Portrait of an Emerging Profession: A Microdata Look at Mining Engineering in America in 1880

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The emergence of a professional class of mining engineers in the late nineteenth and early twentieth centuries was a transformational force with profound impacts on the American (and ultimately worldwide) mining industry. Historians have explored this transformation at a variety of scales and using a wide assortment of sources.[1] Despite the scholarly attention the subject has received, there are many questions that have hitherto been left largely unaddressed.

For example, given the importance of professional societies in fostering occupational professionalism, can we track how membership in the American Institute of Mining Engineers (AIME) spread (or not) across America? Where were mining engineers located, and how did that change over time? Did different mining areas show different patterns of professional engineering activity?

This article will take a crack at some of these big-picture questions as they might have appeared in 1880. As a moment to take a snapshot of the professionalizing mining engineering sector, 1880 works well, capturing an American industry in its professional adolescence. It is also a census year, and the first time that the decennial count was handled by trained personnel appointed for their acumen instead of their political connections.[2]

Many important institutions of professional activity existed in 1880, but were only recently established.[3] The AIME was not yet a decade old, and the U.S. Geological Survey would celebrate its first birthday that year. Mining engineering training was available in the U.S.—Columbia College's School of Mines had opened in 1864—but most of the western mining schools had yet to open and many college-trained mining engineers would still have gotten their education overseas at places such as Freiberg and the Ecole des Mines. Industrial mining was well-established on the Comstock, the Keweenaw, the Michigan iron mines, and the anthracite coal fields, among other districts. Leadville, Butte, and the Homestake were just getting cooking, but many of the big producers, including the great open-pit operations of the Mesabi and the western porphyry coppers, were as yet in the future.

What might newly available sources be able to describe about that pivotal time? The Minnesota Population Center has made available a complete-count set of 1880 U.S. Census microdata, along with additional coded information, including occupation. This dataset contains every individual in America found by the census takers, including mining engineers.[4] I will use this microdata, along with smaller data sets of my own creation, such as AIME membership lists, to try to analyze and describe the American mining engineering profession in a variety of ways as it existed in 1880. My hope is that a microdata-driven technique might be able to add to our existing understanding of mining engineers, much as the efforts of the New Social Historians decades ago rounded out our historical understanding of Americans otherwise difficult to find in the traditional historical record.[5]

If the idea is to better understand the origins of American mining engineering, especially the creation of a professional class of mining engineers, can we learn something new by applying digital history techniques? Does a different data source contradict or complement existing historiography? Can we glean any hints about unexplored historical ground?

The discussion begins with a brief recapitulation of the historiography of mining engineers, to set the stage, then moves to an examination of the available data, which will underpin the rest of the analysis. From there, some notable themes will be drawn from the data, in dialog with the existing historiography. Social history-style demographic data about mining engineers in 1880 will also be examined, and the article will conclude with suggestions for future research.

Historiography of Mining Engineers

Mining engineers are by no means unstudied by historians. Perhaps the starting point for any investigation of mining engineers as a class is Clark Spence's 1970 classic, *Mining Engineers and the American West: The Lace-Boot Brigade, 1849-1933*.[6] Spence's account of mining engineers was assembled from painstaking research among the personal papers of practicing engineers, together with anecdotes gleaned from a wide examination of the mining technical press. Spence accurately notes several themes that are significant in understanding the early history of this American profession, including important questions about professional training, whether achieved on the job, at institutions overseas or in the classrooms of American colleges.

Spence's work was one of several studies of engineering professionalization which emerged at roughly the same time, covering approximately the same time period in the latter nineteenth and early twentieth centuries. Monte Calvert's examination of mechanical engineers emphasizes the conflict of origins and values that emerged during the transition from "shop culture" to "school culture" as a form of training.[7] Calvert has little to say about mining engineers specifically, but Edwin Layton's examination of engineering professionalization, *The Revolt of the Engineers: Social Responsibility and the American Engineering Profession*, includes them among the other engineering fields in his study.[8] To Layton, mining engineers were perhaps incompletely professionalized, due to the persistent inclusion of non-technical people among their membership and their early and ongoing positive relationship with business.

An important 1996 article by Logan Hovis and Jeremy Mouat traces the relationship between university-trained mining engineers and the transformation of the mining industry itself, especially in the West, after about 1880.[9] Trained engineers oversaw the shift from selective mining, which relied upon a workforce of skilled miners, to non-selective, mass-production mining, in which engineering and metallurgical expertise, together with heavy equipment on a large scale, compensated for the judgment of individual miners. This change made possible far greater levels of mineral production. Hovis and Mouat paint in broad strokes a picture that is consistent with the deeper (but more limited in scope) illustration provided by Kathleen Ochs in her 1992 study of alumni records from the Colorado School of Mines, which similarly emphasizes the shift over time of engineers into managerial roles.[10] Timothy LeCain carries these insights further in his book *Mass Destruction* (2009), plumbing the enviro-technical outlook of these engineers that carried substantial consequences for the earth.[11]

Three relatively recent books return to cover the earlier period of the mid-nineteenth century—when mining engineers were emerging as a professional group—in search of historical narratives about the origins of industrial mining in the United States and the role played by mining engineers. Kent Curtis emphasizes the importance of Freiburg-trained mining engineers and, like LeCain, uses a predominantly enviro-technical historical lens to discuss the development of mineral resources in the American West.[12] Sarah E. M. Grossman's recent study, *Mining the Borderlands*, shows how mining engineers and consultants provided both technical and financial expertise to capitalists (often located in the East or Europe) seeking to develop mines on both sides of the U.S.-Mexico border.[13] And my own book, *Seeing Underground*, explores the importance of visual representations in the work of professionalizing mining engineering.[14]

What emerges from these studies—and others which recount the stories of specific engineers in specific mining places—is a clear agreement on the stakes of the question. Undoubtedly, the history of how mining engineering came to be a profession, and came to be closely allied with the businessmen and investors who financed the growth of industrial mining, is critical to understanding the shape and logics of the enormous, globalized mining firms that emerged in the twentieth century. These later firms, and to a more limited extent their nineteenth-century predecessors, have literally reshaped parts of the planet, impacting military and consumer society with the goods made from mined materials, and reshaping the environments from which those materials were mined. That so many fine histories analyze this underlying issue from multiple viewpoints suggests not only that the question is a worthy one, but also that attempts to further contribute in this area would not be unwarranted.

The Data

Toward that end, this article will use two overlapping sets of information to explore the American mining engineering profession in its adolescence, in the year of 1880. The hope is that this data, while sparse concerning any individual engineer, might help historians capture a snapshot of the profession as a whole. Perhaps a few faces might be recognizable in a panorama of the crowd, as it were, but this is not intended to be a composite of detailed portraits.

