



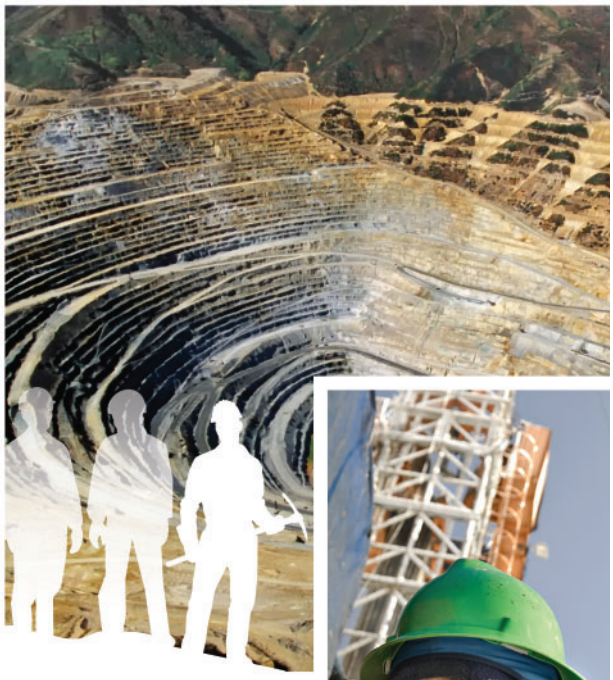
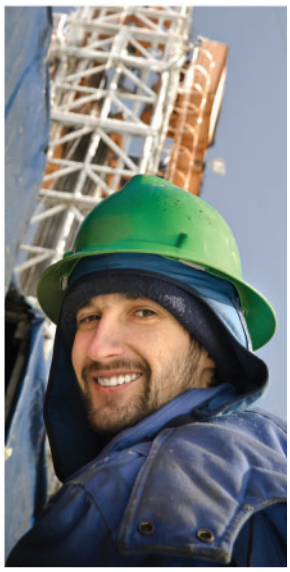

Emerging Workforce Trends in the U.S. Mining Industry

By Clifford N. Brandon, III
Automated Systems Alliance Inc.

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for
The Society for Mining, Metallurgy and Exploration
National Mining Association
National Stone, Sand & Gravel Association
Industrial Minerals Association – North America

Abstract

It is unlikely that there will be sufficient skilled mine labor to satisfy the demand over the next 20 years. This does not mean the positions will not be filled. Retirement and a projected global increase in demand for mine labor will likely provide a steady stream of new jobs with attractive wages. For a period of time, the U.S. will have a workforce composed of very young and very senior workers. A number of health and safety issues may likely result from this situation. Finding and retaining skilled labor is likely to be a problem for mines and to some degree this may force many companies to instigate process improvements and new automation solutions. Coincidental with these labor issues, a trend toward mineral nationalism and a potential rise in commodity prices due to a rapidly expanding global middle class may force the U.S. to reassess the value of the mining industry in the U.S.

Introduction

To understand if and how mining labor demands will be met over the next 20 years, this study first considers some of the factors that are currently driving the mining business in the U.S. as well as issues that are anticipated to drive the business in the near future. It then looks at the workforce by mining sector to understand how labor is divided up and suggests reasons why the employment estimates vary depending on what data source is used. Compensation, workforce age, retirement rate, skill level, retention, and education issues also are evaluated. Health and safety is addressed last as many of the preceding topics have an impact on this subject. The Exhibit section contains the logic and calculations for data source assessments, calculation of mining's contribution to the U.S. economy, and the factors affecting the aging of the labor workforce.

Study Scope

This study seeks to understand how U.S. mine labor has changed over time to produce the current workforce and to project how it will change over the next twenty years. Because similar skill sets are required for coal, metals, non-metals, sand and gravel/crushed stone mining these sectors are assessed together for the purposes of this study. However, each of these mining sectors serves different markets and has different operating needs, rules, regulations and risks. Excluded from this study are commodities extracted by drilling (e.g. oil, gas and helium).

Background

In July of 2011 Automated Systems Alliance, Inc. was tasked with presenting results of a mining labor study to the *National Academies Division on Earth and Life Sciences Policy and Global Affairs Division Board on Earth Sciences and Resources Committee on Earth Resources Board on Higher Education and Workforce (The Committee)*. The following mining organizations participated in this study:

- Society for Mining, Metallurgy, and Exploration (SME)
- National Mining Association (NMA)
- National Stone, Sand & Gravel Association (NSSGA)
- Industrial Minerals Association – North America (IMA-NA)

Preliminary results were shared with the Committee on August 23, 2011 and addressed the questions laid out in the *Emerging Workforce Trends in the U.S. Energy and Mining Industries* task list (Exhibit A). A final presentation was made to the Committee on November 9, 2011.

