of flaunting their own status as social elites, Such an assertion can readily be interpreted to be a gloss of Ricketts' desire to "understand" working miners so as to learn how to manipulate his workers, or, in a more sinister fashion, subvert workers' attempts to organize on their own behalf. To some extent, of course, this is true – mining engineers did not like working with unions, which they rightly understood to be powerful political forces that could easily disrupt mining operations and destroy hairline budgets. Yet Ricketts was not completely cynical. The prevalence of the discourse of identification with working miners in trade publications as well as personal letters and memoirs; the critical importance of programs such as the Columbia Summer School for getting budding mining engineers into the tunnels; the continued need for skilled, apprentice trained miners through the early twentieth century; all point to real practical advantages for mining engineers who could easily grasp how their directives sounded to a working miner. An experienced miner was likely to have spent time working with both good mining engineers and poor ones, and to have worked

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[244] Walter R. Bimson, *Louis D. Ricketts (1859-1940): Mining Engineer, Geologist, Banker, Industrialist, and Builder of Arizona,* (NY: Newcomen Society of England, 1949), 19; T.A. Rickard, *Interviews,* 455.

his share of successful and unsuccessful mines. He could tell when a mining plan might fail, because he had seen it happen before.

The rationale behind the desire to empathize with working miners has been overlooked by historians of labor, who tend to assume that as mining engineers were structurally opposed to mine workers in labor disputes, they operated from a position of cynical contempt for workers. A. Yvette Huginnie, for example, insists that mining engineers used their "expert knowledge" to "gain leverage over the workers" in Arizona towards the end of the nineteenth century.[245] What leverage, precisely, did highly educated engineers have over the average mine worker that less well-educated, apprentice-trained, "up through the ranks" foremen and superintendents did not? Working miners were not the audience for mining engineers' displays of erudition; their supervisors were. Whether or not miners felt a kninship with engineers who had experience with manual labor is somewhat ambiguous, although it is likely that such experience could generate respect. As Frank Crampton, a miner-turned-mining engineer observed of his fellow engineers, "most of them were too far up in the clouds to have truck with ordinary hard-rock stiffs. They would have done better and learned more had they comedown [sic] the earth."[246] By this, Crampton meant that the miners thought that

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[245]Spence, *Mining Engineers*, 176-178; A. Yvette Huginnie, "'Strikitos,': Race, Class, and Work in an Arizona Copper Industry, 1870-1920," (PhD diss., Yale University, 1991), 124.

[246]Frank A. Crampton, *Deep Enough: A Working Stiff in the Western Mine Camps*, (Denver: Sage Books, 1956), 51.

engineers did not understand how mining labor was organized, nor did they understand the tremendous physical labor it took for miners to extract ore from the ground.

.Mark Wyman and Ronald Brown both argue that the introduction of mechanized technology into western mining camps, attributable to the presence of engineers, led to the de-skilling and proletarianization of miners. In turn, this led to the increasing radicalization of the mining labor force, assuming engineers to be perpetually in opposition to working men.[247] Nineteenth century mining engineers, however, were invested in the lives and experiences of both labor and management, and the pride many mining engineers felt in the physicality of mining work was useful for them in negotiating that liminal position.[248] Although many mining engineers did serve as the de facto face of the company in on-the-ground negotiations with working miners, they tended to bemoan labor conflicts, not only because they lost money, but because they gave voice to the inequities of mining camps which engineers, with their valorization of

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[247]Mark Wyman, *Hard Rock Epic: Western Miners and the Industrial Revolution,* (Berkeley: University of California Press, 1989); Ronald Brown, *Hard Rock Miners: The Intermountain West, 1860-1920,* (College Station: Texas A&M University Press, 1972). Hovis and Mouat persuasively argue that Wyman and Brown romanticize the hand miners and thus blame labor deskilling on the process of mechanization – the introduction of machine drills, and the use of explosives, e.g. While these tools were dangerous and undoubtedly contributed to labor unrest, Hovis and Mouat point to the rise of non-selective mining -- mass-mining – as the cause of the de-skilling of mine labor in favor of the expertise of engineers. Hovis and Mouat, "Miners," 429, 439, 332-449.

[248]Oldenziel, *Making Technology Masculine*, 74-75.

physical work and pioneering identity, would likely prefer to ignore. Trained to read geographic landscapes, to extract ore from hard rock, and to build complex machinery, mining engineers were poorly equipped by their education to handle labor management issues. Courses in administration and accounting were not typically added to university programs until the twentieth century, and even then took a back seat to math, physics, and mechanics.[249] As Louis Janin found at Concepcion, when mining engineers expressed strong feelings about labor-management issues, their voices were likely to be ignored. Thus mining engineers had a strong incentive to concentrate on technical issues rather than issues of personnel, and the evidence is strong that they weighed in on the actual question of which workers to hire, and how to treat them, only under duress.

A salient aspect of the class distinction in mining camps in the southwestern borderlands that mining engineers ignored rather more successfully were racial and ethnic divisions within mining camps. In general, mining engineers appeared to have shared in the anti-Mexican sentiment common in the United States in the nineteenth century. These beliefs consisted of a lazy and thoughtless stereotyping of Mexicans as lazy, dirty, and/or unethical; Mexican food as gruesome; and a general sense that Mexican mining was characterized by "indifference, waste and insufficient machinery."[250] Given how closely many mining engineers worked with non-Anglo

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[249] Governing Board Minutes, 5 February 1906, folder 56 box 6, Sheffield Scientific School Yale University, Records (RU 819). Manuscripts and Archives, Yale University Library.

[250] See for instance a characterization of Mexico as a land of "frijoles and… tortillas, patted by the unwashed hands of dirty Mexican women" in Edward Reilly to James

workers, however, they could be clear-eyed about the antagonism bred by such attitudes. Raphael Pumpelly once observed that the Mexican workers "felt only hatred" towards their American employers in the silver mines near the U.S.-Mexico border. He acknowledged that this may have had something to do with the practice of the American companies of "paying the Mexicans the greater part of their wages in cotton and goods, on which the company made a profit of from one hundred to three hundred per cent" – hardly a circumstance to warm the relationship between employer and employed.[251] A common sentiment among mining engineers was that "Mexican labor is cheap, and if properly managed can be used to great advantage," but that Mexicans always needed to be trained to accomplish tasks that white Americans were already competent to fulfill.[252] That sentiment, not surprisingly, was a canard, as many white mine workers were hired as skilled workers – blacksmiths, furnacemen, or mechanics – and any unskilled workers, Mexican or otherwise, would have to be trained to fill such positions.

What Pumpelly observed of the poor treatment of Mexican (and later, Mexican-American) workers by American companies was only the beginning of a clear practice of

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Douglas, 14 February 1881, folder 29, box 3, JD, AHS; Louis Janin, Jr. To James D. Hague, 12 July 1889, M -15, JDH, HL; [unknown], "Preliminary Report on the Smelter at Bonanza, Zac., Mexico, and on some of the Mines in that Vicinity," 24 December 1901, folder 4, box 6, HAT, AHC; *Prospectus of the Loma de Platta, or Hill of Silver Mine, of Mexico, Situated in Altar District, State of Sonora, Republic of Mexico,* (Atlantic: Telegraph Steam Printing House, 1880), 5.

[251] Pumpelly, *Across America and Asia*, 32.

[252] Ottokar Hoffmann to George Crane, Esq., 5 November 1885, K-3, JDH, HL.

discrimination, one which mining engineers, as a group, failed to protest: the dual wage system. This practice, of having one pay scale for white workers and another for non-white workers, was widespread, and was justified by the belief prevalent among mining engineers that non-white workers were more ignorant than their white counterparts. One mining engineer in southern Arizona summarized the prevailing attitude towards the available workers when he fitfully complained that

> we have found it exceedingly difficult to get competent labor of all classes…. We find that the Mexicans we get here are of a very disreputable and tough class, and on pay days generally cause riotous disturbances. We, however, employ them where skill is not required…[253]

A particularly striking example of the income disparity was in place at the Longfellow Mine in 1880, where Chinese miners were paid $40/month; Mexican miners $50/month, and "American" [white] miners $75/month.[254] The Chinese and Mexican workers were underground ore miners; the Americans were on "dead-work," or work that was not directly profit-making, such as preparatory work of opening a mine, and, later, shoring up the mine shafts and performing routine maintenance. Although the dead work is critical to the functioning of a mine, it was usually held in low regard by mine owners and operators. Indeed, the cost of dead work was often estimated out by mining engineers at

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[253] "Report of the General Manager of the Ray Copper Mines…" 30 June 1900, P108 JDH, HL.

[254] "Extract from the Report of Arthur W. Wendt on the Longfellow Mine," January 1880, folder 91, box 5, James Douglas Papers, AHS.

approximately $1/ton of ore produced, while ore extraction cost three times as much.[255] That the Longfellow management entrusted the usually higher-valued underground work to non-white workers indicates that the company was probably in dire financial straights. The ingrained nature of the dual-wage system is underscored at a mine where white workers, doing work deemed of secondary importance were paid almost double the wages of non-white laborers on operations considered critical to the management.[256]

Despite mining engineers' reluctance to allow Mexican workers to hold positions of responsibility, many engineers took small steps to make those workers on whom a mine was dependent comfortable. As managers, engineers consistently looked for ways to encourage workers to be more productive or to undermine their desire to unionize, which many engineers considered to be the same thing. In 1889, for instance, William Church established both English- and Spanish- language reading rooms for employees at

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[255] Joseph Henry Collins, *Principles of Metal Mining*, (New York: G.P. Putnam's Sons, 1874), 34, 65; The *E&MJ* 1 March 1884, [page 153] bemoaned the fact that mining engineers tended to underestimate the expense of dead work when writing up their reports on mines, "it is dangerous not to make liberal allowances for sums not needed directly in the extraction of ore… How many promising mines have been swamped during the past few years because disappointment followed in wake of 'extraordinary expenses'?"

[256] Except for Raphael Pumpelly's observation about Mexican workers in Tubac in the 1860s, cited above, I've seen no evidence that any mining engineers objected to the dual-wage system, or advocated for higher wages or better housing conditions for working miners.

the Phelps, Dodge properties in Morenci, Arizona. He believed that access to these small libraries was critical to maintaining the morale of the workers, and wrote to his principals requesting reading materials.[257] As early as 1885, some mining engineers in Mexico advocated hiring men for three eight-hour shifts, rather than for two ten-hour shifts, on the understanding that underground work was simply too exhausting to be undertaken for ten hours straight.[258] The rumor circulated in 1900 that the United Verde mine at Jerome raised wages 15% and put men on an eight-hour shift. In response, an engineer at the nearby Ray Consolidated engineer told his Board of Directors "this is liable to cause trouble to other mine owners,"[259] and, by extension, to other engineers. Engineer John G. Greenway, who as the president of the Arizona Copper Company was one of the executives involved in the infamous Bisbee Deportation of 1917, and was not known for generous policies towards non-white workers, established Sunday as a day of rest throughout his mines in Arizona, a progressive action for 1910.[260] Even if Greenway's decision was made for the most cynical of reasons, to undercut a strike effort and to

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[257]William Church to William Dodge, 7 May 1889, folder 4, box 2, LD, UA.

[258][Morris Parker Memoir], 96, folder 1, box 1, MBP, HL; Ottokar Hoffmann to George Crane, Esq., 5 November 1885, K-3, JDH, HL.

[259] "Report of the General Manager of the Ray Copper Mines…" 30 June 1900, P108 JDH, HL.

[260] Katherine Benton-Cohen, *Borderline Americans: Racial Division and Labor War in the Arizona Borderlands,* (Cambridge: Harvard University Press, 2009), 130; John Greenway to Theodore Roosevelt, 9 August 1910, folder 2718, John and Isabella Greenway Collection, AHS.

police the leisure-time activities of the company's workers – and there is reason to believe it was – as a mining engineer who had spent considerable time underground, he believed that a mandated day of rest materially benefited the lives of workers at the Arizona Copper Company.

Although there is no evidence that engineers colluded, or even formally discussed, wage scales or welfare provisions for working miners, the contradiction within their labor-management goals – the need to placate workers and their need for keeping labor expenses low – was difficult to overcome. Mining engineers had a practical desire to stave off unionization without resorting to violence or other disruptive measures. The rhetorical emphasis on middle-class decency was a weak attempt to assert a consistent labor strategy over an aspect of mine engineering work that fell outside the parameters of technical knowledge, yet was not as susceptible to manipulation via the vigorous assertion of a frontier masculinity as were mining engineers' peer-to-peer relations.

Among themselves, and to a lesser extent in the public sphere of the eastern United States, mining engineers affected a distinctly western masculinity, one that allowed them to feel comfortable among the men they supervised and interacted with in the field. Nothing could be more damaging to a young engineer's standing at the mine than to be labeled a tenderfoot, and mining engineers worked hard to escape that designation. Mining engineers gave themselves a means to empathize with ordinary miners; in turn, this identification with miners as *men* provided mining engineers with their primary way to understand how to manage workforce relations, and to understand what it meant to be a "working stiff" in a hard-rock mining camp.

During the most aggressive era of U.S. capital investment in Mexican and southwestern mining projects, the 1880s through roughly 1910, mining engineers negotiated a set of overlapping gender and class identities to legitimate themselves to an audience of employers, employees, and other mining engineers. A mining engineer's ability to create a real or imagined empathetic bond with the men he supervised or directed could make or break a mining enterprise. In the field, the popular image of mining engineers as physically adventurous men was an asset for mining engineers. A mining engineer's elite status, however, could stand in the way of his relationship to ordinary miners, both because of the resentment it engendered, and because it failed to provide engineers with the tools they needed to be successful managers of labor. Invoking western and masculine identities helped mining engineers in this region overcome this "deficiency" in their training. Invoking a blandly middle-class morality, with an emphasis on the importance of "man-to-man" interaction could help mining engineers elide their own discomfort with the class divisions within a mining community. The labor-management interaction in the mines of the borderlands can best be understood by analyzing the complex interplay between competing notions of identity and expertise.