AIME Data

The first source of data is a membership list from the American Institute of Mining Engineers (AIME), which will be referred to as the "AIME list" or "AIME data." For many years, the AIME published an annual list of its members in the society's *Transactions of the American Institute of Mining Engineers*. The list was typically as current as possible, reflecting the latest information about members as the volume was being published.

This study uses a membership list from Volume 8 of *Transactions*. That volume covers the AIME's meetings held in May 1879, September 1879, and February 1880. The list of officers is those elected in February 1880. The main membership list, however, was current as of December 1880.[15]

The nineteenth century AIME membership lists were further subdivided into a handful of categories. This study will examine the "List of Members and Associates," which contains by far the largest portion of the membership. The December 1880 record contains 675 "members" and 104 "associates."[16] For each member, it gives some kind of mailing address, probably enough to get a letter to that member in 1880. In many cases this is just a town and state, in others it is a physical address or P.O. Box, and in some it is a "care of . . ." address.

It is worth noting the other AIME membership lists published in Volume 8, and how they factor into this analysis:

Honorary Members: There were only six of them, all but David Thomas located overseas. Thomas, of Catasqua, Pennsylvania, was not in the regular members' list.

Life Members: Nine life members were listed, eight of them domestic. All of these appear in the main members' list as well.[17]

Foreign Members: Fifty-two individuals were listed as foreign members, with another five listed but marked as deceased. These foreign members were not analyzed because they would not appear in the U.S. Census data. Note, however, that a handful of regular members had foreign addresses but did not appear in the "foreign members" category.

Deceased: Name and year of death were given. For obvious reasons, these were not included. However, a case could be made for including those from 1880, as they may have been alive at the time the census was taken, but since no location information was provided they were reluctantly skipped.[18]

In addition to the AIME's list of "foreign members," twenty-nine persons on its regular membership list had foreign addresses. Some of these were Canadian and probably would have participated in the AIME in the usual way—especially considering that the September 1879 meeting, whose proceedings were recounted in this volume, was held in Montreal, Quebec. Others were likely Americans who joined in the usual way and then found themselves overseas, perhaps consulting, perhaps receiving further professional training, or the like. These members were excluded from the comparisons because, obviously, they could not be found in the American census.

Thus, the first source of data, the AIME's December 1880 membership list, provides the names and locations of a total of 779 members and associates, 29 of whom were living outside the United States of America.

Census Data

The second set of data comes from the U.S. Census of 1880, with enhancements added by twenty-first-century researchers. The U.S. Government has conducted a complete counting of the U.S. population every ten years since 1790. Modern census results are published as reports that summarize the complete count, yielding statistics such as the total population of particular places. That summary data provides information on persons having a characteristic, but not any additional information about the individuals themselves.

However, as anyone who has dabbled in genealogy surely knows, the U.S. Government releases the raw forms of a census seventy-two years after it was conducted. These manuscript forms (or "schedules") contain the basic data about each person and each household as census takers found it on the day they visited. These forms allow researchers to know more about persons, such as race, sex, age, marital status, birth state or country and that of each of their parents, position in the household and relationship to its head (wife, son, boarder), and sometimes occupation.[19]

Population researchers call this information "microdata." It is not a life history, or even a biographical sketch. It is just some basic facts, a snapshot in time, about a person. The Census Bureau counts up this microdata to create the summary data that it publishes, but historical demographers use the original microdata to summarize the population in new and previously unimagined ways.

For 1880, historians are extremely lucky, because a research group has made the complete manuscript census microdata available in a machine-readable format that can be imported into a database for research. This group, the "North Atlantic Population Project" (NAPP), is an effort by the Minnesota Population Center at the University of Minnesota and several international partners.[20] For the 1880 U.S. census, NAPP worked with the Church of Jesus Christ of Latter-day Saints, which, as part of its well-known efforts to encourage genealogy, had previously conducted a massive volunteer transcription of the manuscript census of 1880.

The Church agreed to provide NAPP with the microdata information for research as long as researchers were prohibited from using it for genealogy. NAPP then built on the raw data by adding additional variables to help make the data easier to use and to compare across time and different countries. The result is a database that contains every line—every person—recorded by the U.S. Census of 1880, more than fifty million in all, with a wide range of associated information, derived from the few bare questions of the census, for each record.[21]

Some of these NAPP efforts tackled occupation.[22] The 1880 Census asked for each person's occupation, and the census taker recorded the answer freehand. Those handwritten answers were transcribed by Church volunteers with the rest of the manuscript census information. NAPP then coded those answers into a series of standardized categories, which allows them to be compared. NAPP coded against two different standards: the "Historical International Standard Classification of Occupations" (HISCO),[23] and an occupational classification system developed by the U.S. Census in 1950.[24]

One category in each system covers mining engineers, and the NAPP coders did their best to judiciously place mining engineers into it. Both categories were then used to find mining engineers in the 1880 microdata, even if there were small differences in the actual "occupation" line recorded freehand on the census form. For example, the HISCO mining engineer category (2700) covers several different census responses, as illustrated in Table 1. (One can also see the transcribers' efforts to be faithful to original spellings and phrasings.)

OCCSTRNG (Occupation)	**Number**
MINING ENGINEER	417
MINING EXPERT	66
OIL WELL ENGINEER	20
MINNING ENGINEER	14
MINING ENG.	13
MINING ENGINER	7
MINE EXPERT	6
COAL ENGINEER	5
MINING ENGR	5
MINING ENGR.	5
ENGINEER MINING	3
MG. ENGINEER	3
MINING CIVIL ENGINEER	3
MINING ENGINIER	3

Table 1: Most Popular Occupation Responses in the HISCO Mining Engineering Category (2700)

A similar analysis could be performed with the U.S. Census' 1950 occupational categories, applied retroactively to the 1880 data by the NAPP team. The results would be substantially similar, as mining engineers were a category in the 1950 classification as well.

These categories allow us to find mining engineers in the 1880 census microdata, but they are also potentially troublesome. For example, as historian Robert Spude has noted, many mining engineers worked as assayers, especially at the beginning of their careers,[25] but assayers and metallurgists are lumped together in their own HISCO classification, separate from mining engineers.[26] However, the 1950 codes break things down differently. Metallurgists and metallurgical engineers get their own category, but assayers proper are listed as "chemists," since there is no "assayer" category.[27]

There are some important challenges and caveats that must be kept in mind when working with this 1880 microdata. First, the person responding to the census taker in 1880 needed to give a useful response. Respondents could misunderstand the question, under-report their work out of modesty or for other reasons, or be represented by someone who did not fully understand what they did—maybe the census taker got information from the maid if no one else was home.