Data Sources and Data Source Comparisons

The stated purpose of the study is to understand the need and availability of U.S. workers for the various mining sectors identified. Ideally, all individuals (employees, contractors and others) that work in a mining operation or directly support the mineral benefaction processes are accounted for in this study.

To accomplish this task, headcount information was compiled from various public sources. This section examines the data sources, attempts to explain the differences between data sets, and discusses how the data was used.

It is important to understand the origins of the information used to generate this study, particularly as it applies to headcount. There are several different data sets used that, in some cases, differ by 10 percent or more in headcount.

There are three primary sources of mining labor data used in this study:

- Bureau of Labor Statistics (BLS): Used for mine labor aging and labor projections.
- Mine Safety and Health Administration (MSHA): Most useful definition of mine labor for this study and used to break labor into sectors.
- U.S. Energy Information Administration (EIA): Derived from BLS data. Useful for its labor projections.

A PriceWaterhouseCoopers (PwC 2008) mining industry study commissioned by the National Mining Association [1] is included as it defines an upper limit to mine labor in the U.S. It should be noted that EIA labor data is derived in part from BLS data, and PwC information relies on both BLS and MSHA data. BLS and MSHA data are collected by different agencies with different goals and may be considered independent.

These data sets differ from one another. A more comprehensive discussion of the data sets and their uses along with an analysis of the differences in the data sets is provided in Exhibit B.

Other Data Sets

Several additional data sets (U.S. Geologic Survey, Census Bureau, etc.) were used in this study although they were not directly related to mine labor headcount. This includes information such as: mine production, mineral usage, labor rates, as well as other pertinent industry information.
Several other publically available data sources also were used such as the Minerals Information Institute (Mii) "Mineral Baby" compilation (compiled by SME from USGS, NMA and other sources) and SME's summaries on education.

Mining Labor Drivers: U.S. and Global Resource Consumption

There is a need for a mining labor force in the U.S. only if there is a need for mining in the U.S. Presently mining is not held in high regard in the U.S. by much of the population. There are many well known reasons for this which will not be reconsidered here. Instead, the following sections identify some emerging mineral issues which may require the U.S. to reconsider the value of domestic mining and therefore the need for mining labor.

Global Consumption

The rise of the middle class is occurring globally. This is most evident in China and India. There is no reason to believe this will not result in a considerable upswing in consumption and corresponding increase in the demand for natural resources. For example:

- Today, at 400 million, China's middle class is already larger than the entire population of the United States (314 million) and is expected to reach 800 million in fifteen years. [2]
- Credit Suisse expects China's share of global consumption to increase from 5.2 percent at US $ 1.72 trillion in 2009 to 23.1 percent at US $15.94 trillion in 2020, overtaking the U.S. as the largest consumer market in the world. [3]

- McKinsey Global Institute (MGI) suggests that if India continues its recent growth rate, average household incomes will triple over the next two decades, and India will become the world's 5th largest consumer economy by 2025, up from 12th in 2011. [4]

October 31, 2011 was designated as the day the planet's human population hit 7 billion [5]. At a population of 310 million, the U.S. has only 4.5 percent of the world's population but is amongst the richest countries. In 2004 one billion residents of high income countries consumed 80 percent of the global total and the U.S. consumed 33 percent of the global total in the same year [6]. While some of what the U.S. consumes is turned into products that are then exported, there is a larger question: Is the rate of U.S. consumption sustainable in light of the world's rising middle class, most notably in China and India?

U.S. Mineral Consumption

One way of understanding U.S. natural resource consumption is to divide the total amount of resources consumed by the U.S. population. Based on information compiled by SME from U.S. Geological Survey data and provided by the Minerals Information Institute (Mii), over the last 15 years each person counted in the U.S. Census has, on average, consumed between 37,000 and 49,000 lbs of raw materials (both energy and minerals) [7]. As shown in Figure 1, the minimum occurred in 2009 and likely reflects a drop in consumption related to the U.S. and global recession. Given the departure from the 12 years prior to 2007, the 2009 value may well represent the lowest level of consumption one could expect for the U.S. economy.