Chapter Five

Corporate Capitalism:

Engineers and the Birth of Mass Mining

In 1913, an editorial in the *Engineering and Mining Journal* bemoaned the so-called "new miner" in the western mines who was no longer a "jack of all trades and master of several." Rather, the editorial lamented, the new miner lacked skill, industry, and intelligence.[261] Historians Logan Hovis and Jeremy Mouat argue that such perceived decline in the quality of the mining labor force was caused by new engineering practices, particularly the spread of so-called "mass mining." The working lives of mining engineers also changed with the adoption of mass mining. While this new system of mining simplified the work of average miners such that companies could now hire less expensive unskilled labor, the work of mining engineers became in some respects more complicated. Technological change grew out of changes in the socio-technical system of mining itself. The advent of electricity fundamentally altered the economics of copper mining; as demand for copper rose – slowly through the 1890s and with increasing urgency after 1900 -- it became profitable to mine the massive, yet relatively lower-grade copper deposits of the U.S.-Mexico borderlands.[262] The interaction between the

[261] *Engineering & Mining Journal*, 95 (8 March 1913): 534, cited in Hovis and Mouat, 455.

[262] Proponents of gas drilling in the Marcellus Shale in 2011 make a similar argument about the financial feasibility of hydraulic fracturing – an argument that is somewhat less persuasive than the argument for low-grade copper in 1900.

social world and technological change is at the heart of many scholarly debates surrounding the agency of technology; the introduction of mass-mining techniques at the turn of the twentieth century highlights how the mining industry functioned systemically, as changes within society seemed to lead inexorably to technological change.[263] Techniques of mass mining were developed by mining engineers in answer to a newfound demand for copper, and in turn, the new technology had a profound impact on the work of mining engineers. Not only was the daily work experience of mining engineers and the work-flow (in general) of the mining industry changed by the new processes, but the life experiences of mining engineers also altered as the profession became less mobile -- both in terms of physical mobility (i.e. moving from job to job) and in terms of professional mobility (i.e. advancing within the profession).

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[263] The classic text on "socio-technical systems" and the embeddedness of technology within society is Thomas P. Hughes, *Networks of Power: Electrification in Western Society, 1880-1930*, (Baltimore: Johns Hopkins, 1983); see also Bruce Bimber, "The Three Faces of Technological Determinism," in Merritt Roe Smith and Leo Marx, eds., *Does Technology Drive History?,* (Cambridge: MIT Press, 1994); Wiebe Bijker and Trevor Pinch, "The Social Construction of Technology" in Wiebe Bijker, Thomas Hughes, and Trevor Pinch, eds., *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology*, (Cambridge: MIT Press, 1987); Ronald R. Kline, *Consumers in the Country: Technology and Social Change in Rural America*, (Baltimore: Johns Hopkins, 2000); David Nye, *Electrifying America: The Social Meanings of a New Technology*, (Cambridge: MIT Press, 1990).

Much has been written about the impact of mass mining on the average worker, generally focusing on the effect on miners of the de-skilling of the workforce. Where selective mining required skilled miners and mining foremen to operate pick-axes, explosives, and hand-drills to burrow tunnels following underground ore veins, non-selective mining was just that: nonselective. Huge quantities of dirt, rock, and low-grade ore were removed from the ground all together; once extracted, small quantities of ore were separated from massive quantities of waste dirt. In selective mining, a mining engineer might design a dig, but he generally left the quotidian operation of the underground dig to the foreman and skilled workers, providing technical oversight, or revising, important decisions regarding the progress of the dig. With mass mining, the mining engineer or engineers designed the entire dig, and the miners removed the resulting earth: dirt, rock, and ore. There was little need for individual expertise or knowledge of ores and their properties on the part of miners or foremen. In Arizona, which in 1910 produced more copper than any state in the nation, and throughout the U.S. – Mexico border region more generally, the shift to mass mining meant mining operations increased dramatically in size and number. An influx of immigrant workers from southern and eastern Europe, and an increased number of Mexican workers, flooded the region to attend to the labor shortage. Along with the new population of laborers, the pressures of industrial organization increased on the mining industry, as a radicalized workforce steadily gained a foothold in an industry already familiar with the complications of labor actions. In addition to the extant division between the American Federation of Labor and the Western Federation of Miners, miners were further distanced from one another by language, ethnicity, and nationality.[264] By the early twentieth century the regional industry became larger, more industrialized and more integrated into the economic life of the nation than seemed possible just a few short decades earlier.

The shift to nonselective mining in the western metals industry was orchestrated by a small cohort of mining engineers. Faced with a rising demand for copper in the marketplace and the declining purity of subsurface copper deposits, mining engineers were tasked to find new ways of extracting copper from the quartz in which it was embedded through the southwestern United States. Far from being simply a new technological approach to mining, the implementation of mass mining restructured the mining industry. As a more technology-intensive than labor-intensive way of mining, it favored large, capital rich companies over smaller organizations, speeding up the consolidation of the mining industry.

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[264]U.S. Bureau of Mines, *The Production of Copper in 1910,* (Washington, D.C.: Government Printing Office), 23; Michel E. Parrish, *Mexican Workers, Progressives, and Copper: The Failure of Industrial Democracy during the Wilson Years,* (La Jolla: Chicano Research Publications, 1979), 4-5. Historian Mark Wyman argues that despite the militancy of the WFM through the 1890s, by 1910 or so the miners unions were relatively weak, in part because the "machinery, technology, crews, systems of ownership, and dynamics of local politics" were constantly shifting in the metals mining industry, and so unions were perpetually having to change their approach to the problems of fair labor. Wyman, *Hard Rock Epic: Western Miners and the Industrial Revolution, 1860-1910,* (Berkeley: University of California Press, 1979), 256-258.

The image that comes to mind when we think of mass mining is the open-pit, but the term encompasses a broad approach to metals extraction that pushed the industry towards greater mechanization of the labor force. Environmental historian Tim LeCain has aptly named non-selective mining "mass destruction," as it constituted an inversion and adaptation of the mechanized production being implemented by factory managers elsewhere in the United States. In mining, the work being standardized was the dismantling of the landscape as opposed to the construction of a Model T. LeCain's larger point is that techniques of mass destruction so heavily mediated the relationship between mine workers and the environment that the conditions of labor became much more dangerous, as technological solutions were sought for the environmental problems caused by such large-scale earth-moving ventures.[265] While such a full-scale embrace of technology might seem, on the surface, to benefit the workplace status of mining engineers, raising the value of their technical and technological expertise ever higher in

[265] Timothy J. LeCain, *Mass Destruction: The Men and Giant Mines that Wired America and Scarred the Planet*, (New Brunswick: Rutgers University Press, 2009), 38-39; 47; 130-131. LeCain is part of a new movement of so-called "envirotech" scholars who are extending the socio-technical realm to include the impact of technological systems on the natural world, such as Chris Jones, "A Landscape of Energy Abundance: Anthracite Coal Canals and the Roots of American Fossil Fuel Dependence, 1820-1860," *Environmental History* 15 (July 2010): 449-484; Brian Frehner, *Finding Oil: The Nature of Petroleum Geology*, (Lincoln: University of Nebraska Press, 2011); Sara Pritchard, *Confluence: The Nature of Technology and the Remaking of the Rhône*, (Cambridge: Harvard University Press, 2011).

the minds of mining capitalists and investors, for individual mine engineers the reverse was often true. Rather than gaining power and leverage within mining corporations, a growing number of engineers actually worked in engineering units, which permitted much less vertical movement within the profession. Mass mining also reduced the opportunities for mining engineers to travel extensively, a major feature of mine-engineering identity in the nineteenth century that remained a critical aspect of the "romance" of mine engineering that drew young men into the field well into the twentieth century.

The story of the rise of mass mining often begins the way Tim LeCain begins his narrative of the environmental history of Butte, Montana, with mine engineer Daniel Jackling's design of the open-pit mine at the Guggenheim-financed Bingham Canyon mine near Salt Lake City in 1908. While the dramatic open-cuts at Bingham Canyon did indeed presage a more aggressive era in copper mining, Jackling was not not the only mining engineer experimenting with the new techniques. Rather, he was the most successful of a cohort of mining engineers who were struggling to solve the problems posed by the low-grade western porphyry coppers – not simply how to remove the ore from the ground, but how to profitably process commercial copper once the ore was removed from the ground.

Early Mass Mining

In the borderlands region, as in the rest of the western United States, mass mining arose from the peculiar problems posed by mining copper. One characteristic of copper is that it forms bonds with numerous other elements, and thus copper ores are rarely found in nature in a pure state. In the borderlands region in the 1890s, pure native copper ore was present in quantities that were profitable for commercial production only at Santa Rita, New Mexico.[266] Far more typical of the rich mines in the southwest was the Longfellow Mine in Clifton, Arizona, which was composed of veins of chalcocite, a copper ore with a relatively high copper content, generally between 55% and 75% copper, embedded within limestone. Still more mining districts in the southwest presented completely or primarily within porphyry, or volcanic, rock. Sometimes veins of chalcocite or another relatively rich ore were embedded within the porphyry -- for example, the Detroit Mine had a porphyry vein that was over 100 feet wide at the surface. Usually, such relatively rich surface veins quickly dispersed at lower levels into the porphyry, and the lower rock could yield as little as .4%- 1% copper. Prior to the 1890s, such porphyry deposits were considered unprofitably low-grade ore, and could not really be extracted by tunneling through the rock. The most profitable regional copper mine in the 1880s was Phelps, Dodge & Co.'s Copper Queen in Bisbee, Arizona, where the copper yield averaged 10%.[267]

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[266] Santa Rita, New Mexico, about 15 miles east of Silver City, should not be confused with the Santa Rita silver mining district near Tucson in the Arizona Territory discussed in chapter one. Native ore formed the bulk of the copper present in the Lake Superior Copper district in Michigan, which until the 20th century was one of the most productive minine sites in the world. Edward Dyer Peters, *Modern Copper Smelting*, 7th ed. (New York: Scientific Publishing Co., 1895), 7.

[267] J. Foster and J.D. Whitney, *Report on the Geology and Topography of a portion of the Lake Superior Land District*, part I (Washington: House of Representatives, 1850), 177;

The lack of purity of copper ores compounds the problem for miners of how best to refine the metal for sale. Copper is found in concert with a host of other metals, including silver, gold, lead, and iron; throughout the borderlands it frequently was found embedded in limestone or quartz and alongside and within eruptive rocks such as porphyry. The complexity of copper ores mean that copper could not be refined from ore in a single process. The goal of smelting copper was to produce a highly concentrated ore in a sulphide solution, called a matte, which contained as much of the copper and other metals (often silver and gold) from the ore as it was possible to profitably separate. Waste material from this process, which frequently contained significant amounts of copper (almost always more than 2%) was called "slag" and was dumped.[268] This matte was then further refined to separate the copper from the other metals. The expense of separating copper from the bulk of the ore, through roasting, concentrating or "ore dressing," and the two-part smelting process was a major hindrance to the regional copper-mining community well into the 1890s, despite the higher demand for copper caused by the market for electricity.

The Arizona Copper Company, founded in Edinburgh, Scotland, in the 1870s, was one of the earliest companies in Arizona to turn a profit mining porphyry deposits. The company got its start not by sending out its own prospectors, but by purchasing the Longfellow, Humboldt, Yavapai, and the Detroit copper mines, all located in the Clifton district in southern Arizona. At the time that the company began working the properties,

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Peters, *Modern Copper Smelting*, 10, 21-24; James Douglas, "Conservation of Natural Resources," *Transactions AIME* 40 (1910), 422.

[268] Peters, 234.

in 1883, there was little ore of a quality appropriate for smelting. Frustrated by the lack of high-quality ore in the ground, the head of smelting operations, a mining engineer named James Colquhoun, turned to the slag left by an earlier generation of miners who had worked the area using relativeley inefficient processes. He determined that there was enough copper ore in the slag to successfully mine and smelt it, after first concentrating the ore in primitive "jigs." The success of this method of concentration kept the Arizona Copper Co. in business, although without great profits, for about five additional years. By 1892, just as the company considered closing down, Colquhoun (by this time the general manager of the Company) devised a plan to concentrate some of the low-grade oxidized copper ores that the company's property contained, as Colquhoun himself recalled, "in plenty."[269] He proposed to do so using sulphuric acid produced on-site from a small vein of iron pyrites.

Since Colquhoun's plan would require an expansion of the mine at a time when the owners were seriously thinking of closing it down, they brought in an outside mining engineer as a consultant – John Hays Hammond. After consulting Hammond, the Board of Directors determined to build the leaching plant that Colquhoun desired. Colquhoun himself traveled to New York with the chairman of the company to try to raise money for this new construction. The two men failed to find investors, which was not surprising, as Arizona Copper had a poor history as a dividend-paying operation and lacked any valuable property to put up as security. But Colquhoun persisted, finally persuading the Board to allow him to draw on the profits from the company's rapidly diminishing ore

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[269] James Colquhoun, *The Story of the Birth of the Porphyry Coppers,* (London: William Clowes and Sons, [1931]), 8-10.

reserves, while the Board president persuaded the company that held a mortgage on the property to stop collecting payments until the new leaching plant was operational.[270] As James Douglas observed, "had not the shareholders [of the Arizona Copper Company] been willing to accept hopeful promises in lieu of dividends," the company would never have remained in operation.[271]

In order to produce enough ore to run through the leaching plant, Colquhoun engaged in "open quarrying," a method of extracting the ore from the top down. After scraping away the surface soil, the ore body was blasted open, and miners dug the ore out by digging steps down through the ore body. This was an inexpensive way to extract both low-grade and first-class ores.[272] Colquhoun's combination of inexpensive mining and large-scale leaching facilities proved extremely lucrative for Arizona Copper, which by 1895 was able not only to pay its mortgage, but was also able to pay its investors a small dividend – a remarkable achievement for a company that was all but bankrupt three years previous. Beginning in 1896, Colquhoun also began working a couple of bodies of porphyry ores that the company had recently discovered, which contained between 1-4% copper.[273] The pilot concentrating plant that Colquhoun devised could process 100 tons

[270] Colquhoun, *Birth of the Porphyry Coppers*, 12.

[271] Douglas, "Conservation of Natural Resources," 424.

[272] Colquhoun, *Birth of the Porphyry Coppers,* 12-14; Henry Stafford Osbourne, *A Practical Manual of Minerals, Mines, and Mining*, 2nd ed., rev. (Philadelphia: Henry Carey Baird & Co., 1896), 300-303; Horace J. Stevens, ed., *The Copper Handbook*, vol. 3 (Houghton, MI: Horace J. Stevens, 1903), 183.

[273] Stevens, *The Copper Handbook*, 183.

of ore per day; No. 3, the first full-scale porphyry concentrator at Arizona Copper, came on-line in 1898, and could process 700 tons of ore per day. That year, Arizona Copper Company produced over 13 million pounds of copper, which was about 10% of the refined copper produced in Arizona, making it one of the top producers in the United States. By 1901 Arizona Copper was the eleventh largest producer of copper in the world.[274] Colquhoun himself pointed to some of these accomplishments in his modest personal history of the Arizona Copper Company, to demonstrate that he was the first mine engineer to successfully process porphyry copper, fully ten years before Daniel Jackling and the Utah Copper Company began mass mining it at Bingham Canyon in 1908.