For example, I found famous U.S. Geological Survey geologist Samuel Franklin Emmons in Leadville in 1880 and corroborated his presence there with outside sources. He was working at the time on the report that eventually became known as the "miner's bible."[28] But his occupation is listed as "surveyor." Surveying was probably an accurate description of the particular work he was doing that week, but it was certainly not Emmons' occupation.

A second challenge is that the census takers had to record accurately. If a person did two things, usually only one was recorded. Misspellings and mis-hearings are rampant, both of names and of occupations. And some census takers were lazy, or perhaps did not speak directly to the person, and wrote only general things or nothing at all. Thus, if a census taker put just "engineer," it is almost impossible for historians, now, to know what that meant.

A third caveat is that this handwritten information needed to be manually transcribed, and those transcriptions had many possibilities for error. The originals can be very difficult to read, and even the best-trained transcriber can struggle with indecipherable handwriting or, worse, blurry microfilm. Additionally, in specialized occupations sometimes the transcriber might "see" something more common instead of the correct word. ("Inn" for "Iron", for example.)

A final hazard might be found in the coding process. NAPP coders may have erred or made difficult choices. Deciding what, exactly, was meant by a particular occupation is incredibly difficult, and the NAPP team reported that occupational codes were "the most complicated variable to code consistently" in the entire dataset.[29]

To summarize, the NAPP-provided microdata, with its occupational codes, grant researchers an enormously powerful tool for finding out more about people as they were captured in the snapshot of the 1880 Census. However, the limitations of the data need to be kept keenly in mind, and errors undoubtedly exist in this dataset.

Combining AIME and Census Data

Combining these two sets of data—the AIME membership list and the 1880 microdata from NAPP—allows us to analyze mining engineers in 1880 from several angles and to incorporate comparisons to other groups, as long as the limitations of the data are borne in mind.

First, I loaded the NAPP data into a relational database, to permit complex queries.[30] I next transcribed the AIME's membership list into digital form (to avoid OCR errors), and carefully looked for each person in the 1880 census database. Sometimes they were easy to find and sometimes they were found with reasonable certainty though spelled differently or located in a different place. It was frequently necessary to cross-check the NAPP data against digitized copies of the 1880 census microfilm.[31] Sometimes there was not enough information (or too much) to make a confident judgment, as with extremely common names (e.g., William Jones). While others, especially those known to be beyond American soil, simply could not be found. Of the 779 persons on the AIME membership list, I was able to locate 525 in the 1880 Census (67.4 percent).

If we combine the NAPP census data identifying 624 mining engineers with the AIME list containing 779 persons as a Venn diagram, five distinct groups emerge, as seen in the table below.[32] Of the mining engineers identified in the census data, some are also found in the AIME list and some are not. Of those individuals on the AIME list, they could have been listed in the census as a mining engineer, listed in the census as something other than a mining engineer, or not found in the census at all.

The first group, those persons identified in the NAPP microdata, is straightforward, though subject to the challenges noted above.[33] Some of these identifiable mining engineers appeared on the AIME list as well. Others on the AIME list were found in the census, but had occupations other than mining engineering listed.

Themes in the Data

Despite the necessarily cautious approach to interpretation because of gaps in the data, some broad areas of analysis can be fruitfully explored. One of these is the composition of the membership of the AIME as a professional organization, and the other is a closer look than previously possible at the demographic makeup of identifiable mining engineers as a group.

Potential Challenges with the Data

We should be cautious about ways in which this data might be misleading, since 32.5 percent of the persons in the AIME's membership list could not be identified for certain in the census data. There are several plausible reasons why so many AIME members might not have been found. One, common to all such work with census sources, is that some people were not properly recorded in 1880. Another challenge is the prevalence of common names (e.g., "William Jones"), which cannot always be matched with certainty. To attempt to overcome this, both a person's geographical location in the census and occupation were considered, but some were simply too obscure to identify successfully.

Abbrev.	Group	Number
Census ME	Identified in the census as a mining engineer	624
AIME ME	Census-identified ME, and on the AIME list	79
AIME non-ME	On the AIME list, but a different occupation in the census	446
Non-AIME ME	Census-identified mining engineer not on the AIME list	545
AIME NL	Listed by AIME, not located in the census	253
Total	Identifiable in data (Census ME + AIME non-ME)	1070

Table 2: Identifiable Groups in Combined Census and AIME Data

There are also two data challenges peculiar to this study. Potentially, the first is that the work performed by mining engineers was frequently seasonal, field based, or both. In either case, it meant that the mining engineers found in June 1880 by the census takers might well have been somewhere different than their December 1880 mailing address indicated. Being in the field might have also increased the chance that they could have been overlooked by the census taker, and, of course, if their consulting work brought them to another country that June, they would not have been included in the census. A search was performed across the data set when such a situation was encountered, and some individuals were successfully located, but this factor undoubtedly contributed to the difficulties of matching the AIME list with the census, and it raises the prospect of an under-count of mining engineers generally.

The second concern is that people doing the work of mining engineers might not have been identified specifically enough by the census taker to show up in our non-AIME data set. If the person was listed simply as an "engineer" by a hurried enumerator, and was not found by virtue of being in the AIME, then that individual would not end up in the data analyzed here.

On the other hand, any person who *did* identify specifically as a mining engineer, whether an AIME member or not, was relatively easy to discern. Unlike job categories that shade very finely into others, or that sound like other jobs—such as a "mechanical engineer" compared to an "engineer" compared to a "mechanic"—mining engineers or mining experts generally were labeled clearly enough that they would be correctly coded by the census transcribers of NAPP. With the census information, in other words, there may be mining engineers who were not found, but the persons who *were* found were certainly mining engineers. With these caveats in mind, we can explore the data.

Composition of the AIME

To begin, it is really striking how few mining engineers there seem to have been in the AIME in 1880. Recall, the AIME list contained 779 names, including regular members with foreign addresses, and of those 779, 525 individuals were successfully located in the census (67.4 percent). Therefore, in the following discussion, we can examine known membership as a percentage of total AIME membership in best-case or worst-case scenarios (as though all the missing members described themselves as mining engineers or all did not).