Figure 1

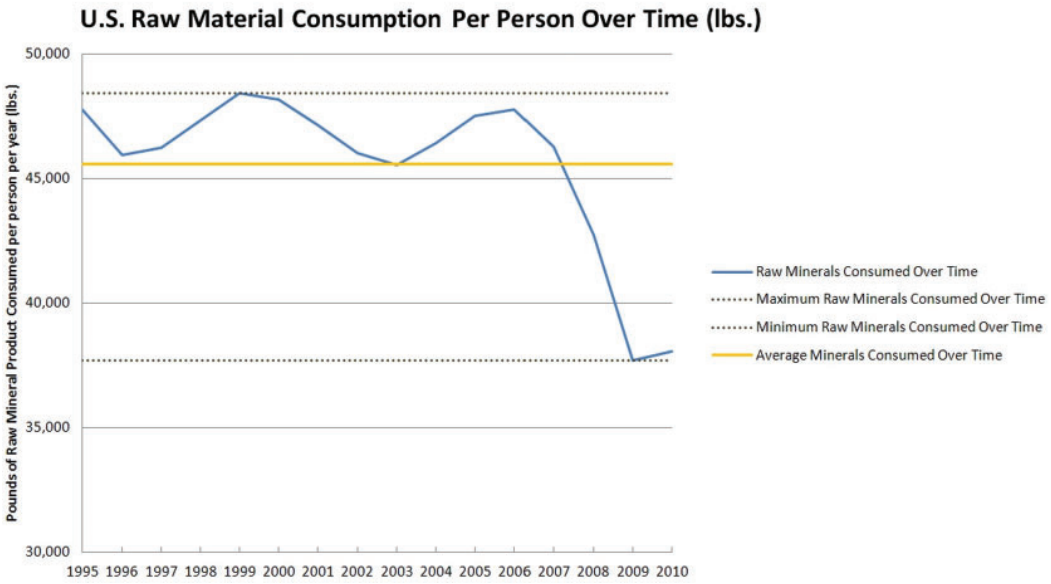
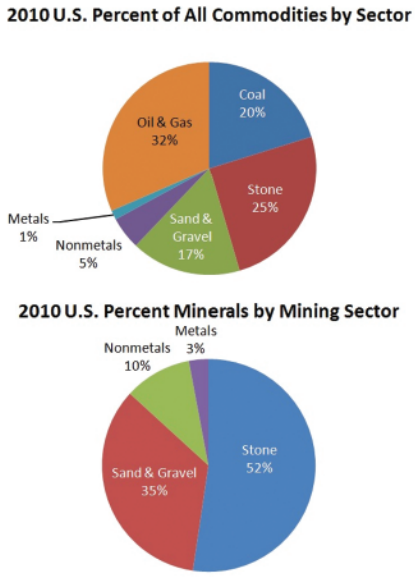


Figure 1.
Pounds of material consumed each year, on average, for every person in the U.S. Identifies maximum, minimum and average values. [7]

On average the U.S. consumes 45,557 pounds of raw materials per person every year (average of the last 15 years). To put this into perspective, a standard dump truck holds 10 yards of material or about 10 tons (20,000 lbs.) of material.

That means every man, woman, and child in the U.S. consumes, on average, somewhere between 2 and 2.25 dump truck loads of raw material each year (on average, 22.8 tons). Based on the weight of the commodities, one dump truck contains energy commodities (oil, natural gas, and coal) and the other contains minerals (sand and gravel, stone, metals, and nonmetals). Figure 2 below indicate the proportions of commodities from the various sectors.

Figure 2



As the U.S. population continues to grow, so too will our consumption of commodities. Figure 3 shows the relation between mineral and energy consumption (billions of tons) and population over time.

According to the National Bureau of Economic Research the U.S. economy entered a recession in December of 2007 [10] that lasted until June of 2009 [11]. An abrupt downward spike in mineral and energy consumption (figure 1) in 2007 and the uptick seen in 2009 is primarily a result of the recession.

Figure 2.
Percent by weight of commodities by sector for all commodities including oil and natural gas (left) and for only mined commodities (right) for 2010 [7].