At approximately the same time that Colquhoun was experimenting with porphyry copper deposits at Clifton, Phelps Dodge was in the process of constructing its own mine to be excavated and processed on a mass scale. The level of communication between Colquhoun at Arizona Copper, and L.D. Ricketts at Phelps Dodge is impossible

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[274] D. Houston & Co., *Copper Manual: Copper Mines, Copper Statistics, Copper Shares,* (New York: D. Houston & Co., 1899), 286; Horace J. Stevens, ed., *Mines Register: A Successor to the Mines Handbook and the Copper Handbook, Vol. III,* (Michigan: Houghton, 1902), 566-568. Note that in his *Birth of the Porphyry Coppers*, Colquhoun does not dispute that the Bingham mine operated with vast efficiencies of scale that Arizona Copper never reached, and that the overall method of mining at Bingham and its open-pit successors was vastly different from that practiced by Colquhoun in Clifton-Morenci in the 1890s and early 1900s. Colquhoun, *Birth of the Porphyry Coppers*, 20, 23-27.

to determine, but as Ricketts worked as a consulting engineer for the Arizona Copper Company while holding a position as the manager of mine operations at Phelps Dodge's latest acquisition in Nacozari, Sonora, it is certain that Ricketts was aware of the innovative concentrating methods Colquhoun was working on in Clifton. Although engineers at rival companies rarely collaborated outright, there was somewhat open communication between engineers. Naturally they read and regularly wrote about the processes they implemented in trade journals such as the *Engineering and Mining Press* and the *Mining and Scientific Press*. Mining engineers also made regular site visits to nearby mines, as discussed in chapter four, both to talk to their professional peers and to improve their knowledge of regional geology and to get a sense of the wealth of neighboring mines. More casually, mining engineers were social peers and would often hear of new techniques or experiments in passing as part of normal conversation.

L. D. Ricketts became the manager of the Moctezuma Copper Mine, the Phelps Dodge property near Nacozari, in 1897. Unlike Colquhoun, whose innovations at Arizona Copper were the result of necessary and expedient experimentation, Ricketts arrived at Moctezuma with a vision for the mining camp. Although Nacozari was famous for the wealth of its copper deposits in the 1860s, by the 1890s the area had a lot in common with other borderland copper mines – plenty of low-grade ore, some in the ground, some in slag heaps from earlier, less-efficient mining projects. Inspired by the mechanical processes he saw being implemented in factories, Ricketts envisioned Nacozari as a fully industrial mine, and he made it so.[275] The mine began operation in 1901.

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[275]Truett, *Fugitive Landscapes*, 56; Robert Glass Cleland, *A History of Phelps Dodge, 1934-1950,* (New York: Knopf, 1952), 130-131; Press Reference Library (Western

The previous owners of the Moctezuma, the Guggenheim family, had attempted unsuccessfully to smelt the Nacozari ores on-site. By installing a newly mechanized transportation process at the mines, however, Ricketts was able to remove significantly larger quantities of ore from the ground. He designed and built a much larger concentrator and smelter out of steel, and connected the smelting works to the mining works with mechanized conveyor belts. The whole mine was powered by a central power station. Ricketts initially wanted the mine to run on gas, but the remoteness of the location made that unfeasible, and so from 1901 until the 1910s, the furnaces at Nacozari were powered by wood gathered from the surrounding forests. In its centralization of power, mechanization of infrastructure, and use of structural steel, Ricketts' mine at Nacozari was innovative, and exemplified what the mass mines of the twentieth century could look like. The size of the concentrator enabled the mine to process the larger quantities of ore that was typical of the borderlands copper mines.

Nacozari proved to be extremely profitable, and the enhanced technological system of the mine enabled still more centralization in the early years of the twentieth century. From the time he took on the task of managing the mines at Nacozari, Ricketts worked to persuade James Douglas, the head of Phelps, Dodge mining operations, to build a train to Nacozari to more readily connect the mine to other regional PD operations. The standard-gauge branch line to Nacozari, a spur of the line that stretched

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Edition), *Being the Portraits and Biographies of the Progressive Men of the West*, vol. II, (New York: International News Service, 1915), 123; T. A. Rickard, *Interviews with Mining Engineers,* (San Francisco: Mining and Scientific Press, 1922), 436-437.

from Bisbee to El Paso, was finally completed in 1904.[276] In the years following Rickett's transformation of the mines at Nacozari, the landscape and economy of the border region transformed dramatically. In order to cope with the vast quantities of ore now being extracted from the ground, Phelps Dodge built a new smelter capable of processing over fifteen hundred tons of ore per day, and a new town to serve the smelter, the border town of Douglas, Arizona. Although Phelps Dodge already ran one of the largest smelters in the country — the T. A. Ricketts' designed concentrator of the Detroit Copper Co., a Phelps Dodge subsidiary in nearby Morenci — the new smelter at Douglas had the capacity not only to refine copper from the many Phelps Dodge properties, but also to work with ores from other mining companies along the border.[277] The technical and economic problem of how to treat low-grade ore in a cost-effective manner inspired, and perhaps demanded, the centralization of engineering work in the copper mining industry. This, in turn, changed the regional mining industry, and the working lives of all those associated with it.

Impact on Mining Engineers

[276] Rickard, *Interviews*, 436-438.

[277] *The Copper Handbook,* Vol 3, 278, 289; [Douglas Biography], 190-191, 208-209, 219, folder 3 box 1, MS 1031, James Douglas Papers, Arizona Historical Society, Tucson, AZ; Samuel Truett, *Fugitive Landscapes: The Forgotten History of the U.S.-Mexico Borderlands,* (New Haven: Yale University Press, 2006), 83; Cleland, *A History*, 117, 125, 133-135.

The technical solution to the problem of mining low-grade copper deposits had a profound impact on the organization of the working lives of mining engineers. In essence, mass mining sites are extremely complicated building projects. Such low grade copper needed to be processed in enormous quantities. These mines required a consulting engineer to suggest a strategy for the digging and refining to take place, and a managing engineer to oversee operations. In addition, an entire engineering department worked to determine where and how to dig, adopt or invent the best procedure for procuring and refining the specific ores at the mine, and to draw up and implement plans for linking the various parts of the mining operation together mechanically.[278] The engineers who worked in the engineering department at Phelps Dodge after the methodological transition at Nacozari had a very different work experience from those mining engineers of an earlier generation. Ricketts himself, for instance, worked throughout his career primarily as an independent contractor. Yet rather than receiving his instructions from the owners or supervisors of the company, an engineer in an engineering department primarily interacted with other engineers in the engineering department, solving problems and designing cuts as directed by the head of the engineering department. His work was subject to greater oversight by people who themselves possessed technical knowledge and the ability to effectively weigh the judgment of a mining engineer.[279]

[278]Logan Hovis and Jeremy Mouat, "Miners, Engineers, and the Transformation of Work in the Western Mining Industry, 1880-1930," *Technology and Culture* 37:3 (July 1996), 441.

[279] Peele, *Handbook*, 1269.

The early career of Eugene Sawyer is illustrative of how changes within the profession might affect the career of an individual mining engineer. Sawyer studied mining at the Lawrence Scientific School, where he was a middling student, receiving an A.B. from Harvard University, followed in 1907 by an E.M. – a mining engineering degree – from Lawrence.[280] In 1910, Sawyer moved to Arizona to take a job in the engineering department of the Copper Queen mine. In Bisbee, Sawyer enjoyed all the privileges brought by his status as a skilled white worker. He and his roommates, other mining engineers at the Copper Queen, lived in a house on “Quality Hill.”[281] Sawyer's work at the Copper Queen was not all office work, and involved a certain amount of independent engineering. He spent a considerable amount of time underground touring the shafts, and when the company enacted a digging plan that he designed, he was gratified to be “mixing in with the proceedings” to such a great extent.[282] Unlike mining engineers of previous generations who had done so much work alone in the office or in the field in company with only one or two assistants or fellow engineers, he also spent a great deal of time “mixing in” in the office with the other engineers. Fortunately for Sawyer, the company struck ore at two of the locations where he recommended they dig; he therefore impressed not only Walter Douglas, a son of James Douglas and the

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[280] Records of Students in the Lawrence Scientific School, 1888-1911, Harvard University Archives, Cambridge, MA.

[281] Eugene Sawyer to Mrs. Sawyer, 10 January 1910 and 18 January 1910, folder 1, box 1, MS 360 Eugene Sawyer Papers [hereafter MS 360], AHS.

[282] Eugene Sawyer to Mrs. Sawyer, 14 March 1910, 22 March 1910, 7 August 1910, folder 1, box 1, MS 360, AHS.

managing director of the Copper Queen at the time, but also L.D. Ricketts, whom Douglas had hired as a consultant. Sawyer was awed by Ricketts, "the biggest mining man in this section of the country," and flattered by the senior engineer's humble manner. "[Ricketts] comes into my office nearly every day," the young engineer wrote to his mother, "[and] spends a good part of the afternoon sometimes over my maps and asks my opinion on nearly every question."[283] For an early career engineer, work in this engineering department threw him in with his professional peers on a daily basis, and also brought him into contact with some of the biggest names in profession.

As companies consolidated and there were fewer "new" mining prospects for engineers to work on, mining engineers experienced a contraction in their career options: it was increasingly difficult to obtain the kinds of experiences that Ricketts, or Louis Janin, or even James Douglas had early in life that would establish an engineer's reputation and provide a good background for a consulting career. But young mining engineers also experienced gains from the increasingly automatized, centralized, and industrialized operations. Mining engineers such as Sawyer benefitted enormously from joining an established profession. Although relatively less adventurous, there were more positions available for newly- credentialed mining engineers. When on the job, young mining engineers were more likely to have the opportunity to come into contact with senior engineers, who could serve as mentors – earlier mining engineers had entered a field in which work experiences were far more atomized and geographically dispersed, and more frequently than not worked alone. Eugene Sawyer clearly benefited from both of these new aspects of the mine engineering profession: obtaining a good position

[283] Eugene Sawyer to Mrs. Sawyer, 7 August 1910, folder 1, box 1, MS 360, AHS.

shortly after graduating from Lawrence; working closely with L.D. Ricketts; and developing a close relationship with Walter Douglas. Sawyer, of course, was particularly fortunate in his position, as there were only a handful of engineers of Ricketts' stature in the United States, yet while the specifics of his position were remarkable, the general trajectory of his early career was not.

Sawyer's eagerness to be involved, and his apparent talent as an engineer, led him to advance up the corporate ladder quickly. In August 1910, after only a few months in Arizona, he was asked by Walter Douglas to be the general manager for a new prospect that Phelps Dodge was considering in the Catalina Mountains, near the town of Oracle just north of Tucson. Although pleased to be entrusted with the new responsibility, Sawyer was less enthusiastic about the work: "I was a little disappointed with the looks of the ground up there," he wrote. "If I had been doing it [the survey], I don't know as I should have reported so strongly in favor of it as Grele [the surveying engineer] did."[284] Sawyer's work in Oracle, which consisted of surveying the ground at the mine site, purchasing mining equipment and transporting it into the mountains, and hiring laborers, was not remarkably different from that of James Douglas when Douglas first began operations in Arizona for Phelps Dodge. The path Sawyer took to that work, however, depended as much on his ability to work within the bureaucratic systems now in place at Phelps Dodge as on his talents as an engineer and skills as a manager.

When the mine at Oracle failed to turn a profit, Sawyer thought it likely that the company would move him back to the engineering office at Bisbee, although as a

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[284]Eugene Sawyer to Mrs. Sawyer, 7 August 1910, 15 August 1910, and 22 August 1920, folder 1, box 1, MS 360, AHS.

manager, rather than as a staff engineer. He had mixed feelings about this. The possible promotion "set me ahead in my profession more than five years" yet the work at Oracle spoiled him. "It has been a wonderful experience" he reflected, "… [and] I like the exercise and all round work [of field engineering] best."[285] Yet Sawyer did not consider leaving his position at Phelps Dodge to find a field engineering position at a smaller company. Despite his youth, he could likely have gotten recommendations from some of the top engineers in the business had be decided to move on.

This demonstrates a degree of company loyalty that is profoundly different from the attitude of Ricketts and his contemporaries, who changed company affiliations with alacrity and apparently little professional ill feeling. At the time when Sawyer met Ricketts, "the Doctor" was in fact salaried as general manager for the Cananea Consolidated Copper Company, owned by William Greene, and a consultant for Phelps Dodge, the local rival. Sawyer, however, left his professional advancement in the hands of Phelps Dodge, and determined to take the next position the company offered to him.[286] After all, he noted, "everyone kow tows to the Queen," and he evidently determined that the work in the engineering office at Bisbee was a better professional opportunity than trying to find the "all round work" that he preferred elsewhere.[287]

As mass mining became more entrenched in the copper industry and mining engineers had relatively less itinerant working lives, their family lives changed as well. With few exceptions, nineteenth century mining engineers tended to live apart from their

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[285]Eugene Sawyer to Mrs. Sawyer, 17 March 1912, folder 3, box 1, MS 360, AHS.

[286]Eugene Sawyer to Mrs. Sawyer, 23 July 1912, folder 3, box 1, MS 360, AHS.

[287]Eugene Sawyer to Mrs. Sawyer, 25 September 1910, folder 1, box 1, MS 360, AHS.

wives and children. The incessant travel, long hours, and in the southwest borderlands region in particular, the lack of physical security and the amenities of town living did not make for an appealing lifestyle for the elite eastern women who were often the wives of mining engineers. Mary Halleck Foote, for instance, who had a successful career herself as an author and illustrator of highly romanticized tales of life on the frontier and in the mines of California, Idaho, and Mexico, relished the extent to which she flouted convention by following her mining engineer husband all over the western hemisphere because they could not afford to maintain two households. Although she occasionally socialized with the wives of other mining engineers, in particular her sister-in-law, wife of James D. Hague, she did not maintain a home in San Francisco or New York through the 1870s and 1880s, and was self-conscious of her differences from her peers.