Only 10 to 15 percent of AIME members identified themselves as a mining engineer to the census takers.[34] Furthermore, a large proportion of the AIME's membership—at least half and perhaps up to 85 percent—identified themselves as something other than a mining engineer.[35] Under even the most optimistic scenario, if we assume that all AIME members who could not be found in the census did, in fact, identify themselves as mining engineers, mining engineers would still comprise only 42.7 percent of the AIME's 1880 membership.[36] So, no matter how you slice this data, a *minority* of AIME members in 1880 would have called themselves mining engineers.

A look at the population of mining engineers identified in the census suggests that the AIME likely meant little to most people who self-identified as mining engineers. Of the mining engineers found in the census—and the caveats above suggest that this number of discovered mining engineers is likely to err conservatively, rather than the reverse—only 12.7 percent (79/624) were members of the AIME.

Historians, the author included, have frequently assumed that the AIME's activities were somehow representative of, or aspirational for, mining engineers as a whole, but in the early years of professionalization this does not seem to be the case. This striking pair of findings may be sufficient justification for the entire data undertaking, as it shows plainly that we must be careful about conflating the AIME with mining engineers, especially in this earlier period.

Non-Mining Engineers in the AIME

Next we return to the AIME's 1880 members. Who were they, if not identifying themselves as mining engineers? The membership of the AIME included several types of engineers, persons associated with the iron and steel trade, supervisors of furnaces, mills, mines, and coking works, and other professionals.

Several dozen members of AIME called themselves "civil engineers" rather than mining engineers. This very likely reflects a different orientation to their work, rather than a wholly different kind of engineering work, although, of course, many civil engineering skills, such as surveying, excavation, and water management, would have been of direct benefit to mining work.

Civil engineers, historian Edwin Layton argues, were the vanguard of considering themselves an independent, professional elite. Civil engineers were less likely to work for a business, were more likely to consult and retain their independence, and often proclaimed a dedication to their profession and to the public. According to Layton, at that time, civil engineers considered themselves a technical elite, and were less likely than mining engineers to be business or management oriented. So the number of civil engineers listed may indicate a group who held to a different understanding of what it meant to be an engineer, even though they might be deeply involved in mining.[37]

The group of civil engineers found here also represented a transition period in mining engineering, as the young engineering branch coalesced from older civil engineering traditions. America's mining engineering profession was still a young one in 1880. The AIME itself was less than a decade old, having been founded in 1871, and the first volume of the society's *Transactions* was published in 1873. The first successful American mining engineering college, Columbia's School of Mines, was only a few years older than that, having been founded in 1864, and most of the western schools of mining were yet to be founded.[38]

MINING ENGINEER	60
CIVIL ENGINEER	46
CHEMIST	31
ENGINEER	14
GEOLOGIST	8
IRON MERCHANT	7
IRON MANUFACTURER	5
IRON MASTER	5
LAWYER	5
MINER	5

Table 3: Top Occupations as Transcribed of AIME Members Identifiable in the Census

In 1880, the AIME and its membership were dominated by eastern iron and steel interests. This included iron mining (properly the domain of mining engineers), as well as iron and steel making. Furthermore, the membership lists found many members with occupations that did not necessarily sound like iron-specific ones—such as "chemists"—who were, in fact, working in an iron-and-steel context.

The membership lists suggest an intriguing pattern, in which particular firms valued AIME membership and encouraged employees to join, perhaps by paying for their memberships. Identifiable in the data when many members came from the same tiny towns where an iron works operated, these AIME-friendly firms included Cambria Iron Works in Pennsylvania, Roane Iron Works in Tennessee, and some of the steel plants designed by A. L. Holley.[39] Job titles suggest that many AIME members in iron and steel were working on the milling and manufacturing side rather than the mining side of this industry. All this points clearly to the usefulness of advanced scientific training in iron and especially in steel production, as new processes for making large quantities of steel emerged.

Some other surprises also emerged from the data. Both Calvert and Layton have remarked that the AIME was the professional home of many mechanical engineers prior to the formation of the American Society of Mechanical Engineers (ASME) in 1880, and it would seem that this group would be a visible and substantial minority on the membership roster. Such a group is not obvious, however, in the census-provided job titles of AIME members. To truly resolve this issue would require a compilation of early ASME lists along with more years of AIME membership for comparison.

A second surprise was the robustness of managerial and ownership participation in AIME's membership. Layton has noted the AIME's longstanding friendliness to businessmen in addition to technical men as members. However, in 1880, other factors may also have been in play. One possibility is that, as industrial firms were not yet inevitably the corporate structures they would later become, owners and managers might very well have been technically qualified. They would then be participants in the technical context and in the overall project of the professionalization of mining engineers. Eckley Coxe is but one outstanding example of such an owner whose technical training and contributions to the engineering field were substantial.[40]

A third surprising finding was the emergence of recognizable centers of professionalism. Some such centers have been identified before, such as the importance of New York City and Philadelphia among mining engineers. Similarly, universities that offered instruction in mining engineering might be expected to have at least a handful of professors and perhaps students as AIME members. But more striking were those centers rooted in corporate activity, such as the Cambria Iron Works in Johnstown, Pennsylvania, the Holley-influenced steel works, and the Roane Iron Works in Chattanooga, Tennessee. The link between particular companies and professionalization has been suggested before, as when Clark Spence noted how the North Star Mine in Grass Valley trained a generation of young engineers.[41] The census data, however, suggests that this phenomenon may have been more widespread and potentially important than previously recognized, and could be a worthy subject for closer examination.

Demographics of Mining Engineers

The following section uses the demographic information available about the mining engineers and AIME members in our dataset to sketch some basic information about their personal lives, as their individual trajectories may have shaped both the substance of their work as mining engineers and the profession as it was emerging.

Regional Variations

The AIME's dominance by its eastern members has been recognized by Layton and is visible in the data, as noted above. Table 4 is a list of the top states where mining engineers (as recorded in the census) and AIME members (respectively) were located.

If we examine the top ten state locations for each group, the eastern emphasis in the AIME stands out distinctly. Pennsylvania had the most AIME members of any state, but did not even rank in the top ten for census-identified mining engineers. Similarly, Ohio, Missouri, Massachusetts, Illinois, and Michigan all appear in the AIME membership top ten but fail to make the top ten of census-identified mining engineers. New York ranks high on the AIME list at second, but appears sixth behind two lightly-populated western territories in the census list, as does nearby New Jersey at fourth and eighth, respectively. Colorado and California dominated the list of census-identified mining engineers, at first and second respectively, but appeared lower on the

Census M.E.s		**AIME Members**	
Colorado	216	Pennsylvania	265
California	185	New York	150
Nevada	59	Ohio	41
Utah Territory	46	New Jersey	35
Arizona Territory	43	Colorado	32
New York	34	Missouri	32
Montana Territory	22	Massachusetts	25
New Jersey	16	Illinois	21
Idaho Territory	14	Michigan	19
New Mexico Terr.	14	California	17

Table 4: Top Ten Locations of Mining Engineers Found in the Census and on AIME Data, 1880

AIME member list, at fifth and tenth. The census found numerous mining engineers in the western mining states and territories of Nevada, Utah, Arizona, Montana, Idaho, and New Mexico, though none of those areas made the top ten locations for AIME members.