Figure 3

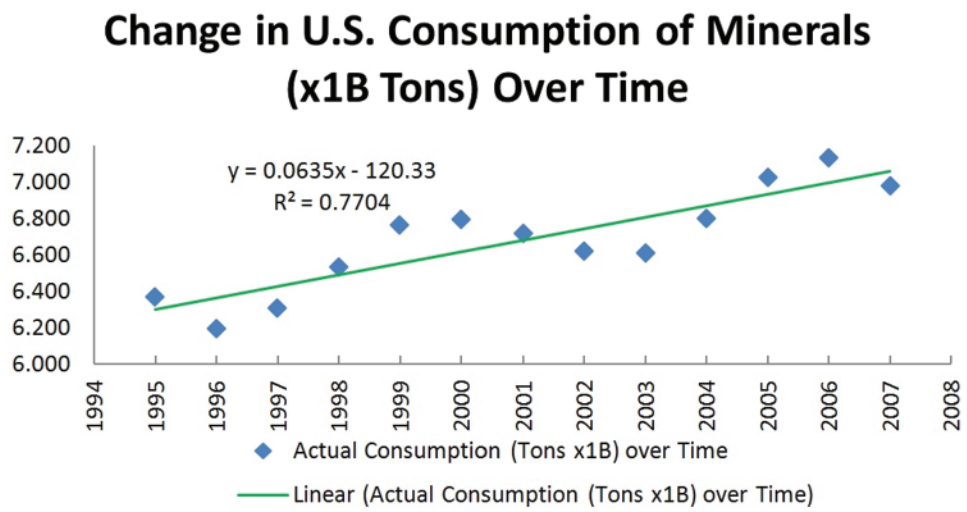
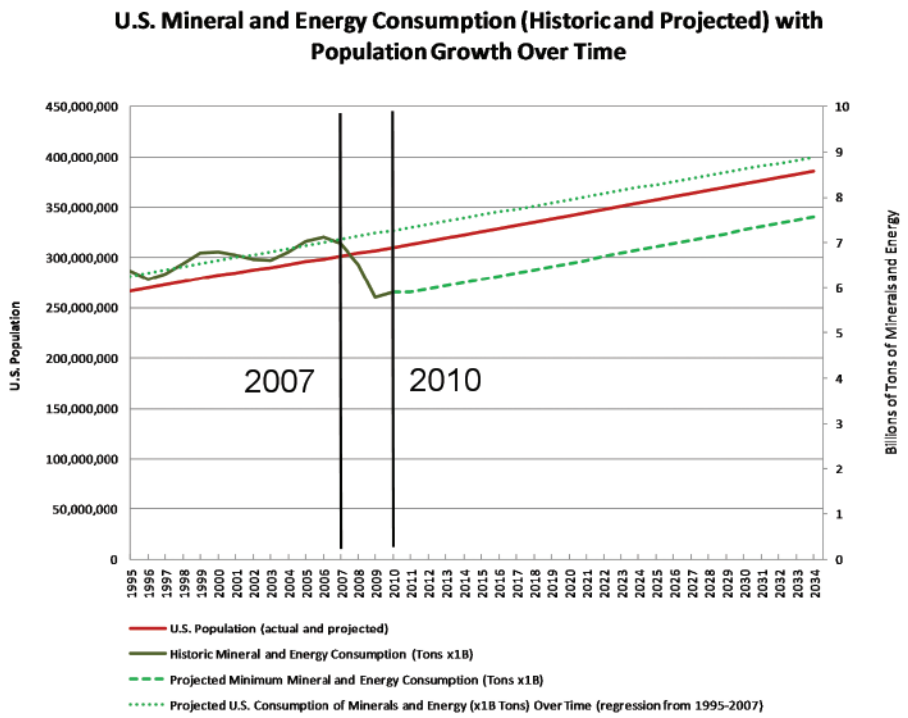


Figure 3.
Trend line for mineral and energy consumption has been constructed from the Mii for the period from 1995 through 2007. [7]

This trend line was superimposed on the actual consumption and population trend displayed in figure 4. This trend is probably a reasonable indicator of an upper limit of consumption going forward (green dotted line). The lower limit is likely the low point of consumption at the bottom of the recession (green dashed line). It should be noted that these trends do not take into account advances in technology, material substitution, material availability, and economic changes.

Figure 4
Actual and projected U.S. consumption of minerals and energy through 2034 [7]. Actual and projected U.S. population is included on the graph for reference [8] [9].