Engineers worried about working in places that were difficult to reach. When discussing whether he would take over the on-the-ground management of the Cusihuiriachic mining company in 1886, Ellsworth Daggett explained, "If the inducements are sufficient and the locality such that I can take my wife I would go for a year or some fixed time." For Daggett, being on-site was only a possibility if it were for a short period of time; clearly, Mrs. Daggett was willing to live at a mine site under certain very specific circumstances; possibly Daggett did not get paid enough to maintain two separate households.[288] William F. Staunton met his wife, Mary Neal, in Tombstone while he was working at the Tombstone Mining and Milling Company in the 1880s. Mary was the sister of Annie Cheyney, the wife of the managing director of the company.

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[288] Ellsworth Daggett to James D. Hague 6 December 1885, Folder M-13, James D. Hague Collection,

Although most mining engineers met their wives while in school or when visiting friends and families back east, the trajectory of the Staunton's married life together was probably fairly typical. After their marriage, the Stauntons lived with the Cheyneys in a two-story company-owned adobe near the mines in Tombstone. The sisters apparently spent most of their time together, engaged in a variety of artistic pursuits that their husbands regarded with indulgence if not admiration. When Staunton moved to superintend the Congress Mine, near Prescott, Arizona, his wife and son moved with him, although the question of where Mrs. Staunton was to live was a difficult one. The manager of the Congress lived in Prescott with his wife in a house that was not large enough for two families. Mrs. Staunton moved to Congress, instead. After a few years, other workers brought their wives and children and the mine had a small community of families, of which the Stauntons were the most prominent. After moving about within Arizona a couple more times, Mrs. Staunton eventually moved to a property the couple bought in southern California.[289] The great distance between Staunton's mining business in Arizona and southern California was doubtless ameliorated by both the ease of train travel by the 1910s, as well as by the Stauntons' wealth.

The re-organization of mining business, however, gave more mining engineers the opportunity to consider the possibility of bringing their families to the places they would be working. At one time, the ability to send the family to live in Santa Barbara or Los Angeles was an indication of the success of a mining engineer. By the early twentieth century, the opportunity to work at a location where one might bring a wife, and possibly children as well, proved important to many mining engineers as they considered which

[289] WFS Papers Box I Memoirs

job to take. "I wish to take my wife to a district less isolated than this," one engineer wrote in an application letter, "and one [a district] where there may be more chances of advancement."[290] Certainly this engineer wanted a better opportunities for himself, but his primary impulse in seeking new work was to re-locate his family to a larger mining camp. Another mining engineer, hoping to relocate from Alaska to Jerome, Arizona, was more explicit about his wife's needs:

> I am writing fully not because I am dissatisfied with my present position or its opportunities, but because the long Alaskan winters and great distance from other large mine operations and from communication with the states are conditions which preclude the possibility of an indefinite stay in this district with my wife and baby.[291]

This engineer clearly did not think that being explicit about his wife's needs would in any way diminish his own chances of getting hired. Indeed, he

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[290] Allan D. Robinson to James E. Hyslop, 5 August 1909, folder 1, box 3, Hyslop – Beckmann family papers, MS 211 [hereafter MS 211], C.L. Sonnichsen Special Collections Dept., University of Texas at El Paso Library, El Paso, Texas [hereafter UTEP]; Cite WFS here. See also Cyrus Cole to David Cole, 23 January 1903, and Cyrus Cole to David Cole, 29 November 1903, folder 2, box 1, Cananea Mining Papers, 1893-1930, MS 1311 [hereafter MS 1311], AHS; G.J. Geer, Jr., to John Greenway, 9 November 1912, folder 2720, box 196, John and Isabella Greenway Collection , MS 311 [hereafter MS 311], AHS.

[291] Henry DeWitt Smith to Robert E. Tally, 19 April 1917, folder 1, box 1, Henry DeWitt Smith Collection, #7721, AHC.

may have had good reason to believe that being married would make him a more attractive employee. Employers who had a vested interest in the job satisfaction of their most expensive workers cared about the familial status of mining engineers. Marriage was used as a marker to denote a man's seriousness of purpose, and likelihood of remaining on the job. One man recommended a mining engineer to the manager of the Cananea Consolidated Copper Company by explaining that the engineer, Charles Ratcliff, wanted a new challenge and "P.S.[:] Ratliff is a married man, about 38 years old, and has a small family, I believe, who are with him in San Pedro."[292] While Mary Halleck Foote, as an educated white woman, had been so much an aberration in the mining community that her "salons" in remote locations such as Leadville and Idaho were famous among a certain generation of mining engineers, by the early twentieth century, the upper-middle class wives of mining engineers were frequently found in the larger mining camps.

With the shift to mass mining, the expertise needed by mining engineers also underwent a change. Nineteenth-century mining engineers spent a great deal of their time conducting surveys, assaying ore bodies, and construction plans of operation and the technologies that would enable those plans to succeed. With the expansion of the engineering department at ever larger mine sites, those particular skills were practiced by fewer and fewer men. Rather, in addition to geology and surveying, mining engineers needed to know more about metallurgy and chemistry than ever before, and to have a

[292] J. O'Grady to George Mitchell, 31 October 1901, Cananea Consolidated Copper Company Records, 1898-1969, MS 1032 [hereafter MS 1032], AHS.

solid understanding of hydraulics and steam engineering.[293] After graduation, mining engineers needed to stay informed of the latest developments in mining techniques, which began to change at a rapid rate. The membership of professional societies surged, filled with engineers who wished to keep up with the new sciences, and new, more regional societies were formed, often explicitly to share scientific and technical knowledge among their members. As historian Kathleen Ochs demonstrated in her quantitative study of the graduates of the Colorado School of Mines, "what [mining engineers] actually did" encompassed a broad range of administrative and managerial tasks, far greater than might be supposed by reading by the articles published in mining journals.[294] In their most ideal state, professional organizations, by providing a forum for face-to-face meetings between mining engineers, facilitated discussion within the mine engineering community about how to approach these new tasks.

The larger and older organizations, most notably the American Institute of Mining Engineers, remained critical as the instigators of major networking events. In 1901, led by then-president of AIME Eben Olcott, who had spent his formative years as a young engineer working in Sonora, AIME sponsored a trip to Mexico. The mission of the trip was ostensibly to forge strong ties between Mexican engineers and American engineers; as the *Engineering and Mining Journal* phrased it, "Mexican engineers surely have lots to

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[293] Engineering schools changed their course of study to reflect these new professional realities. See Governing Board Minutes, folder 56, box 6, Sheffield Scientific School, Yale University, Records (RU 819). Manuscripts and Archives, Yale University Library.

[294] Kathleen H. Ochs, "The Rise of American Mining Engineers: A Case Study of the Colorado School of Mines," *Technology and Culture* vol. 33, no. 2 (April 1992): 278-79.

learn from US mining." In reality, of course, the primary accomplishment of the journey was to function as a networking opportunity for the American engineers, 160 of whom gathered in two specially chartered Pullman trains, fully equipped with sleeping compartments, multiple drawing rooms, and a two private cars, one of which was for James Douglas, president of Phelps Dodge, to travel from New York to Chihuahua, making stops at a number of mines both large and small, and at the new ASARCO [later Guggenheim]-owned smelter in Aguas Calientes.[295] The American engineers were impressed by what they saw, and also by what they learned of mining conditions in Mexico, which included (they were told) no labor strikes, and laws more favorable to mining, in particular with respect to the law of the Apex. The trip, which to modern eyes is indistinguishable from a corporate junket, concluded with a dinner with Porfirio Diaz, about whom the *Engineering and Mining Journal* gushed, "This opportunity to see and grasp the hand of one of the greatest men in modern history was fully appreciated by all."[296]

Smaller, more regional organizations than the AIME also played a critical role connecting mining engineers to one another for social and professional reasons. One example is the "Society of Engineers and Metallurgists of the Republic of Mexico," established circa 1907. Membership numbers are difficult to determine, but the Society's pamphlets, which were published in English and in Spanish, contain essays by several English-speaking engineers in Mexico City and Chihuahua, suggesting that the Society's writings circulated throughout the nation and that working mine engineers were

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[295] *Engineering and Mining Journal*, 72 (30 November 1901), 693-698.

[296] *Engineering and Mining Journal*, 72 (30 November 1901), 695.

interested in supporting such an organization. The avowed aims of the Society were to promote the exchange of professional expertise among members, to investigate matters "having some bearing… upon the condition of the mining industry of Mexico, or the professional workers associated with it," and more generally to liaise between the community of mining engineers and the government of the Republic of Mexico, so that the community of mining engineers could present a united front in a nation that "stands in the very front rack in a comparison with the other mining countries in the world." As one pamphlet explained, the co-operation between members of the Society would address instances

> in which two or more men are working on the same problem, though in districts several hundreds of miles apart. One may find a ready solution... but the others may be less fortunate, and being in ignorance of the fact that there is a solution they may finally give the fight up in despair, or their work may result in dire failure.[297]

The stated goals of this Society point to the persistence of the concern within the community of mining engineers that as a profession they be considered the honest, and final, arbiters of mining valuation and practice.

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[297] [unknown], "Aims and objects of the society of Engineers and Metallurgists of the Republic of Mexico," typed mss [1907], and H.S. Denny, "Aims and Objects of the Society of Engineers and Metallurgists of the Republic of Mexico," [1908-1909], FF13, MS 211, UTEP.

The mass-mining techniques that spurred these professional and social rearrangements throughout mine engineering occurred as engineering institutes were turning out more and more mining graduates, as discussed in chapter 2. These changes within mine engineering also stripped the profession of those tasks that had made mining engineers into romantic western figures in the nineteenth century. Mining engineers, in general, no longer ventured into unknown territory as part of exploring parties, as Louis Janin had in the 1860s as part of the Butterfield Expedition. They no longer necessarily lived in relative isolation, on contested territory and without the protection of the U.S. government, as Raphael Pumpelly had in Tubac. They no longer had to prospect in the open countryside on horseback for days, searching for outcroppings that might suggest the presence of a large deposit of gold, silver, or copper. When mining engineers did undertake relatively isolated work, as did Eugene Sawyer, it was under the auspices of a large company, with ample capital investment and a relative ease of communication with the outside world. Although it still took Sawyer two weeks to haul a boiler from Tucson to Oracle, he himself was able to ride into Tucson, twenty miles away, with great frequency (although he was somewhat at the mercy of the stagecoach schedule), and Oracle was equipped with a phone line to Tucson.[298]

Despite these changes within the profession, in the early 1900s the public still perceived a mining engineer's life as one of romantic adventure. In part, this is because of the social and political prominence of a small handful of mining engineers, such as John Hays Hammond or Herbert Hoover. Hammond, who spent a considerable amount

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[298] Eugene Sawyer to Mrs. Sawyer 22 August 1910, and 5 September 1910, folder 1, box 1, MS 360, AHS.

of time in the southwest and northern Mexico, was a heroic figure in the eyes of many, on account of his exploits in Africa with Cecil Rhodes. Hoover, who was to rise to world-wide prominence and an enduring domestic popularity during WWI for his role organizing the relief effort for Belgium, was already well known in mining circles as a young engineer who made a fortune mining in Australia and working in China just before the Boxer Rebellion.[299]

Another indication that the cultural status of mining engineers remained firmly embedded in the world of adventure is the relative popularity of H. Irving Hancock's series of action books for boys, *The Young Engineers*, published in the 1910s. With titles such as *The Young Engineers in Mexico, or, Fighting the Mine Swindlers*, and *The Young Engineers in Arizona, or, Laying Tracks in the Man-Killer Quicksand*, these books chronicled the adventures of two young men who, after high school, gained experience working as surveyors in diverse and exotic locations out west.[300] The young heroes

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[299] Jeremy Mouat and Ian Phimister note that Hoover's fame, among mining engineers at least, stemmed from his financial acumen rather than his skill as an engineer or his heroism under duress. Hoover's fortune dates from his work in China. During this time he was implicated in a nasty financial scandal, accused of defrauding Chinese mine owners during the confusion surrounding the Rebellion. Hoover himself disliked talking about his time in China. Mouat and Phimister, "Engineering Herbert Hoover," *Pacific Historical Review,* 77 (no. 4): 558.

[300] H. Irving Hancock, *The Young Engineers in Mexico,* (Philadelphia: Altemus, 1913); H. Irving Hancock, *The Young Engineers in Arizona,* (Philadelphia: Altemus, 1912); H.

started out as civil engineers working on railroad projects, working their way into the unknown deserts, caverns, and mountains of the southwestern U.S. and northern Mexico, while amassing technical experience along with frontier credibility. In the mythology of the series, Tom and Harry got involved in a gold mine that went into bonanza (*The Young Engineers in Nevada, or, Seeking Fortune on the Turn of a Pick*) and, having learned from that experience all there was to know about mining, were full-fledged consulting mine engineers by the time they uncovered a tremendous mining fraud in *The Young Engineers in Mexico*. Although obviously stylized juvenile fiction, the *Young Engineers* series nonetheless encapsulates many of the tropes of mine engineering first expressed by both travel writers such as journalist J. Ross Browne, and fiction writers such as Mary Halleck Foote who wrote about western mining between the 1870s and the 1890s.

Although this romance persisted in the popular imagination, and at least one mining engineer admitted that it was a key component of his decision to pursuing the profession, it was at odds with how a number of mining engineers, both elite and rank-and-file, were beginning to think about their careers.[301] Increasingly, mining engineers observed a distinct lack of opportunity for their younger colleagues to gain access to the kinds of consulting work that could prove both interesting and lucrative. When Theodore Roosevelt solicited the advice of his old friend, John Greenway, the president of the Arizona Copper Company, as to whether his son Kermit should pursue a degree in

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Irving Hancock, *The Young Engineers in Colorado,* (Philadelphia: Altemus, 1912); H. Irving Hancock, *The Young Engineers in Nevada*, (Philadelphia: Altemus, 1913).

[301] Fred Bailey Oral Interview, No. 115, Oral History Collection, UTEP.

mining, Greenway responded with caution. To succeed, Greenway noted, Kermit needed to get a degree, as “entering the business Kermit with a Mining Engineer’s Degree… Will have a better chance to win out than Kermit without the training such a Degree means.” Clearly, Greenway believed that all the connections in the world could not help a man who wished to advance in the profession without a degree.[302] However, before entering university, Greenway strongly suggested that Kermit spend a year in underground work to get a feel for what mining entailed. He offered to take Kermit on himself or to recommend Kermit to “our mutual friend, Cleveland Dodge [of Phelps Dodge],” who ran the Copper Queen Mine. What Greenway somewhat equivocally states to Roosevelt regarding the significance of a mine engineering degree was in fact becoming a hard-and-fast rule within mine engineering.