Without question, this eastern slant to the AIME is an important factor to consider in attempting to describe how the mining engineering profession emerged and matured in an American context. It seems likely that a host of issues contributed to weak AIME membership in the West. The difficulty of traveling across the country to attend AIME meetings in person seems like one obvious explanation for lower western participation. One might expect that mining engineers too far away to travel might still derive value from the published *Transactions*, however, in those years many items that eventually reached their final form in the AIME's *Transactions* were published first in other organs of the technical press, especially the *Engineering and Mining Journal*. So a second explanation might suppose that western, scientifically minded engineers could get the technical content that they wanted from the *Engineering and Mining Journal* and the California-published *Mining and Scientific Press* without having to join the AIME.

The eastern slant could also represent other phenomena, such as an association with capital and finance. If AIME membership was thought of less as a statement of professionalism and was instead more about access to financing and capital networks, the eastern dominance could be more readily explained. New York and Philadelphia both were important centers of finance in this context, though both cities also had mining activity in their commercial hinterlands. The appearance of Massachusetts at seventh on the AIME member list invokes the importance of Boston capital in mining, despite a lack of mining opportunities in the Commonwealth itself.

We should also engage thoughtfully with this location data with respect to the potential for seasonal patterns in nineteenth-century mining engineering. Indeed, as mentioned above, some engineers considered eastern from the standpoint of the AIME list were found in the field in the West by the census takers. However, there seems to be little question that there was a significant body of mining engineering professionals in the West, most of whom did not carry an AIME member-

Type	**Avg. Age**
Electrical	36.947
Civil	37.242
Mining	38.318
Mechanical	38.545
Metallurgical	41.324
Engineer (not elsewhere classified)	41.443

Table 5: Average Ages for Census-identified Engineers, 1880

ship. They pose an important and perhaps still understudied set of questions about their role, if any, in the formation of their profession more broadly, and about their relationship with capital and technical expertise.

Age

The historical significance of some available data, such as that about age, is perhaps more elusive. The average age of mining engineers was near the middle of the pack, compared to other engineering branches, at about 38 years old.[42]

The average age for engineers of all types was 37.56 years.[43] Perhaps unsurprisingly, the youngest engineers were members of the newest field, electrical engineering. The youthfulness of civil engineers is perhaps a bit of a surprise, given that civil engineering was the oldest of the engineering branches, but a cautious guess might be that some number of people identifying themselves in the 1880 census as civil engineers could have gotten their start as young adults learning about railroad and earthworks construction during the Civil War.

Examining the mining engineers more closely may not create additional clarity. The average age for non-AIME mining engineers was 39.31, while the average age for AIME members was 38.36. These numbers likely reflect bias in the data, in that young mining engineers may not have been in positions that identified them specifically as mining engineers, potentially being labeled as chemists, assayers or draftsmen instead.

Family

The family lives of mining engineers, as part of a broader set of personal contexts which shaped the way that they went about their work, probably deserves closer attention. In decades to come, after the turn of the twentieth century, as a professional class of educated technical experts emerged in the large multi-national mining firms, companies took steps to attract and retain married mining engineers on the general theory that married men would be more stable and productive.

We might ask, then, what was the situation in 1880? The table shows that nearly 63 percent of all mining engineers were married, and further, that more than 54 percent of all mining engineers were living with their spouse at the time of the census. AIME members had an even higher rate of marriage, both in general (67.05 percent combined) and with a live-in spouse. Non-AIME mining engineers still had a high rate of marriage (over half were married, 59.08 precent combined), but lower than the AIME members and with a much higher rate of being married without the spouse present. This latter figure lends some credence to the idea of western, non-AIME mining engineers spending summers engaged in work in remote mines, then perhaps returning to their families during the winter season.

These marriage rates were higher than those

Status	**% All MEs**	**% AIME**	**% Non-AIME**	**% All Eng.**
Married, spouse present	54.49	63.81	45.50	50.76
Married, spouse absent	8.50	3.24	13.58	5.42
Divorced	0.28	0.38	0.18	0.28
Widowed	3.93	3.62	4.22	3.70
Never married/single	31.59	28.00	35.05	38.27
Indeterminate/unknown	1.21	0.95	1.47	1.57

Table 6: Marital Status of Engineers

for engineers generally. The combined marriage rate for all engineers was 56.18 percent, almost 3 percent below even non-AIME members and almost 7 percent below mining engineers generally.

Many mining engineers also had children living with them in the home. However, 55.2 percent of mining engineers had no children at home—the census dataset can only reveal children living within the same household at the time the census was taken—while 10 percent had one child at home, 11 percent had two, and almost 9 percent had three. The childless rate was slightly higher among all engineers, at 58.8 percent.

Taken together, this suggests the potential fruitfulness of further investigation into the family lives of mining engineers. Did corporate favoritism toward married engineers begin earlier than the 20th century? Was there something about mining engineering work that was especially compatible with family life, even more so than other branches of engineering? What was it like to marry a mining engineer, or grow up in a mining engineering family, in the 1880s? Some of the best sources we have on these latter questions have come from the families of mining engineers, such as Mary Hallock Foote's classic memoir, but the data suggest the remaining potential for useful research along these lines.[44]

Race and Sex

Unsurprisingly, the mining engineers in the data set were overwhelmingly white. Only one black mining engineer was found—James Scott, thirty years old, living in Pembroke, Giles County, Virginia—who was not a member of the AIME. (Scott was born in Virginia before the Civil War, but it is not known if he had been free or enslaved.) He and a white mining engineer, H. C. Reichardt of Pennsylvania, were boarding together in a farmer's house.[45]

Finding women mining engineers in 1880 is also difficult. Two female mining engineers were reported in the database, though one appears to be due to a data error.[46] Ellen Swallow Richards is the other, wife of Robert H. Richards and an excellent chemist in her own right.[47] This author is not aware of any female members of the AIME in 1880 apart from Richards, but if there were, they may have used initials or been otherwise difficult to correlate correctly with the census records.