Figure 4



Mining's Contribution to the U.S. Economy

Mining is one of the few industries where long-term, well-paying jobs are currently being added. According to the Bureau of Labor Statistics and reported by the 2011 American Resources Review:

> "In one year – between June 2010 and 2011 – coal mining jobs grew 7.6 percent, metals mining jobs grew 3.9 percent, and jobs in support activities for mining grew at a rate of 19.2 percent, and mining job growth has continued to be robust in 2011...." [12]

And from testimony by Hal Quinn, President and CEO of the National Mining Association to the U.S. House of Representatives Committee on Natural Resources, 9/14/2011:

> "Even this last year, as overall job growth hit a standstill, mining continues to add jobs at an impressive rate. From June 2010 to June 2011, metal and coal mining added 11,000 direct and 17,000 mining support jobs at salaries well above the national average for all private sector jobs." [13]

Mining labor, as defined by MSHA, constitutes less than one quarter of one percent of the available U.S. workforce (age 16+). Yet this small workforce is the starting point for a value chain that consistently contributes 13 percent to 14 percent of the U.S. economy, excluding the value of the energy generated from coal (see Table 1).

Table 1

	DOMESTIC MINING'S IMPACT ON THE U.S. ECONOMY					
	[Billions of dollars]	2006	2007	2008	2009	2010
1	Gross Domestic Product	13,377	14,029	14,292	13,939	14,527
	U.S. Economy - Mining Contribution					
2	Domestic Mining	105	110	123	100	111
3	Mining as a % of GDP	0.78%	0.78%	0.86%	0.72%	0.76%
4	Processed Domestic Minerals	398	414	404	347	412
5	Processed Minerals as a % of GDP	2.97%	2.95%	2.83%	2.49%	2.84%
6	Value Added to Processed Products (1)	1,835	2,002	2,045	1,819	1,966
7	Value Add as a % of GDP(2)	13.72%	14.27%	14.31%	13.05%	13.54%
	U.S. Workforce - Mining Contribution					
8	US Labor Force (16 and over)	151,408,833	153,125,500	154,330,667	154,205,750	153,893,000
9	MSHA Labor	363,497	378,123	392,719	355,720	361,167
10	Mining as a % of Labor Force	0.24%	0.25%	0.25%	0.23%	0.23%

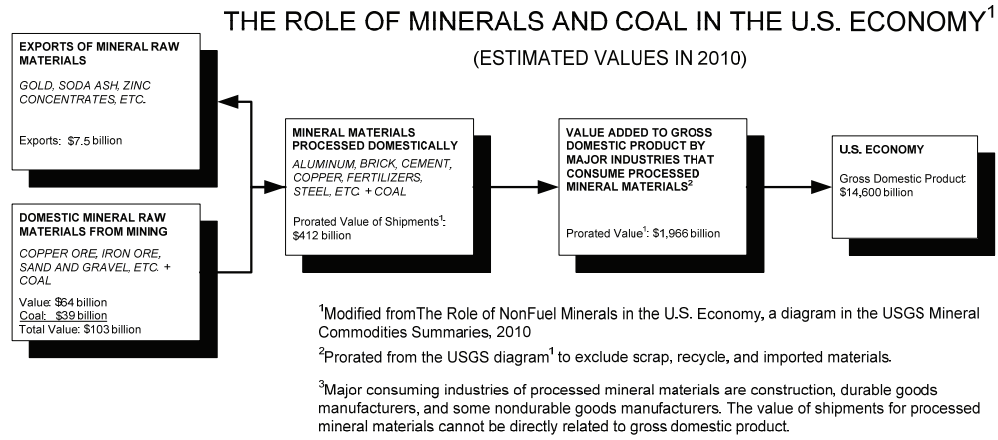
(1) Does not include the value of the energy produced from the coal.

(2) The percent value indicated is for comparison only as the value of shipments for processed mineral materials cannot be directly related to gross domestic product.

Table 1
U.S. mining's contribution to the U.S. economy from 2006 through 2010. (GDP [14], See Exhibit 'C' for Mining Contribution to U.S. Economy [15], U.S. Labor Force [16], MSHA labor (see Exhibit 'B'))

Each year the U.S. Geological Survey produces the *Mineral Commodity Summaries* publication for the prior year. As part of that summary, the USGS produces a chart that illustrates the role of non-fuel minerals in the U.S. economy. The 2010 version of this diagram appears in Exhibit C.

Figure 5



Sources: U.S. Geological Survey and U.S. Department of Commerce

Figure 5
2010 value chain for mining in the U.S. Economy. Derived from the 2010 USGS Mineral Commodity Summaries [15].