In the early twentieth century, an early-career mining engineer, whether in Arizona or Sonora, had a very different career trajectory than did a mining engineer starting out only a generation earlier. One manager at a Phelps-Dodge property kept a journal clipping that addressed this circumstance: “frequent attempts have been made to arrive at a satisfactory definition of an engineer with more or less varied success” the clipping noted,

> An engineer is one who, through application of his knowledge of mathematics, the physical and biological sciences, and economics, and with aid, further, from results obtained through observation, experiences, scientific discovery, and invention, so utilizes the materials and directs the forces of nature that they are

[302] John Greenway to Theodore Roosevelt, 29 November 1911, folder 2718, box 196, MS 311, AHS.

> made to operate to the benefit of society. An engineer differs from a technologist in that he must concern himself with the organizational, economic, and managerial aspects, as well as the technical aspects of his work.[303]

The breadth of the alleged scope of an engineer's realm speaks to some extent to the importance that mining engineers – justifiably by this point in time -- placed on their own work within the mining industry. The introduction of the mass-mining techniques of mechanized transportation and exceptionally large smelting facilities required knowledge of math and physics; establishing operations to treat the low-grade copper ore that made up a high percentage of the ore mined in the borderlands regions required knowledge of chemistry; adapting these processing techniques to handle the range of ores processed in centralized treatment plants in places such as Douglas required a flexible inventiveness; and drawing a budget for all this rather expensive work that could still pay dividends to investors required a basic understanding of economics. Although the breadth of work that a single engineer undertook was no greater than in previous generations (and in many cases was much more narrow), no engineer could do his work without working closely with engineers who oversaw or designed other aspects of the mine, and thoroughly understanding their work and the pressures under which they operated. That this Phelps Dodge manager kept a definition of "engineer" in among his notebooks is indicative of the transition underway within the profession of mine engineering.

The early twentieth century is the time historian Edwin Layton identifies with "the revolt of the engineers," a moment when certain branches of the engineering

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[303] "What Is an Engineer" Box 16, Frank Ayer Collection, #3341, American Heritage Center, University of Wyoming, Laramie, Wyoming.

profession recoiled from over-identification with capitalists, and embraced the rhetoric of the Progressive reform movements. Layton's engineers recognized that as technical workers, engineers were uniquely placed to be reform-oriented political actors. He points out, however, that the 'reform" attempts of AIME ended before World War I, and chiefly consisted of amending the membership rules to be more friendly to business.[304] This change reflects the new subservience of mining engineers to the needs of the large corporations. Mining companies were powerful local entities in economic matters – recall Eugene Sawyer's succinct summation "everyone kow-tows to the Queen." The mass mining companies were also powerful forces in the lives of up-and-coming mining engineers, who for the sake of professional and personal stability sought positions in successful mining companies. The mining engineers of the early twentieth century were a far cry from the "westering" engineers who headed into the silver mines of Tubac, or Alamos, forty years earlier. The mining engineer's "dilemma," as Layton observed, had become "at base, bureaucracy, not capitalism."[305]

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[304] Layton, *Revolt of the Engineers*, ch. 2. See also Ronald Kline, "From Progressivism to Engineering Studies: Edwin T. Layton's *Revolt of the Engineers* Reconsidered," *Technology and Culture*, 49:4 (October 2008): 1018-1024.

[305] Layton, *Revolt of the Engineers*, 1.

Chapter Six

Mining Connections:

Engineers and the Technocratic Landscape

Mining engineers were crucial actors in the development and expansion of mass mining by large and powerful U.S. mining companies in the borderlands. Such corporations were not, however, the only companies for which mining engineers worked. Mining engineers were also employed by development companies and exploring companies, two types of mining investment companies that arose in the late nineteenth century and operated in a distinctly different way than did traditionally established mining companies. These kinds of companies viewed the mining industry and the mining landscape through more broad-based lens than that of traditional mining companies, which tended to focus, rather narrowly, on the extraction of a single kind of mineral. Although quite different from one another and from traditional companies, development and exploration companies had an expansive, regional perspective, and relied on mining engineers both to map that region and to act on the promise of the resources they highlighted.

For a company such as Phelps Dodge, all decisions revolved around the principle mine site. All of L.D. Ricketts' innovations, for instance, were designed to increase the efficiency and productivity of the company's copper mining project. In buying property, as in Nacozari, the company looked for copper mines; in constructing equipment, as at Douglas, the company looked to maximize its ability to process the ore from different locations. The goal of Phelps Dodge was to process copper for the market. Development companies, by contrast, sought to find underperforming or abandoned, ignored, or poorly managed mines, and to rehabilitate them using the latest extraction and processing technologies and engineering methods. An exploration company, although similar to a development company, operated on a different principle, seeking and surveying for new mining opportunities, usually as a contractor for interested investors rather than as a developer in its own right. Both development and exploration companies took a broad-based view of an entire region, considering all the different types of minerals present, and strategized how to create financial returns. Although financed differently – with development companies, as their name suggests, raising money for developing resources and exploration companies serving as contract consultants for investors, both kinds of companies viewed the mining landscape with a level of abstraction that was quite different from that of more traditional mining companies – even the increasingly large mass-mining corporations. Both exploration and development companies were dependent upon the professional credibility and technical expertise of mining engineers.

Mining-development companies are not often analyzed by historians as unique operators in the mining world. Yet they occupy an important niche in the expansion of the U.S. economy at the turn of the twentieth century. Historians tend to locate the massive expansion of the U.S. economy in the twentieth century in a concerted push among policy-makers and intellectuals to seek new markets for American goods and services.[306] Yet mining-development companies operated on a different model, bringing

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[306] Walter LaFeber, *The New Empire: An Interpretation of American Expansion 1860-1898,* 35th Anniversary Edition, (Ithaca, NY: Cornell University Press, 1998), 1-3;

greater efficiency to an extant extractive industry by investing in building infrastructure and exploiting local labor and industrial resources. Connecting financiers and industrial technology to aggressive infrastructure development, development companies, no less than the more traditionally structured mining corporations, helped to turn mining industry into a truly transnational industry, linking labor, expertise, finance, and profits across national lines.[307] They did so by treating the mining districts of the southwest and Mexico as a coherent technocratic landscape, rather than as a set of discrete sites in competition for resources and market share. Mining engineers were critical actors in development companies, without whom the companies could not function. However, the position of mining engineers within development companies varied dramatically. These distinctive roles illuminate an important shift in the role of mining engineers throughout southwestern and Mexican mining districts, as they changed from the instigators of exploitation they had been in the mid-nineteenth century into enablers of broad-based corporate expansion. A brief examination of the work of mining engineers in a development company and in a large exploration company illustrates the central importance of technical workers in these diversified companies. It further illuminates the establishment of a technocratic mining landscape through the mining districts of the southwestern U.S. and northern Mexico.

William Appleman Williams, *The Tragedy of American Diplomacy,* (New York: W.W. Norton, 1972), 57-59.

[307] Paul Sabin, "Home and Abroad: The Two 'Wests' of Twentieth Century United States History," *Pacific Historical Review* 66 (August 1997): 314-315; 318.

The Development Company of America

When William F. Staunton was growing up in Ohio, he was inspired to become a mining engineer by the example of his neighbor, John A. Church. After obtaining a degree in mine engineering from Columbia School of Mines in the early 1880s and gaining varied experience in east coast mining ventures, Staunton ventured out west, finally settling in Tombstone, Arizona, thanks to the assistance of his erstwhile neighbor, now an established and well-respected engineer working the mines of the Tombstone Mill and Mining Company.[308] As he recalled in his memoir, Tombstone in 1883 was a boomtown, and appeared to the young engineer to be a mining camp with a future. Unfortunately for Staunton, he was mistaken. Tombstone was peaking; the mines tapped out almost as quickly as they boomed. By the time Staunton was promoted to superintendent, in 1887 the rapidly dropping value of silver on the American market mired the company in debt, and Staunton was forced to close the smelter and to ship the small quantities of ore the mines produced off-site for processing, a move that dramatically reduced the likelihood that the company would earn dividends. At around the same time, the Tombstone miners struck water just below the 500' level of the mines. For a few years, several companies, including the Tombstone M&M Co., struggled to drain the basin under the mines, but a fire at the Contention Mine destroyed all the most

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[308] "List of Recent Graduates," *Columbia School of Mines Quarterly* 5:2 (January 1884): 162.

valuable pumping equipment, and with it the ability to mine at depth.[309] The rising water levels in the Tombstone mines, the weakening value of silver on the market, and the failure of the pumping system combined to end the project of mining Tombstone ore.

Around the same time as the Contention fire, Staunton was offered the position of superintendent at the Congress Mine, a gold and silver mine located in Yavapai County near Prescott, Arizona. The Congress was successful in all the ways the Tombstone Mill and Mining Company was not, producing five million dollars in gold profits through the 1890s. By 1900, Staunton was a wealthy man, superintendent and part owner of one of the most profitable precious metals mines in the region.[310]

One of the owners of the Congress Mine was Frank Murphy, who has been described by one historian as "the Southwest's greatest financier." The brother of the governor of territorial Arizona, Nathan Oakes Murphy, Frank purchased his first mining claim in Prescott in the 1880s. He used the profits from its sale to establish himself as a player in southwestern finance, and had a hand in funding many infrastructure projects in

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[309] William P. Blake, *Tombstone and its Mines*, (New York: Development Co. of America, 1903), 15-20; [William F. Staunton Memoir], William F. Staunton Papers [hereafter WFS], University of Arizona Special Collections, Tucson, AZ [hereafter UASC].

[310] Robert L. Spude, "Frank Morrill Murphy, 1854-1917: Mining and Railroad Mogul and Developer of the American Southwest," in *Mining Tycoons in the Age of Empire: Entrepreneurship, High Finance, Politics, and Territorial Expansion,* ed. Raymond E. Dumett (London: Ashgate, 2009),156.

Arizona and northern Mexico, particularly railroads. Murphy was the primary developer of the Santa Fe, Prescott, and Phoenix Railroad (SFP&P), and the El Paso and Southwestern branch line to Tombstone. He also eventually negotiated the sale of the SFP&P to the Atchison, Topeka, & Santa Fe (ATSF), and of the Phoenix and Eastern to E.H. Harriman of the Southern Pacific, connecting significant southwest mining sites to major transcontinental rail providers and thus to the rest of the country. Murphy's interest in the Congress Mine was almost certainly the reason that despite its hard-to-reach location at the foot of the mountains west of Prescott, the Congress was connected to a rail line early in its operation.[311]

In 1901, Murphy and a few other men involved in the Congress, including Staunton, the president of the Congress Mine, E.B. Gage, the lawyer Henry Robinson, and Benjamin Cheyney, a Boston financier and part-owner of the SFP&P, formed the Development Company of America (DCA), a corporation devised to run development schemes in the southwest, principally Arizona, and funded via the public sale of 6% bonds. Frank Murphy was the vice-president, and maintained an active managerial interest in the operation. The initial investors retained a 51% ownership stake in the DCA, and held 20% of the company's dividend profits as an operating budget. The first action of the Development Company was to purchase the Congress Mine and all the mines in the towns of Tombstone, and Poland, Arizona. The DCA later purchased the Silverbell mines of the Imperial Copper Company located near Tombstone, and in conjunction with the Southern Pacific built a rail line from Silverbell to the new Phelps Dodge smelter at Douglas. By 1906, the DCA was the largest holding company in the

[311] Spude, "Frank Morrill Murphy," 152-153, 157-159.

southwest, ranked as the seventy-sixth largest company in the United States, with capital assets in excess of $34.4 million.[312] Staunton, who continued to superintend the Congress, was also given responsibility for the management of mining Tombstone, where the DCA united all the mines under the aegis of the Tombstone Consolidated Mining Company. He soon assumed the superintendency of Silverbell.[313] Staunton's role in the company was of technical manager, overseeing the engineering and mining decisions of three fairly large mining operations. The DCA’s expansion at this time was qualitatively different from the contemporaneous expansion of Phelps Dodge. Where the growth at Phelps Dodge was diven by technical and engineering problems – processing ore from site X will be expensive, but it can be made more efficient by mixing it with ore from site Y – the expansion of the DCA was an end in and of itself. As a development company, its resources were necessarily diversified, and the acquisition of new property was driven

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[312]In size, the DCA was roughly equivalent to that of other mining companies in the region, including Greene-Cananea and the Guggenheim Exploration Company, although it remained somewhat smaller than Phelps Dodge. All the southwestern and Mexican companies were tiny compared to Anaconda, the company that controlled the mines in Butte, MT, and had assets of over $170 million. Norman R. Collins and Lee E. Preston, “The Size Structure of Large Economic Firms,” *American Economic Review* 51:5 (December 1961): 1005; 1008.

[313][Memoir], 105; 107-109; V.L. Mason to William F. Staunton, 11 November 1905, folder 6, box 3, both WFS, UASC; Spude, “Frank Morrill Murphy,” 156-157.

by a quest to always be able to offset losses, rather than by the need to streamline a technological system.

The fate of the mines at Tombstone, and of William Field Staunton as the superintendent of DCA mining operations, offers a clear example of the role of mining engineers such as Staunton in a diversified development company such as the DCA. Despite the failure of the Tombstone mines in the late 1880s, they were widely considered by mining experts at the turn of the century to contain plenty of silver and gold, albeit in quantities that needed modern methods and great patience to extract.[314] The difficulty of working the Tombstone mines on a mass scale became apparent after the Tombstone Consolidated took over production in 1901, and quickly sunk the bulk of its resources into draining the underground reservoir. The quantities of water removed from Tombstone were remarkable for the arid southwest, exceeding one million gallons per day by 1909.[315] In the best of circumstances, pumping water out of mine shafts was a difficult and expensive proposition, but the DCA had enough money to purchase heavy-duty pumps, and enough men to run them and to fix the technical problems that inevitably occur at an industrial site.[316]

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[314]William F. Staunton, "Report, Tombstone Mill and Mining Co." (1888); William F. Staunton, "Report Tombstone Mill and Mining Co." (1889); William A. Farish, "Report on the Mines of the Tombstone Consolidated Mines Co., Ltd." (1901).

[315]William F. Staunton to V.L. Mason, 31 January 1909, folder 6, box 3, WFS, UASC.

[316]William F. Staunton to Development Company of America, 16 June 1903, folder 6, box 3, WFS, UASC.