Birthplace and Migration

The standard accounts of the professionalization of mining engineering note the importance of foreign experts in the early years of the field. What is less clear from the literature, however, is precisely when foreign-born engineers gave way to American-born ones within the profession (if indeed such ever happened). The census data for 1880 seems to suggest that either the preponderance of foreigners in the early years of the profession was overstated, or that such a foreign-born bubble was largely over by that time.

In 1880, most mining engineers had been born in America, and indeed some 60 percent had been born there to American-born parents.[48] However,

Person	**Parents**	**% Min. Eng.**	**% All Eng.**	**% U. S. 18+**
Native-Born		74.9	76.8	
	Both Native	60.3	60.8	
	One Native	5.0	4.6	
	Both Foreign	6.6	7.9	
Foreign-born		25.1	23.0	22.5

Table 7: Nativity of Mining Engineers, Compared with Others

All		AIME members		Non-AIME	
Foreign country	269	Pennsylvania	150	Foreign country	184
Pennsylvania	207	New York	103	New York	78
New York	181	Foreign country	85	Pennsylvania	57
Massachusetts	83	Massachusetts	42	Massachusetts	41
Ohio	61	Ohio	33	Ohio	28
Connecticut	36	Connecticut	25	Illinois	20
Illinois	25	New Jersey	12	Michigan	14
New Jersey	23	Maine	9	California	13
Maine	22	Vermont	7	Maine	13
Michigan	17	Virginia	6	Connecticut	11
Virginia	15	Illinois	5	New Jersey	11
California	14	Missouri	5	New Hampshire	10

Table 8: Most Frequent Birthplaces

compared to engineers as a whole, 2 percent more of the mining engineers were foreign born—a small percentage, but perhaps relevant given the "foreign expert" question.[49] By comparison, both engineers generally and mining engineers specifically included a slightly higher percentage of foreign-born individuals compared to the United States' population over the age of eighteen. In 1880, 22.5 percent of those aged eighteen and above were foreign-born.[50] (The number and percentage of native-born people is much higher if children are included.)

A closer look at their birthplaces reveals that mining engineers in 1880 came from many places, but some clear trends emerge from a table of the most frequent birthplaces. The top five birthplaces were the same for all three categories in our data: AIME members, census-identified mining engineers, and the combination of both groups. These were, perhaps unsurprisingly, some of the most populous states in the union: New York, Pennsylvania, Massachusetts, Ohio. But each of these states was also an important center of mining activity, whether that be financial or corporate (New York, Pennsylvania, Massachusetts) or in terms of actual mining. Foreign-born engineers made the top five in all three categories and were the single most prominent category for non-AIME engineers. This may be somewhat surprising given the AIME's intentionally cosmopolitan international stance and its embrace of expertise from abroad.

Status	% Min. Eng.	% All Eng	% US 18+
Lives in birth state	29.53	34.81	51.20
Lives in birth country, not state	45.23	42.01	27.20
International migrant	25.10	23.00	22.50

Table 9: Migration of Mining Engineers, Compared with Other Groups

The birthplaces of American-born engineers had a few seemingly important differences between those who were in the AIME and those who were not. Most of the California-born engineers were not AIME members, and the same was true of those born in Michigan. This again suggests the eastern dominance of the AIME, although it is also potentially useful to ponder the development outside of the East of robust technical cultures not aligned with the AIME.

However, even American-born mining engineers seem to have moved a lot.[51] Comparing the states where they were born to the states where they were found living in 1880 shows the tremendous mobility of mining engineers, as more than 70 percent of all mining engineers in the data lived in states other than the ones in which they were born. They moved more than engineers in general,[52] and likewise moved far more than U.S. adults as a whole.[53]

Themes from the Data

Examining detailed demographic data about mining engineers is a potentially fruitful exercise, especially as advancements in digital history and genealogical data sets make it possible to connect small, hand-crafted databases to larger-scale information. Here, we have examined mining engineers in the year 1880, using AIME membership rosters together with U.S. census microdata. Juxtaposing these two sets of information allows us to capture a snapshot of the mining engineering profession in that year, as the acceleration of professionalization was firmly underway.

Specifically, our study of this data suggests at least four themes which emerge from the analysis. First, this data-driven history clearly shows the need to consider the mining industry, and the roles of mining engineers specifically, as part of broader processes. Such bigger trends include the cycles of business, forces driving professionalization in various technical fields outside of the mining engineering field, and even the social life of engineers. The best mining history already does this, of course, but the microdata presented here make it clear how essential it is to think broadly about how the profession was created and shaped.

A second theme emerging from this look at mining engineers in 1880 is the clear need to further examine largely unexplored influences that shaped the mining engineering profession, especially in its early years. These influences include easterners generally (particularly their connections to networks of finance and scientific expertise); the role of iron and steel interests; specific sites where professionalism was advanced or molded, such as particular iron firms or schools; and the role of managers and management in shaping technical professionalization. Many of these topics might be further illuminated through using additional specialized data sets (such as rosters of iron manufacturers), as well as additional digital tools (such as GIS mapping on historic boundaries) not attempted here.

A third emerging theme is the role of non-AIME mining engineers. Given how different their demographics appear to be, at least by some measures, one wonders about the substance of their contribution to the professionalization of mining engineering. Certainly, answers to this line of inquiry might very much depend upon where one is standing and what sources are available.[54] Is a professional association—the AIME in this case, with its trappings of meetings and publications—an essential component of professionalization?

Many sources about the process of professionalization would suggest that it was, but the evidence here opens the door to considering what non-associational professionalization might look like. The history of mining's transformation from a craft to an industrial pursuit directed by professional engineers offers much to ponder on this point. The worldwide Cornish diaspora of technical expertise might be seen as the opening salvo of professionalization or the last efforts of the older craft traditions. By contrast, the engineers of the Comstock Lode—later framed somewhat condescendingly by professionalized eastern mining engineers as "Old Comstockers," largely bereft of formal technical training—unquestionably shaped American (and to an extent, worldwide) mining engineering practice for decades.[55] Yet engineers such as the Old Comstockers do not fit neatly into professionalization narratives which require technical organizations, meetings, and publications.

A fourth theme is a reassurance that, considered carefully, the historiography of mining engineers generally holds up quite well. Although classics such as Spence's *Mining Engineers in the American West* and Layton's *Revolt of the Engineers* were not constructed from microdata in the way that the study presented here was, and each was first published fifty years ago, they can be seen as generally coming to complementary conclusions. A further consequence might be to increase a sense of trust in both types of sources—that is, the older prosopographical approach and a data-driven microdata approach as seen here—since they both point to similar conclusions.