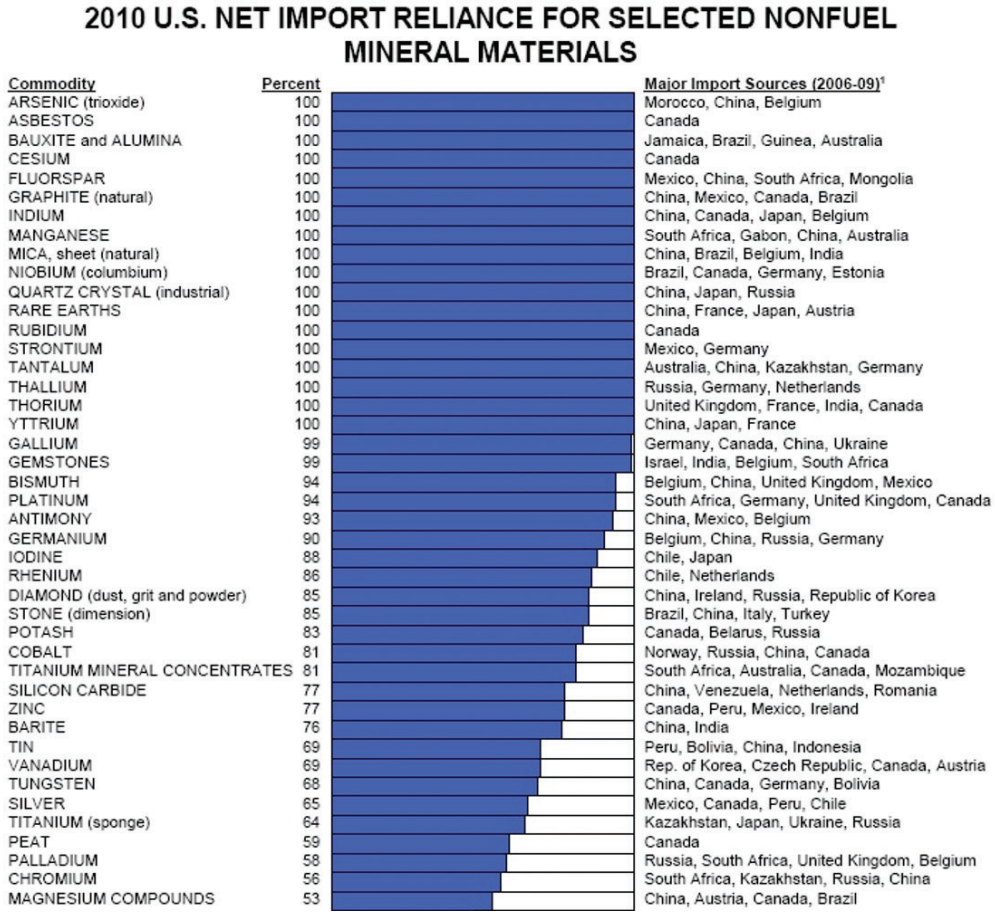
For the purposes of this study the logic and figures from USGS *Mineral Commodity Summaries* for 2006 through 2010 were used with some adjustments (see Figure 5) to isolate the domestic mining contribution to the economy. Specifically, scrap, recycled materials, and imports were excluded. Please see Exhibit C for the calculations related to Table 1 and Figure 5.

Mineral Security

The U.S. is reliant on many other countries for much of our mineral supply in an age where mineral nationalism is an emerging trend. The USGS *Mineral Commodity Summaries* for 2010 reported that, of the 67 commodities tracked, the U.S. was 50 percent or more dependent on 43 commodities and was 100 percent dependent on 18 percent of those commodities [15] as illustrated in Figure 6 below.

Figure 6
2010 Net U.S. import reliance on 67 nonfuel minerals. Minerals with 50 percent or more reliance. Modified from 2010 USGS Commodity Summaries. [15]