By financing the work of the Tombstone Consolidated Mining Company, in particular the pumping of water, the DCA enabled Tombstone to exist as a mining camp for several years beyond the time when a less diversified company would have had to pull out. In addition, the DCA brought into Tombstone large quantities of heavy industrial equipment, including four boilers weighing twenty-five tons apiece, which required a team of thirty-four horses to haul up the road from the nearby rail depot at Fairbanks; all new steam pumps capable of pumping over seventeen hundred gallons of water per minute, and a non-flammable steel pump house, enabling the Tombstone Consolidated to mine ore bodies located below the water table without risking a fire. As mining engineer W.P. Blake noted in a report on the property prepared shortly after the DCA began setting up in Tombstone, "the great advantages resulting from the consolidation of interests... are evident."[317] By centralizing the administration of the mine-draining operation, the cost of staffing the boiler-and-pump system was dramatically reduced. Such economy of scale was possible because the Development Company of America absorbed the high start-up and operating costs. The DCA, with its diverse holdings, was further able to stave off the expense of running the mine at Tombstone as profits at its other mine sites could offset the expenses at Tombstone.

As general manager, mining engineer William Staunton was pleased to have centralized authority over the work at Tombstone, Congress, and Silverbell, but he was less enthused by the fact that his own work at each locationwas also subject to significant oversight. Staunton was accustomed to having the last word, and the excellent relationship he had with the president of the Congress mine, E.B. Gage (also the first

[317] Blake, *Tombstone*, 19-20.

president of the Development Company), predisposed him to think relations with the DCA would be equally friendly.[318]

Staunton's relationship with Frank Murphy, however, was plagued by mutual recriminations and misunderstandings. Although Staunton was a powerful, well-connected, and remarkably successful mining engineer, within the DCA Staunton's position was less comfortable than it appeared. The radical centralization of DCA management -- in which one board of directors had oversight of several distinct mine sites -- meant that it was easy for the corporation, in the person of Frank Murphy, to call Staunton to task when there were technical or operational problems, rather than relying on Staunton’s engineering and managerial expertise. Murphy micromanaged Staunton, insisting that the engineer allocate his time at the various properties according to Murphy's wishes. In the early years of the DCA, when they had a fairly respectful relationship, Murphy cloaked his directions in Oxford sandwiches of praise. To a suggestion from Staunton that the workings at the Congress be slightly rearranged, for instance, Murphy responded,

> Situated just as we are, all things considered, I am inclined to feel as stated in my telegram that it is going to be necessary for you to give considerable personal attention to conditions at Congress... While I realize that you have a first class organization there, I cannot help but feel it was so that you could spend a little more time on the property, that better results would be obtained, – although I may be entirely mistaken. I don't think

[318] [Memoir], 73, 77-80, 88, WFS, UASC.

> you can blame me for feeling this way, having as I do implicite [sic] confidence in your ability to meet and overcome difficulties[319]

Surely, as technical director, Staunton had hired “a first-class organization” to oversee engineering details precisely so that he could spend less time at the Congress Mine rather than more? As the major problem for the Development Company was the Tombstone Consolidated Mining Company, surely Murphy would want his chief engineering officer, in whom he had “implicit confidence,” to allocate his time according to technical necessity? Despite Staunton's ostensible authority over the engineering details of the workings at the DCA's mining operations, Murphy always had his eye on the bottom line, quibbling with Staunton's every move, and Staunton felt perpetually disrespected. “[A]n expression of dissatisfaction with the way the work has been managed,” Staunton complained about Murphy's telegraphic griping, “can only tend to discredit a manager in the eyes of his subordinates, who necessarily see them, and this is advantageous neither to the company nor the standing of the manager.”[320] This dispute between Staunton and Murphy was not so different from that of Louis Janin and the Board of Directors at Concepcion. Where Janin’s conflict stemmed from differing interpretations of mine engineering expertise, however, Staunton’s conflict with Murphy was rooted in their disparate sense of purpose. The DCA turned a profit because it was diversified, but diversification made the technical oversight of each project more complicated. While the large copper companies built integrated systems for the efficient extraction of copper,

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[319] Frank Murphy to William F. Staunton, 9 January 1904, folder 1, box 3, WFS, UASC.

[320] William F. Staunton to Frank Murphy, 5 May 1910, folder 5, box 3, WFS, UASC.

development companies such as the DCA were principally about the efficient extraction of profits. Staunton continually raised questions about the efficiency of the DCA's engineering projects, while Murphy was concerned with the efficient working of the DCA as a whole.

The work at Tombstone did not proceed smoothly, which undoubtedly made Murphy's de facto dismissal of Staunton's engineering expertise particularly galling to the engineer, who was, as he put it, "ambitious to join the charmed circle" of the elite mining engineers of Arizona such as James Douglas, T.A. Ricketts, and John Greenway.[321] Yet those men oversaw integrated mining operations that focused on the engineering of copper; the technical focus of the DCA was never so clear and that ambiguity put Staunton, as technical manager, in a difficult position. Adding to the conflict, Staunton and Murphy were tripped up more than seems usual by continued miscommunication about the financial situation at the different mines, which exacerbated their already tense relationship.[322] The telegraphic codes employed by all mining operators at the time did not help matters, as an incorrectly translated transmission could cause considerable distress, as on the occasion when Murphy understood Staunton's telegraph that he was unable to estimate the ore-body at Silverbell with enough exactitude to "stand verification by possibly *hypercritical* examining engineer" to read "by possibly *hypocritical* examining engineer" and had a fit, presuming an offense to the examining engineer he had hired as a consultant. In this instance, as in countless others, Staunton begged

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[321] [William F. Staunton Memoir], 177, WFS, UASC.

[322] My emphasis. William F. Staunton to Henry Robinson, 26 December 1908, folder 1, box 4, WFS, UASC.

Murphy's forgiveness, stating that he “guess[ed he] was unfortunate in choice of words.”[323]

Matters came to a head in 1910, over the purchase of approximately $40,000 of new pumping equipment, the installation and maintenance of which would cost an estimated $200,000. The new equipment was needed because an accident, coupled with the heavy demands placed on the pumps, had rendered five of the Tombstone Consolidated pumps unworkable. Staunton declared that the value of the mines at Tombstone did not “warrant one in advising such an expenditure” of new pumping equipment, and, furthermore, “we have reached a time when we ought to stop putting money into Tombstone until we get into a position from other operations to afford to carry on the work.” He suggested that Murphy call in one or two consulting mining engineers to inspect the Tombstone operations, to get an outside opinion on the viability of the mine.[324] Murphy castigated Staunton for his lack of faith in the Tombstone mines, asserting that Staunton bore sole responsibility for the failure of the pumps. The mining engineer resigned his position in the DCA. “Further consideration of his [Murphy's] letters seemed to me to make it practically necessary,” Staunton observed shortly afterwards. “I have never been able to discuss our affairs with him in the plain way that it

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[323] William F. Staunton to Frank Murphy, 5 December 1904, folder 1, box 3, WFS, UASC.

[324] William F. Staunton to Frank Murphy, 8 May 1910, and 21 May 1910, folder 5, box 3, WFS, UASC.

seems to me should be done without raising a storm and having my motives misconstrued and I am tired of it."[325]

What is remarkable about Staunton's conflict with Murphy is not that it occurred, as mining engineers often clashed with overly engaged financiers and company officials. But Murphy's dismissal of Staunton's opinions and concerns was remarkable, and suggests that Staunton's technical expertise was of secondary importance to his success at the DCA. Despite the reliance of the DCA on the work of Staunton and other engineers, the vision of Murphy, and therefore of the company, was not of an efficiently run mining operation, but of a fully integrated system with the primary goal of making money and the secondary goal of mining ore, an inversion of the general work of mining engineers. As Staunton's superior, Murphy was able to undermine Staunton's expertise at will and to determine what of Staunton's work was worth implementing and what was simply "expert advice," which Murphy could ignore as, well, it was only advice.

<u>The Guggenheim Exploration Company</u>

The Guggenheim Exploration Company, which operated throughout Mexico with occasional forays into mine sites such as Utah, Colorado, and Alaska, had a similar impact on the development of rail infrastructure in Mexico, particularly in the north, as the DCA had in Arizona. It was, however, a fundamentally different kind of development organization. The Guggenheim family at the turn of the twentieth century has sometimes been called "The

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[325] William F. Staunton to Henry Robinson, 17 May 1910, and 23 May 1910, folder 2, box 4, WFS, UASC.

Copper Kings." Although this appellation suggests a greater control over the world copper market than the Guggenheims possessed, it indicates the influence the family wielded over the copper extraction and refining industry in the Americas. Meyer Guggenheim, the family patriarch, made his second fortune mining silver in Leadville, Colorado, in the 1860s (his first wildly successful business was importing coffee to the U.S.). With his sons – there were seven Guggenheim sons active in the family business – Meyer soon capitalized on this initial success in ore extraction, establishing a smelter in Pueblo, Colorado, managed by a company named, somewhat confusingly, Philadelphia Smelting and Refining. M. Guggenheim Sons intended to use this smelter not only for processing local silver ores, but also for working the rich silver-lead ores being mined south of the border. This plan was derailed in 1890 by the passage of the McKinley Tariff, which taxed imported silver-lead ore in an attempt to stabilize the price of silver in the U.S., essentially excluding Mexican ore from the U.S. market.[326] Undaunted, M. Guggenheim Sons took the next logical step, and at the suggestion of mining engineer Edward Newhouse, built two smelters in Mexico with the full cooperation of the Diaz administration, thereby bypassing the

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[326]Irwin Unger and Debi Unger, *The Guggenheims: A Family History,* (New York: Harper, 2005), 39-40.

provisions of the tariff. The first, in Monterrey, opened in 1892; the second, at Aguascalientes, in 1894.[327]

Between the cost of labor in Mexican smelting, approximately one-fifth of that in Colorado, and the concessions the Guggenheim's received from the Mexican government in the form of duty-free importation of construction equipment for the smelters and low taxes, these two smelters were extremely profitable from the start, and became more so as they began treating the copper ore that was also present in northern Mexico in large quantities.[328] Including the Guggenheim refinery in Perth Amboy, New Jersey, which refined the copper treated in Colorado and Mexico for sale to the emerging electrical industry, the family was responsible for smelting, transporting, and finishing a large percentage of the copper produced in the southwestern United States and Mexico through the 1890s.

This dominance was recognized by other smelter operators in the United States, who joined together to organize the American Smelting and Refining Corporation (ASARCO) in 1901. Invited to join in, the Guggenheim family declined, choosing to focus instead on their new mine exploration business, the Guggenheim Exploration

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[327]Unger and Unger, *The Guggenheims,* 41-42; Isaac F. Marcosson, *Metal Magic: The Story of the American Smelting and Refining Company,* (NY: Farrar, Strauss and Co., 1949), 45-51.

[328]Thomas O'Brien, “Copper Kings of the Americas – The Guggenheim Brothers,” in Raymond E. Dumett, ed., *Mining Tycoons in the Age of Empire: Entrepreneurship, High Finance, Politics, and Territorial Expansion,* (London: Ashgate, 2009), 203.

Company (Guggenex). The reasons the family made this decision are not entirely clear. Possibly they believed that absent a major technological breakthrough in ore processing, current metallurgical practice was unable to satisfactorily process the lower-grade copper ore increasingly being mined through the southwestern Rocky Mountains and Mexico.[329] Possibly the family simply did not want to be involved in any business in which they did not own at least 51%. Regardless, without the participation of the Guggenheims, ASARCO folded, and the owners had to beg the Guggenheim family to buy them out. After 1907, the Guggenheim's controlled not only Guggenex and their own smelter operations, but also a controlling interest in ASARCO.[330]

The Guggenheim Exploration Company was capitalized in 1899 at $6 million, in order "'to prospect, explore, improve, and develop mining properties in any part of the world.'"[331] Under the leadership of the extremely energetic second son, Daniel Guggenheim, Guggenex hired John Hays Hammond, a mining engineer already famous for his exploits in Africa with Cecil Rhodes, to oversee the surveying operations, paying him a base salary of over $200,000, reportedly the highest in the world, plus a significant

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[329]O'Brien, "Copper Kings," 211. This is unlikely to be true, since in the early 1900s the Guggenheim family had an ownership stake in the Bingham Canyon Mine in Utah, a clear example of significant technological development in processing low-grade ore, which mining engineer Daniel Jackling was rapidly transforming into an open-pit copper mine.

[330]Marcosson, *Metal Magic*, 61, 63, 69.

[331]Marcosson, *Metal Magic*, 63.

share in any mines the family decided to develop on his watch.[332] Guggenex was modeled after the London-based, Rothschild-financed Exploration Company, which began exploiting mine sites principally in Latin America, Africa, and Australia in the late 1880s. Like a development company, the Exploration Company used its capital to finance site inspections, but then rather than holding properties itself, it sought other investors and expertise to develop the most promising locations. More traditional mining companies were formed in the wake of significant finds explicitly to exploit particular veins and ore deposits – the Exploration Company was formed to systematize the process of finding mining sites with potential. Many of the mining engineers who were closely involved in the Exploration Company were American (including Henry Janin in his post-diamond-fraud career), and its work was well-known in the United States.[333]

Daniel Guggenheim, the family member most closely associated with the Guggenheim Exploration Company, was widely believed to have placed great trust in the expertise of his technical employees, and to have relied on the advice of experts rather than on his own knowledge of the industry when making investments in mining – the opposite of Frank Murphy's relationship to William Staunton in Arizona.[334] It is certainly

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[332]John Phillips, "Alfred Chester Beatty: Mining Engineer, Financier, and Entrepreneur, 1898-1950," in Dummett, ed., 220.

[333]Clark Spence, *Mining Engineers and the American West: The Lace-Boot Brigade,* (New Haven: Yale University Press, 1970), 137-138.

[334]This point was first made by Isaac Marcosson in his admiring history of ASARCO, but was picked up by later biographers and hagiographers of the Guggenheim family. It falls

the case that the Guggenheims hired many of the most well-known and heavily credentialed mining engineers in the business, and paid their technical experts – known as "Guggies" to other mining engineers -- extremely generously. The high wages were possible due to the low overhead costs of running the Guggenheim Exploration Company, which had to pay for engineers and their assistants, but did not have the equipment and labor expenses with which companies such as the DCA or Phelps Dodge had to contend.[335]

In the past, consulting engineers were hired directly by a board of directors or a set of investors to survey specific mine sites. Even before hiring the engineer, these

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short in explaining the public and extremely acrimonious split between Guggenex and mining engineer A.C. Beatty, who accused Daniel Guggenheim of inflating the stock price of a prospect in Alaska on the basis of what Beatty believed to be a preliminary and less-than enthusiastic report. Marcosson, *Metal Magic,* 45, 46; Anon., *The Men Who Are Building America,* reprint (New York: Read Books Design, 2009), 177; see also Christopher Schmitz, who argues that technological innovation, such as that supported at Guggenheim-owned facilities, rather than financial innovation, was the best indicator of success in the copper smelting industry in the early twentieth century. Schmitz, "The Rise of Big Business in the World Copper Industry, 1870-1930," *The Economic History Review,* New Series 39, no. 3 (August 1986): 392; 404.