Overall, these themes reinforce the broader point that, for mining historians, digital tools and techniques can be helpful if used judiciously. They can help us affirm what we think we know, create clearer portraits from fuzzy ones, identify important (and sometimes hidden) trends and influences, and unearth promising leads for future research. I would encourage all mining history researchers to consider adding digital techniques to their historian's toolbox.

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Notes:

1. Clark C. Spence, *Mining Engineers and the American West: The Lace-Boot Brigade, 1849-1933* (New Haven, CT: Yale University Press, 1970); Logan Hovis and Jeremy Mouat, "Miners, Engineers, and the Transformation of Work in the Western Mining Industry, 1880-1930," *Technology and Culture* 37, no. 3 (1996): 429-56; Eric C. Nystrom, *Seeing Underground: Maps, Models, and Mining Engineering in America* (Reno: University of Nevada Press, 2014); Timothy J. LeCain, *Mass Destruction: The Men and Giant Mines That Wired America and Scarred the Planet* (New Brunswick, NJ: Rutgers University Press, 2009); Sarah E. M. Grossman, *Mining the Borderlands: Industry, Capital, and the Emergence of Engineers in the Southwest Territories, 1855-1910* (Reno: University of Nevada Press, 2018); Kent Curtis, *Gambling on Ore: The Nature of Metal Mining in the United States, 1860-1910* (Boulder: University Press of Colorado, 2013).
2. U.S. Census Bureau, *Measuring America: The Decennial Censuses From 1790 to 2000* ([Washington]: U.S. Department of Commerce, 2002); Margo J. Anderson, *The American Census: A Social History*, 2nd ed. (New Haven, CT: Yale University Press, 2015).
3. E.g., Eric C. Nystrom, "Locating Mining Knowledge: Expertise, Government, and Extraction in 1880s America," presented at the 31st Annual Conference of the Mining History Association, Birmingham, AL, 24 June 2022.
4. This is the North Atlantic Population Project's "1880a" full-count sample. Minnesota Population Center, *North Atlantic Population Project: Complete Count Microdata. Version 2.0* [Machine-readable database], Minneapolis: Minnesota Population Center, 2008.
5. See, e.g., Eric J. Hobsbawm, "From Social History to the History of Society," *Daedalus* 100, no. 1 (1971): 20-45; Laurence Veysey, "The 'New' Social History in the Context of American Historical Writing," *Reviews in American History* 7, no. 1 (1979): 1-12.
6. Spence, *Mining Engineers and the American West.*
7. Monte A. Calvert, *The Mechanical Engineer in America, 1830-1910: Professional Cultures in Conflict* (Baltimore: Johns Hopkins University Press, 1967).
8. Edwin Layton, *The Revolt of the Engineers: Social Responsibility and the American Engineering Profession* (Cleveland: Case Western Reserve University Press, 1971).
9. Hovis and Mouat, "Miners, Engineers, and the Transformation of Work," passim.
10. Kathleen H. Ochs, "The Rise of American Mining Engineers: A Case Study of the Colorado School of Mines," *Technology and Culture* 33, no. 2 (1992): 278-301.
11. LeCain, *Mass Destruction*, passim.
12. Curtis, *Gambling on Ore*, passim.
13. Grossman, *Mining the Borderlands*, passim.
14. Nystrom, *Seeing Underground*, passim.
15. American Institute of Mining Engineers, *Transactions of the American Institute of Mining Engineers* 8 (May 1879 to Feb. 1880): vii.
16. This is my count; it differs from the AIME's published count, published by the list—mine has two additional members. See AIME, *Transactions* 8, xxiii.
17. As with the regular members' list, I had trouble finding many of the "life members" in the Census data.
18. The 1880 deaths were: Caldwell, W. B., Jr.; Fuller, John T.; McIntire, Henry M.; Mickley, J. W.; Pleasants, Henry; Robinson, Thos. W.; St. John, I. M.; and Worthington, Henry R. AIME, *Transactions* 8, xxiv.
19. Some questions were consistent across decades, such as name, sex, age, and race; others only appeared in particular census years. For a full list of the census questions asked on the 1880 population schedules, see: United States Census Bureau, "History: 1880," https://www.census.gov/history/www/through_the_decades/index_of_questions/1880_1.html (accessed 15 June 2022).
20. North Atlantic Population Project, "What is NAPP?" https://www.nappdata.org/napp/intro.shtml.
21. There are 50,169,452 records in the 1880a (100 percent) NAPP dataset. Minnesota Population Center, *North Atlantic Population Project: Complete Count Microdata. Version 2.0* [Machine-readable database], Minneapolis: Minnesota Population Center, 2008; Steven Ruggles et al., *Integrated Public Use Microdata Series: Version 5.0* [Machine-readable database], Minneapolis: University of Minnesota, 2010.
22. For further discussion, see: Eric C. Nystrom, "Exploring Work with NAPP Microdata," http://ericnystrom.org/posts/Exploring_work_with_NAPP_microdata/ (blog post, 26 July 2014).
23. IPUMS USA, "OCCHISCO: Description." https://usa.ipums.org/usa-action/variables/OCCHISCO#description_section . One relevant feature of HISCO coding is that the code numbers have a hierarchical organization with increasing specificity, so engineers broadly speaking is code 2000, while mining engineers more specifically is code 2700, since mining engineers are a type of the broader category of engineers.
24. https://usa.ipums.org/usa-action/variables/OCCHISCO#description_section
25. Robert L. Spude, "To Test By Fire: The Assayer in the American Mining West, 1848-1920," Ph.D. diss., University of Illinois, Urbana-Champaign, 1989.
26. HISCO code 2600, captured by NAPP variable "OCCHISCO."