Figure 6



Commodity	Percent	Major Import Sources (2006-09)[1]
ARSENIC (trioxide)	100	Morocco, China, Belgium
ASBESTOS	100	Canada
BAUXITE and ALUMINA	100	Jamaica, Brazil, Guinea, Australia
CESIUM	100	Canada
FLUORSPAR	100	Mexico, China, South Africa, Mongolia
GRAPHITE (natural)	100	China, Mexico, Canada, Brazil
INDIUM	100	China, Canada, Japan, Belgium
MANGANESE	100	South Africa, Gabon, China, Australia
MICA, sheet (natural)	100	China, Brazil, Belgium, India
NIOBIUM (columbium)	100	Brazil, Canada, Germany, Estonia
QUARTZ CRYSTAL (industrial)	100	China, Japan, Russia
RARE EARTHS	100	China, France, Japan, Austria
RUBIDIUM	100	Canada
STRONTIUM	100	Mexico, Germany
TANTALUM	100	Australia, China, Kazakhstan, Germany
THALLIUM	100	Russia, Germany, Netherlands
THORIUM	100	United Kingdom, France, India, Canada
YTTRIUM	100	China, Japan, France
GALLIUM	99	Germany, Canada, China, Ukraine
GEMSTONES	99	Israel, India, Belgium, South Africa
BISMUTH	94	Belgium, China, United Kingdom, Mexico
PLATINUM	94	South Africa, Germany, United Kingdom, Canada
ANTIMONY	93	China, Mexico, Belgium
GERMANIUM	90	Belgium, China, Russia, Germany
IODINE	88	Chile, Japan
RHENIUM	86	Chile, Netherlands
DIAMOND (dust, grit and powder)	85	China, Ireland, Russia, Republic of Korea
STONE (dimension)	85	Brazil, China, Italy, Turkey
POTASH	83	Canada, Belarus, Russia
COBALT	81	Norway, Russia, China, Canada
TITANIUM MINERAL CONCENTRATES	81	South Africa, Australia, Canada, Mozambique
SILICON CARBIDE	77	China, Venezuela, Netherlands, Romania
ZINC	77	Canada, Peru, Mexico, Ireland
BARITE	76	China, India
TIN	69	Peru, Bolivia, China, Indonesia
VANADIUM	69	Rep. of Korea, Czech Republic, Canada, Austria
TUNGSTEN	68	China, Canada, Germany, Bolivia
SILVER	65	Mexico, Canada, Peru, Chile
TITANIUM (sponge)	64	Kazakhstan, Japan, Ukraine, Russia
PEAT	59	Canada
PALLADIUM	58	Russia, South Africa, United Kingdom, Belgium
CHROMIUM	56	South Africa, Kazakhstan, Russia, China
MAGNESIUM COMPOUNDS	53	China, Austria, Canada, Brazil

The rise of mineral nationalism and restrictions on exports exacerbates the problem of commodity availability. The recent changes in the REE market provide a vivid example of this issue.

In mid-2011 China severely restricted export of rare earth elements (REE) on which the U.S. has been 100 percent important reliant since the mid-1990s. China is widely reported to have 37 percent of the world's REE deposits but, up until recently, has provided 97 percent of the world's supply [17]. Until recently, cost of REEs from China has made it impractical, from an investment perspective, for a prospective U.S. REE producer to go through the costly and time-consuming process of permitting a new mine.

Even though Molycorp, Inc. reopened the Mountain Pass REE mine (California) in 2011 [18], in order to meet the expected demand for REEs in the U.S. and abroad, new REE deposits will need to be identified, permitted, and fast-tracked to production.

Summary - Is there a Mining Labor Issue?

Earlier in this section of the study, it was posited, "We only need a mine labor force if we have mining in the U.S." Consider the following:

- The new global emerging middle class will continue to create competition for resources that will likely increase demand well into the future.
- The U.S. is the world's largest consumer of materials as its economy and population grows.
- One quarter of one percent of the nation's total workforce is the starting point for about 14 percent of the U.S. economy, not including the value of energy produced from coal.
- In 2010, the U.S. was more than 50 percent dependent on other countries for 43 of 67 commodities tracked by the U.S. Geological Survey.
- There is an emerging trend toward mineral nationalism and restrictive trade policies. This could make the U.S. vulnerable to shortages in critical and strategic commodities.

This raises the question: In the next 10 to 15 years, is there a point at which the U.S. will more readily embrace domestic mining? If so, will there be a willing and ready labor force?

Mining Sectors

There are five mining sectors considered in this study: coal, stone, sand and gravel, metal, and non-metal (industrial minerals). Each of these sectors is distinctly different. What they have in common is an objective to safely remove and process materials from the ground at a profit. To accomplish this, companies engaged in this work must have a skilled workforce.

As part of its regulatory mandate, MSHA tracks labor by mining sector. Figure 7 shows changes in headcount by sector over time. MSHA also breaks out contractor headcount, which is also included in Figure 7.