[335]Charles Harvey and Jon Press, "Oversees investment and the Professional Advance of British Metal Mining Engineers, 1851-1914," *The Economic History Review,* New Series 42, no. 1 (February 1989): 74; Spence, *Mining Engineers*, 138.

investors were somewhat committed to the mine; they were interested enough to invest in hiring an expert, after all, to scope out what was there already and to plan for the future. Although the Guggenheim Exploration Company sometimes surveyed extant mine sites for specific clients, it frequently worked on a completely different model. The firm decided where to send its engineers. These engineers worked for their manager, and reported back to him, rather than to a set of investors or an outside company. These managers were experienced engineers who themselves had many ideas as to where the best mines might be located, sent teams of surveyors and assayers to those locations, and, if the results were promising, sought investors.

Guggenex thus upended the traditional expert-client relationship. The examining engineers they hired only had one employer – the Guggenheim Exploration Company – which should have established very specific requirements for what constituted a good prospect. Having such clear standards, in turn, should theoretically have eased the strain of writing mine reports, as the consultants knew exactly what information was required, and how the recipient of the report would interpret it. However, the engineers were no longer writing reports for their clients. They were writing reports that would be read by their corporate supervisors. That supervisor, A.C. Beatty, passed the information up to Hammond and then Daniel Guggenheim as to whether or not a mine was a worthwhile proposition. This bureaucratized and streamlined a decision that had previously been negotiated directly between the consulting engineer and the investor or investors.

Logically, working directly for a manager such as engineer Alfred Chester Beatty ought to have made the everyday workload of Guggenheim engineers easier. After all, there were no conflicts of interest in this relationship as there were in the relationship between consulting mining engineers and an investment company, where the possibility of corruption – of the mining engineer simply finding the information that his employers wanted him to find – was high. Yet the pressure to find previously untapped mining resources, or to discover clever new ways to mine extant-yet-undervalued mining deposits was extremely high in Guggenex. Beatty, in turn, was not an easy man to work with, and he had strong opinions about personnel deployment, and he attempted, from a distance, to regulate very precisely how each engineer ought to divide his time and use his team of assistants.[336] Directives from Beatty could upend an established hierarchy by ordering an engineer to report to a man he thought of as his collaborator, or by dispatching a mining engineer's assistant to a mine a few hundred miles away, leaving the field operatives perplexed and not a little infuriated. Engineer Ross Hoffmann once received a telegram instructing him to immediately forward a report, the result of assays on a property in Chihuahua to Beatty. Hoffmann told Beatty that it was with "great surprise... [I learned] that I am expected to report on any of the properties. I understood definitely that Mr. Gemmel was in charge of the work and I was under his orders." Being asked to write a report he did not expect to have to prepare was of serious concern to Hoffmann, who was pressed for time and money. In this instance, Hoffmann had turned over his original and duplicate assays to Gemmel, a more senior and well-regarded mining engineer. The originals were sent to Monterrey to be assayed; the duplicates were in an unsealed sack in Gemmel's room, a circumstance Hoffmann thought might indicate that they had been tampered with. Hoffmann further complained to Beatty about

[336] A.C. Beatty to Ross Hoffmann, 15 January 1903, folder 32, box 2, MS 3163, AHC.

rushing his work; he felt overextended as it was, and resentful of Gemmel's authority, frustrated by almost every aspect of his survey work in Mexico.[337]

When combined with the challenge of getting American dollars to Guggenex employees working at mine sites in remote villages, and the exhausting pace of mine inspections Guggenex consultants maintained – in his initial letter to Beatty, for instance, Ross Hoffmann noted that if he did not write his report in about half the time he thought he ought to take, his schedule would be derailed and he and his fellow mining engineers would be unable to complete the work they had to before the end of 1903 – it is clear that mining engineers frequently experienced the radical centralization of the Guggenheim exploring method as a mixed blessing.[338] Although their work was salaried, a luxury unknown to mining engineers who worked for less-solvent development companies, Guggenheim engineers had very little autonomy. Just three weeks prior to the telegram requesting Hoffmann's assays, the engineer drafted a letter of complaint to Beatty:

> I am acting now entirely under Gemmel's instructions according to your advice to him – in a recent letter[,] a portion of which was read to us... As I am now in a position which requires very little responsibility.... it will be a great relief and favor to me if you will send some-one to take my place – I feel that I need the rest ~~+ don't want to sacrifice my health under the~~

[337]Ross Hoffmann to A.C. Beatty, 1 July 1903; Longacre to Ross Hoffmann, 4 July 1903; [Robert C.] Gemmel to Ross Hoffmann, 8 July 1903 and 19 July 1903, all folder 32, box 2, MS 3163, AHC.

[338]Ross Hoffmann to A.C. Beatty, 1 July 1903, folder 32, box 2, MS 3163, AHC.

> ~~circumstances~~ + ought not undertake this extended work under the circumstances.[339]

Hoffmann remained in Mexico for some time after writing this letter, and we can only speculate as to whether his complaints may have had the opposite result to that intended, or whether on further reflection he decided not to ask Beatty to move him to another assignment.

That Ross Hoffmann was exhausted from his work in Mexico should not be surprising. Mine inspections were of course hard work with or without bureaucratic frustrations. Mining engineers were expected to scrutinize the full extent of a property. In general, this meant that an engineer, along with his colleagues and assistants, walked or rode on horse or mule-back over the entire property. A well-planned mine inspection provided a map of accurate correspondences of surface and underground points, and elaborated, with specific suggestions on how future work on the mine should proceed.[340] To achieve such a comprehensive survey of a mine, engineers had to find and record each outcropping, waterway, and elevation change, and to accurately depict the latitude and longitude of neighboring claims in order to map the direction, depth, and

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[339]Ross Hoffmann to A.C. Beatty, 6 June 1903, folder 32, box 2, MS 3163.

[340]Charles F. Hoffmann notebook, [n.d.], folder 10, box 1, MS 3163; Arthur Laing to James Douglas, 18 July 1881, folder 29, box 3, James Douglas Papers, MS 1031, Arizona Historical Society, Tucson, AZ; James D. Hague to Santa Eulalia Mining Co., 20 May 1885, L-9, JDH, HL.

breadth of the ore body. There were many means for determining the direction and extent of the ore body, as well as the composition of the ore itself, but when Guggenex was founded the most common method was still to collect samples of the ground at regular intervals and send them to a chemist for assay.[341] The largest mine survey undertaken by the Guggenheim Exploration Company, of a property belonging to the Utah Copper Company, required sixteen engineering assistants, took seven months, and cost $150,000, a staggering sum in 1903.[342]

The reports that the mining engineers of the Guggenheim Exploration Company submitted were extremely detailed, containing descriptions of mining properties and of extant mining technology, analyses of local labor availability, and evaluations and estimates of possible future productivity. Many mine reports also contained exceptionally long introductions into both local culture and into the history of the particular mining site being studied. In conjunction with the economic and productivity analyses conducted by the mining engineers, and the personal letters to Beatty, Hammond, and each other that accompanied these reports and their frequent progress updates, a comprehensive vision of the mining borderlands emerges, as "seen" by mining engineers on behalf of the Guggenheim family.

The Technocratically Legible Landscape

[341]Spence, *Mining Engineers*, 96-99.

[342]Spence, *Mining Engineers*, 91.

The landscape that emerges from engineers' reports of mining districts in Mexico and Arizona is not quite a terra incognita, but rather a region that lacked vitality, as evidenced by the engineer's constant efforts to suggest new ways to increase productivity. There is a broad jingoism and ethnocentrism underlining the observations of slack management in these reports, mirroring ethnic, class, and racial prejudices common among elite white Americans at the turn of the century.[343] A recurring trope in engineer's reports from Mexico, for instance, was the narrative of a landscape that was gradually coming under the influence of a rationalizing force, but that periodically spun out of control. A mining district might have been worked by the Spanish and then by Mexicans, "in a very unsystematic and unscientific manner" albeit with great "clever[ness] at following ore bodies . . . cheaply."[344] A copper mine was referred to by its inspecting engineer as having been "worked by the Mexicans in a desultory manner for the

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[343]Reginald Horsman, *Race and Manifest Destiny: The Origins of American Racial Anglo-Saxonism,* (Cambridge: Harvard University Press, 1981), 210; Matthew Frye Jacobsen, *Whiteness of a Different Color: European Immigrants and the Alchemy of Race,* (Cambridge: Harvard University Press, 1998), 90-95; Sarah Deutsch, *No Separate Refuge: Culture, Class and Gender on an Anglo-Hispanic Frontier in the American Southwest, 1880-1940,* (Cambridge: Harvard, 1987), 110-111.

[344][R.C. Gemmel], "Preliminary Report...," 24 December 1901, folder 4, box 6, Harold A. Titcomb Papers, MS 2220, American Heritage Center, Laramie, WY [hereafter MS 2220].

past 25 years."[345] The labor of Mexicans was thus trivialized or dismissed, although its existence served as an important marker of a mine's potential productivity. Engineers well understood that a mine that had produced significant ore when excavated by hand and treated using the patio process had the potential to produce considerably more when excavated with machinery and treated using the latest smelting technology, and they said as much in their reports.[346]

Of greater significance than the condescension of American engineers towards Spanish and Mexican mining methods was the quantification and abstraction of the landscape that was the consulting engineer's primary methodological device. A 1905 report by a Guggenheim engineer on the Copper Chief Mine in Jerome, Arizona, for instance, consists of little more than a line sketch of a vertical section of the mine coupled with a computation of the quantity of developed ore in the main ore-body plus the probable quantity of ore in an as-yet undeveloped ore-body, divided by an estimate of the cost of extraction, per

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[345] John M'Intyre to S.D. Bridge, 19 August 1899, folder 13, box 6, MS 2220, AHC.

[346] John M'Intyre to S.D. Bridge, 19 August 1899, folder 13, box 6, MS 2220, AHC; [unknown], "Preliminary Report on the Smelter at Bonanza, Zac...," December 24, 1901, folder 4, box 6, MS 2220, AHC; C.W. Geddes, "Report on a Reconnaissance of the Mammoth Mine," folder 19, box 6, MS 2220, AHC; W.A. Farish, "Report on the Mina Grande and Santa Teresa Properties in the District of Hermosillo..." 23 June 1902, folder 20, box 6, MS 2220, AHC; W.A. Farish, Report on the Zaragosa Properties..." 7 July1902, folder 17, box 7, MS 2220, AHC.

ton. In this case, the estimated net value of the mine was $900,000.[347] Such quantification of mining terrain was the reason mining engineers were sent into Mexico; these were numbers that only such technically trained men could produce. The reports contained data points that were of tremendous utility, not only for the Guggenheims as they determined which mines to purchase, but also for those mining engineers, Wall Street bankers, and reporters who watched the actions of the Guggenheims and their several businesses with interest, gleefully noting the incursions of American-backed finance into Mexico.[348]

James Scott famously described the use of highly quantified and rationalized maps and grids to promote the "legibility" of landscapes and populations in the twentieth century as an attribute of "high modernism," a technocratic worldview Scott identified as a precondition for control of a subject population. Scholars of engineering have argued that engineers embody the ideology of high-modernism as described by Scott, possessing a "self-confidence about scientific and technical progress, the expansion of production, the growing satisfaction of human needs, the mastery of nature... and, above all, the rational

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347 [Harold A. Titcomb], Copper Chief Mine Report, 20 May 1905, folder 4, box 2, MS 2220, AHC.

348 "Millions for Mexico," *New York Times,* 1 April 1901; "Millions for Mexican Mines," *New York Times,* 1 November 1902; "Guggenheim's Roads," *Los Angeles Times*, 23 January 1903; "Guggenheim Exploration Company Increases its Capitalization," *Los Angeles Times*, 6 March 1903.

design of social order commensurate with the scientific understanding of natural laws."[349] The Guggenheim mining engineers obviously conform to this standard: they were agents of rationalism, scanning the landscape to bring technical progress to places that by virtue of their inaccessibility had previously escaped industrialization. Mining, particularly on the scale undertaken by Guggenheim interests in the twentieth century, is ultimately and horrifically about human mastery over nature.[350] The ores that the Guggenheim's were interested in, principally silver and copper, are two metals that certainly contributed, through their monetary value and, in the case of copper, significance to the new electrical industry, to "the growing satisfaction of human needs."

Yet Guggenheim mining engineers lacked two key elements of the "high modernism" cited by Scott and others: they were not agents of a state; and although cognizant that a large mining project supported by the Guggenheims would lead to a reorganization of the local labor force and probably the relocation of many workers, the mining engineers of the Guggenheim Exploration Company were not interested in social re-organization. Robert Vitalis argues in his account

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[349]James Scott, *Seeing Like a State: How Certain Schemes to Improve the Human Condition Have Failed,* (New Haven: Yale University Press, 1999), 4; Martin Reuss, "Seeing Like an Engineer: Water Projects and the Mediation of the Incommensurable," *Technology and Culture* 49, no. 3 (July 2008): 543.

[350]Timothy J. LeCain, *Mass Destruction: The Men and Giant Mines that Wired America and Scarred the Planet*, (New Brunswick: Rutgers University Press, 2009).

of the Arabian American Oil Company (ARAMCO) that the history of large corporate firms and the history of states are not dissimilar. Discussing the racialized division of labor common in the mining industry at the turn of the twentieth century, Vitalis notes that large corporate firms in the southwestern U.S. such as Phelps Dodge "organized production in the way that the post-Reconstruction South organized society."[351] An exploration and development company, Guggenex was not as deeply enmeshed in building racially stratified mining enclaves as Phelps Dodge or the Arizona Copper Company, but company engineers were practiced at cataloguing the information that enabled such stratification: population; proximity to towns and major roads; access to resources such as water and timber. Guggenheim engineers performed a job similar to that of the Corps of Topographical Engineers, dispatched westward to survey new U.S. territory in the wake of the U.S. Mexico War, or to John Russell Bartlett's survey of the U.S. Mexico border, during which the cataloguing of the mineral resources of the new territory was almost as important as the survey of the

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[351]Robert Vitalis, *America's Kingdom: Mythmaking on the Saudi Oil Frontier,* (Stanford: Stanford University Press, 2007), 19.

international boundary line.[352] Guggenheim mining engineers produced a quantified and particularist reading of the mining landscape that clarified logistical and technical needs, enabling future exploitation.