27. Metallurgists and metallurgical engineers were in category 47, while assayers were in the chemist category, 7. These are captured in the NAPP variable "OCC50US".
28. Rodman W. Paul and Elliott West, *Mining Frontiers of the Far West, 1848-1880*, 2nd ed. (Albuquerque: University of New Mexico Press, 2001), 130-2.
29. https://www.nappdata.org/napp-action/variables/OCCHISCO#description_tab.
30. I used the SQLite program, which has several important advantages for digital history work: it supports a robust implementation of SQL, the well-known Structured Query Language that is "under the hood" of most relational databases; it uses single-file databases which are easy to move around and back up as necessary; it is loosely typed, which means that it doesn't break when text seems to be numbers or vice-versa (important for working with historical sources); and it is free and runs on multiple operating systems. The program is available from https://sqlite.org/index.html. Specific setup directions for the NAPP census database are available in: Eric C. Nystrom, "NAPP-tools: the gory details," http://ericnystrom.org/posts/napptools:_the_gory_details/ (blog post, 17 Jan. 2014).
31. These are available from a number of genealogy-focused websites, but I used the free copies of digitized census microfilm hosted on the Internet Archive. The 1880 census materials can be found at: https://archive.org/details/1880_census.
32. Technically oriented readers with an interest in digital history and a working knowledge of SQL should be able to follow my footsteps without trouble. The hand-transcribed list of AIME members had columns for SERIAL and PERNUM from the NAPP data added whenever the AIME members were successfully found in the NAPP census data, and was left blank otherwise. The AIME data can be imported into an SQLite database as a separate table from the NAPP data, and then queried either independently or by executing a SQL LEFT JOIN using SERIAL and PERNUM in both tables to query those AIME members found in the census. Searching for Census-determined engineers in NAPP data uses the OCCHISCO field (or could use the OCC50US field instead, if preferred).
33. Note that I'm using the variable OCCHISCO here and throughout to identify mining engineers in the census data, as it includes a handful of retired mining engineers (and one in training).
34. The conservatively low figure is 79 identified mining engineers out of the total list of 779 members, meaning 10.1 percent of the membership. If we estimate instead only on the basis of those AIME members we found, the figure is 15 percent (79/525).
35. Identified AIME members with a census occupation other than mining engineer and its clearest variations was 446. That is 57.3 percent of the total AIME membership (779) or 85 percent of the AIME members identified in the census data (525).
36. If the 254 AIME members who could not be identified in the census are combined with the 79 identified AIME-member mining engineers (for a total of 333 individuals), (254 + 79) / 779 equals 42.7 percent.
37. See: Layton, *Revolt of the Engineers*, especially Ch. 4.
38. Thomas Thornton Read, *The Development of Mineral Industry Education in the United States* (New York: American Institute of Mining and Metallurgical Engineers, 1941), passim. The phrase "young engineering branch" is intended only to suggest that mining engineering, as a professional field, was in its early years, while civil engineering had already had decades of mature professional practice. So, in a world where engineering expertise was needed and there were not many mining engineers, civil engineers might fill that void. Or, related but distinct, an engineer who developed his professional identity in earlier years—say, the late 1850s—might still call himself a civil engineer despite doing work later regarded as "mining engineering." For example, Isaac E. James, the top mining engineer on the Comstock and later at Tombstone, called himself a civil engineer.
39. For Cambria, see: Sharon A. Brown (preparator), "Cambria Iron Company," National Register of Historic Places Registration Form, 26 Jan. 1989, https://npgallery.nps.gov/NRHP/GetAsset/f38bdfe3-9ff2-4318-bf40-686a9d78f171 (accessed 11 July 2022). Although the author has not been able to examine it in person, William Howard Moore's *Company Town: A History of Rockwood and the Roane Iron Company* (Kinston, TN: Roane County Heritage Commission, Inc., 1984) appears to be one of the only historical works about the Tennessee firm. The best work on Holley, touching on his various steel works, is Jeanne McHugh's *Alexander Holley and the Makers of Steel* (Baltimore: Johns Hopkins University Press, 1980).
40. Nystrom, *Seeing Underground*, 48-77.
41. Spence, *Mining Engineers and the American West*, 61-2.
42. Here, the two occupational categories coded by NAPP and used to identify mining engineers give slightly different results. Calculating the average age of census mining engineers using the OCCHISCO measure results in a figure of 38.519 years, whereas the figure using the OCC50US measure is 38.318. The primary difference is that the OCC50US measure explicitly excludes four retired mining engineers and one mining engineering student who are included in the OCCHISCO figure. Note also that there is at least one data transcription error that would impact the number in either case; PARSONS, CHARLES O., SERIAL 3417293, PERNUM 3 has an age of 3.
43. Using the OCCHISCO value of 2xxx. The HISCO codes are hierarchical, so that all the 2000s are engineers, and then 2200 is the civil engineers, 2700

represents the mining engineers, and so on.

44. Mary Hallock Foote (Rodman Paul, ed.), *A Victorian Gentlewoman in the Far West: The Reminiscences of Mary Hallock Foote* (San Marino, CA: Huntington Library, 1972).
45. Scott is found on the manuscript schedules on reel 1367, enumerator district 33, page 36, line 47, https://archive.org/details/10thcensus1367unit/page/n307/mode/1up. He was Virginia-born of Virginia parents, and was a boarder—along with H. C. Reichardt, a white mining engineer from Pennsylvania—in the house of a farmer.
46. A check against the manuscript census schedules shows that Benjamin F. Butler, Jr., of Westchester County, New York, reported in 1880 as a mining engineer, was listed as male. New York, reel 947, enumeration district 125, p. 7.
47. Serenity Sutherland, "Discovering Science for Women: The Life of Ellen Swallow Richards, 1842-1911" (Ph.D. diss., University of Rochester), 2017), http://hdl.handle.net/1802/33009; Lynne Robinson, "Ellen Swallow Richards: The Most Influential Scientist You Probably [*sic*] Never Heard Of (Until Now)," *JOM: The Journal of the Minerals, Metals, and Materials Society* 66, no. 1 (2014): 15-20.
48. This query makes use of the NATIVITY field. The query can be much simplified if the researcher is willing to sum the relevant columns and divide (in this case by 1070) by hand to produce the percentages.
49. As above, utilizing NATIVITY and the OCCHISCO 2xxx categorization for engineers generally.
50. Querying where the value for NATIVITY is either 20 or 30, to capture the full range of those in the NAPP dataset born outside the U.S., and constraining the query to those with an AGE greater than 17, then manually dividing by the total number of entries of AGE greater than 17, yields 6352650/28204289 or 22.5 percent.
51. This can be understood by using the MIGRANT field, which was constructed by NAPP researchers to indicate if the person was residing in the state of birth.
52. As above, utilizing MIGRANT and the OCCHISCO 2xxx categorization for engineers generally.
53. Using MIGRANT together with a value of the AGE field greater than 17.
54. For instance, Clark Spence carefully explored these questions in recounting the history of mining engineers Joshua E. Clayton, who spanned both eras, and the Janin Brothers. Clark C. Spence, "Joshua E. Clayton: Pioneer Western Mining Engineer," *Arizona and the West* 22, no. 3 (1980): 211-22; Clark C. Spence, "The Janin Brothers: Mining Engineers," *Mining History Journal* 2 (1996): 76-82.
55. Eric C. Nystrom, "'Old Comstockers' Revisited: On the Origins of Mining Engineering," presented at the 25th Annual Conference of the Mining History Association, Virginia City, NV, 13 June 2015.