The scale of the Guggenheim Exploration Company was extraordinary, easily dwarfing the contemporaneous work done by more traditional mining companies. According to mining historian Clark Spence, in 1910 Guggenheim engineers conducted over 1600 mine inspections, including preliminary examinations of 268 mines, and full surveys of 74 mines.[353] By 1910, the Guggenheim Exploration Company had been in operation for a decade; the accretion of information on the landscape of the mining districts of the southwestern U.S. and northern Mexico during this time was phenomenal. A small army of engineers and assistants was required to work at a frantic pace to accomplish all these surveys. No wonder Ross Hoffmann worried that he would fall behind in his inspections. As comprehensive as was the information gathered through mine inspections and surveys, encompassing at even the most cursory level information about the transportation infrastructure, the availability of local

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[352]William Goetzmann, *Army Exploration and the American West, 1803-1863,* (New Haven: Yale University Press, 1959), 1, 4, 10; John Russell Bartlett, *Personal Narrative of Explorations and Incidents in Texas, New Mexico, California, Sonora, and Chihuahua, connected with the United States and Mexican Boundary Commission During the Years 1850, '51, '52, and '53,* (New York: D. Appleton, 1854), iv-v.

[353]Spence, *Mining Engineers*, 138.

labor, and the location of timber and water resources, Guggenheim mining engineers paid surprisingly little attention to local or regional politics – indeed, this lack of attention was fairly anomalous in the mining industry. It is impossible to believe that businessmen as practiced and knowledgeable as the Guggenheims did not consider the legal and political implications of every given investment; U.S. tax laws and the concessions granted to foreign investment were important reasons that the Guggenheims invested in their first smelter in Mexico. As noted by historian Mark Wasserman among others, engineering impresario John Hays Hammond counted Porfirio Díaz among his personal friends, and smoothed the way for many Guggenheim ventures in Mexico.[354] Yet it is also notable that considerations of politics and legislation seem to have been beyond the purview of their workaday consulting engineers. Indeed, the narrowness of the Guggies' consideration of mining sites almost amounts to a willful attempt on the part of individual engineers to ignore the significance of the vast infusion of finance signified by the interest of the Guggenheim Exploration Company.

As the borderlands mining industry matured and expanded in the early years of the twentieth century, companies such as the DCA and Guggenex bureaucratized the work of mining engineers as managers and consultants on a much larger scale than was conceivable in the 1870s and 1880s. Although these companies were utterly reliant on the expertise and professionalism of mining engineers, they served to narrow the workload of individual engineers, much as

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[354]Mark Wasserman, *Capitalists, Caciques, and Revolution: The Native Elite and Foreign Enterprise in Chihuahua, 1854-1911*, (Chapel Hill: UNC Press, 1984), 86-89.

did the consolidated mass-mining companies. At the same time, development and exploration companies helped to produce a legible technocratic landscape that served as a blueprint for future exploitation, thus providing work for future generations of mining engineers.

Conclusion

As the head of the joint U.S.-Mexico Boundary Commission in the early 1850s, John Russell Bartlett took it upon himself to make a study of the natural resources of the deserts and mountains in the territory so recently acquired by the United States. "The time is not far distant," he observed, "when crowds as large as those now pressing on to California and Australia will be 'prospecting' among the mountains of Texas, New Mexico, Chihuahua, and Sonora, attracted by similarly rich deposits, and probably with the like splendid success."[355] When American entrepreneurs took up Bartlett's implicit challenge in the southwestern borderlands, they certainly brought with them dreams of wealth shaped by tales of the California gold fields. What they found were rich mining opportunities that would nonetheless require significant work to make them pay. For the next sixty years, mining development appeared to follow a relentless trajectory: mining prospects replete with refractory, low-grade ores were exploited using ever more technologically sophisticated equipment and processes. The profession of mine engineering developed in tandem with these new opportunities, as mining engineers were responsible for identifying these mining prospects as workable and for devising the processes that could exploit them.

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[355] John Russell Bartlett, *Personal Narrative of Explorations and Incidents in Texas, New Mexico, California, Sonora, and Chihuahua, connected with the United States and Mexican Boundary Commission During the Years 1850, '51, '52, and '53,* (New York: D. Appleton, 1854), iv-v.

The development of the borderlands mines, did not follow the pattern of the California gold rush, nor was it the foregone conclusion that Bartlett suggested. In 1864, when journalist J. Ross Browne travelled across southern Arizona, he had quite an adventure, but he was disappointed in the mining:

> the great drawback to mining [here] is, that the owners of feet have no money to expend in extracting their wealth from the ground; and when people who have money desire to invest, the men of feet demand extraordinary sums, because they think claims that attract capital must be of extraordinary value.[356]

In Browne's assessment, the borderlands mines lacked owners who were knowledgeable about finance, as well as regular access to capital, and therefore little development occurred, an observation in keeping with what mining engineers such as Raphael Pumpelly and independent prospectors such as John Denton Hall experienced in the region in the late 1850s and 1860s. Through the 1870s and 1880s, with the exception of a handful of booms such as the silver strike at Tombstone, only companies with deep financial pockets were more than marginally successful at working the precious metals of Arizona or Sonora, while the independent "men of feet" continued to prospect around, occasionally getting lucky. But the advent of electricity in the 1890s changed the market for copper ore and the economics of the region were altered. Copper mining required a massive up-front investment; the financially naïve mine owners described by Browne were bought out by well-connected investors and corporations from New York and San Francisco.

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[356] Browne, *Adventures in the Apache Country*, (New York: Harper, 1871), 72.

The development of the U.S.-Mexico border region, and the development of the profession of mining engineering occurred in tandem, and mining engineers were crucial in shaping the economy of the border. Mining engineers rendered the borderlands legible to investors, by means of their underground surveys; persuaded investors of the critical importance of building infrastructure to aid in mineral extraction; and brought heavy technology to mining sites, building the industrial landscape characteristic of the region. Mining engineers did not merely change and exploit the landscape. They proved more than willing to bend their careers to fit the needs of the regional economy. From the time the earliest mining engineers travelled to the Santa Rita, Mowry, and Heintzelman mines at Tubac, through the Mexican Revolution, the career trajectory of mining engineers changed dramatically. Early engineers, members of an elite and cosmopolitan class of eastern and European men, travelled extensively through their careers, working as consultants or managers as it suited them or as the opportunity arose. Following the democratizing trend of the engineering profession in general, scores of mining engineers took advantage of the educational opportunities brought by the establishment of land-grant colleges, and college-trained mining engineers flooded both the field and the mineral districts of North America. By the 1910s, mining engineers in the borderlands were more likely to work for the large copper corporations such as Arizona Copper, Phelps Dodge, and the Cananea Consolidated Copper Co. than they were to manage on-site business for smaller companies. In the 1920s, mining engineer Ralph Ingersoll was sent by Phelps Dodge to be on-site engineer at Nacozari, the mine that engineer Louis Ricketts so carefully automated at the turn of the century. Ingersoll's responsibility, as engineer, was to measure the work done by each team of miners each day to determine their pay rating. Decisions regarding the actual mining, or the processing of the ore, were made by other people; Ingersoll's mathematical and technological skills were needed to surveille the Mexican mine workers, rather than to design a dig or read a landscape.[357] The success of some mining engineers in constructing technologically sophisticated mining systems had the effect of narrowing the scope of the profession for generations of mining engineers who followed them.

The corporatization and bureaucratization of mining affected the lives of mining engineers in the southwestern U.S. and in Mexico in other ways as well. When mining engineers headed out to Arizona or Sonora in the mid- to late- nineteenth century, they found a place and a society that had little in common with the cities and towns of the northeastern U.S. and Europe to which they were accustomed. Prior to the 1880s, neither the U.S. nor Mexican governments were able to adequately protect their citizens from Apache raiding parties, who quite understandably viewed the encampments of foreigners as incursions into their sovereign territory. The immense distances between mining settlements; the heat; and the small American population combined to give mining engineers a sense that they were out on their own, and that they could rely only on themselves for protection. As Raphael Pumpelly's memoir demonstrates, the high adventures to be found working in such circumstances were not always comfortable, and the political and social circumstances of the early borderlands did not facilitate great advances in the mining business or mining techniques. But the experiences of a few men

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[357] In Ingersoll's memoir, he refers to the town as "El Monte de Cobre," but by virtue of its location and other identifying features it is clear that he was working for Phelps Dodge at Nacozari. Ralph Ingersoll, *In and Under Mexico*, (New York: Century, 1924), 38.

in the 1860s, and of rather more mining engineers in the 1870s and 1880s, served to provide mining engineers with a critical rhetorical device through the end of the nineteenth century: the ability to call upon a self-professed, hyper-masculine identity as westering pioneers in support of their claims of technical expertise and scientific knowledge. Despite the extraordinary changes in both the mining industry and the careers of mining engineers, this "frontiersman" identity proved remarkably persistent, and did not really change over time.

However unlikely the adoption of a self-consciously pioneering masculine identity might have been for a profession of mostly elite white men from the eastern United States, it stands to reason that they would work to find ways to buttress their authority in the field. Despite the undoubted mineral wealth of North America, the profession of mine engineering was slow to take hold in the university system, relative to its sister fields of civil or mechanical engineering. Perhaps because of this, the position of mining engineers as "experts" was tenuous through the late nineteenth century. Whether conducting a mine survey, or working as the resident mine manager, mining engineers had to position themselves as authoritative technical workers vis-à-vis working miners when out in the field—mere credentialing did not hold much sway when the workers were experienced Cornish miners, and was even harder to assert to a population of immigrant miners who did not speak English. Embracing an identity as westering pioneers enabled mining engineers to assert themselves with a distinctive regional authority. When interacting with eastern capitalists, as well, mining engineers found that they established confidence if they could make it clear that they were equally at home in rugged mining camps as in the social clubs of Manhattan or San Francisco.

The emphasis mining engineers placed on rugged living also stemmed from the fact that through the early twentieth century it was difficult to get to, and uncomfortable to remain at, most mining camps in the borderlands. Yet by the 1920s, largely as a result of the industrial push of copper mining, engineer Ralph Ingersoll was able to travel by train to his position in Pilares de Nacozari in great comfort, particularly once he crossed into Mexico where was permitted to smoke on the train and put his feet up on the seat in front of him.[358] At Nacozari, he found a robust community of fifty Americans, including two female schoolteachers and some extremely enthusiastic golfers. This is a tremendous contrast to the experience of Morris Parker, merely twenty years earlier, who suffered, with his wife and three small children, through an uncomfortable, multiday trip involving a couple of different trains and a difficult wagon journey to reach Nacozari. He left the position in under eighteen months because there were only five Americans in the camp and nobody with whom his wife could carry on a conversation. Mining engineer George Kingdon and his family lived for years in full middle-class comfort in Cananea, Sonora, in a white house, with a lawn and a Chinese cook, before his wife and children fled to escape the violence of the Mexican Revolution.[359] As privileged members of the Anglo middle class, the lifestyles enjoyed (or not) by mining engineers at mining camps through the years is a superb signifier of the extent to which the regional economy had been reshaped in the image of the metropolitan United States.

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[358] Ingersoll, *In and Under Mexico*, 7-15.

[359] Maud Kenyon Kingdon, *From out of Dark Shadows*, (San Diego: Frye and Smith), 72-73.

By the turn of the century, the value of the education that set mining engineers apart from both mine investors and working miners was more apparent throughout southwestern mining camps. The new demand for copper wire from the electric industry drove mine exploitation, and mining sites such as Bisbee and Cananea were poised to take advantage of the new market. Although the ore deposits along the U.S.-Mexico border were enormous, the low-grade of the extant copper required new mining techniques, and a knowledge of chemistry and metallurgy better learned in a classroom than on-the-job. Under the aegis of a handful of mining engineers, mining itself changed, from an activity that required skilled workers into one in which nonselective mining predominated. In these new, heavily industrialized mines, mining engineers worked in teams as surveyors and technicians, developing ever-more efficient machinery and means of extraction. Although the more independent aspects of the profession did not disappear, fewer mining engineers were called upon to utilize the breadth of their skill set; they more often spent their careers as corporate functionaries, interacting with other engineers. Even those engineers who remained the most mobile, such as those who worked for the Guggenheim Exploration Company, worked as part of an army of experts rather than as individuals forced to assert their own credentials and professional worth. The complex identity work undertaken by nineteenth-century mining engineers was no longer as important, except as a recruiting tool for new members of the profession – the romance of the old west proved enticing. With the industrialization of mining through the borderlands, and the corporatization of mining companies, mining engineers no longer had to prove they were worth the expense – rather, they were fully integrated into the corporate industry, an industry that could not have been established without their work.

The remnants of the major mining corporations of the early twentieth century such as Phelps Dodge, Cananea Consolidated, and Arizona Copper are self-evident in the borderlands today, in crumbling industrial buildings, polluted rivers, and the monstrous open pits and tailings piles that dot the terrain. The impact of these companies on the landscape of the mining borderlands remains visible and impressive, both in physical terms, and in the prevalence of place names that refer to the mining industry and mining corporations that dominated the economy from the late-nineteenth century onwards.[360] Such industrial detritus resulted from the mediating work of mining engineers in crafting a technocratic landscape which enabled the explosive capitalist expansion in the borderlands.

As industrial operators in the U.S. Southwest and into Mexico, mining engineers were successful innovators, devising new and ingenious ways to extract mineral wealth from the region. Yet more significant than their technological prowess was the impact of mine engineering work on the organization of American business. The revolution in mining methods both encouraged the growth of large mining corporations and drew the

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[360] Richard V. Francaviglia, *Hard Places: Reading the Landscape of America's Historic Mining Districts,* (Iowa City: University of Iowa Press, 1991), 24-27; Robert G. Varady, Helen Ingram, Lenard Milich, "The Sonoran Pimería Alta: Shared Environmental Problems and Challenges," *Journal of the Southwest* 37:1 (Spring, 1995): 120; John Harner, "Place Identity and Copper Mining in Sonora, Mexico," *Annals of American Geographers* 91:4 (December 2001): 660-680.

engineers closer than ever to their corporate sponsors. Mining engineers were the critical workers instigating growth, bureaucratization, and corporate consolidation in the mining industry, which in turn modeled the trajectory of American business through the twentieth century.

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