Figure 7

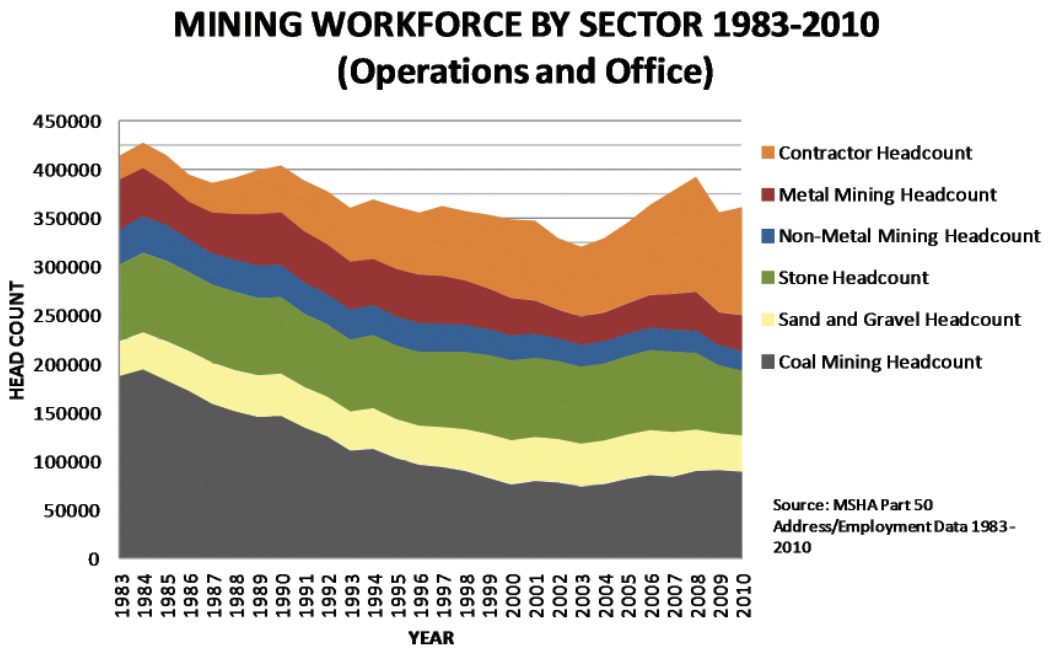


Figure 7
Cumulative U.S. mine labor by mine sector over time [19]. See MSHA data in Exhibit B.

There are several important points to note in Figure 7. In general, mining employment has shrunk since 1983 with the most notable declines in coal. However, the contractor headcount has risen from 6 percent in 1983 to 30 percent in 2008 keeping the overall mining headcount fairly constant at about 350,000, on average.

Contractors

Contractors are not one of the five mining sectors identified for this study. However, at 30 percent of the U.S. mining workforce in 2008, they represent a group that is larger than any other individual mining sector. It is a group that has been expanding since 1983, while general mine employment has been flat or in a slow decline.

There are a number of possible reasons for the increase in contractor use in mining:

- Employment Cost: Reduces the company's cost of finding and hiring a full time employee.
- Shifting Risk: The risks of layoffs, salary increases, burden changes, etc. are shifted to the contractor. Also, if necessary, a mining company can shed contractors more easily than it can employees (note the drop in contractor headcount after 2008 is likely due to the recession).
- Specialization: Reduces the need to have dedicated full-time employees to handle specialized tasks.
- Secondment: It is difficult to second contractors within a mining organization. This permits a group using contractors to focus the efforts of the contractors on specific tasks for long periods of time.
- Productivity: As defined by the BLS, productivity is a measure of industry output and labor hours. Exclusion of contractors from the calculation of productivity would have the tendency to artificially increase a business unit's overall productivity.

There are some consequences for having a high percentage of contractors:

- Knowledgebase: A company's knowledge base may not reside within the business.
- Fence-Hopping: If there isn't equitable pay and benefits, employees may attempt to hop-the-fence and become contractors, or visa-versa.
- Control: A company may have limited control over a contractor's employees.

Because of their numbers and the role they play in mining, contractors may provide an important labor "buffer" for mining. That is, they may provide a pool of somewhat fungible talent that mining organizations would find hard or expensive to maintain as employees.

Labor Analysis Example - Coal

Each of the mining sectors has different constraints, rewards and challenges, but we can only understand what drives labor use by looking at individual commodities. It is not practical to evaluate each commodity individually; therefore coal (all types) has been selected for analysis.

Figure 8.

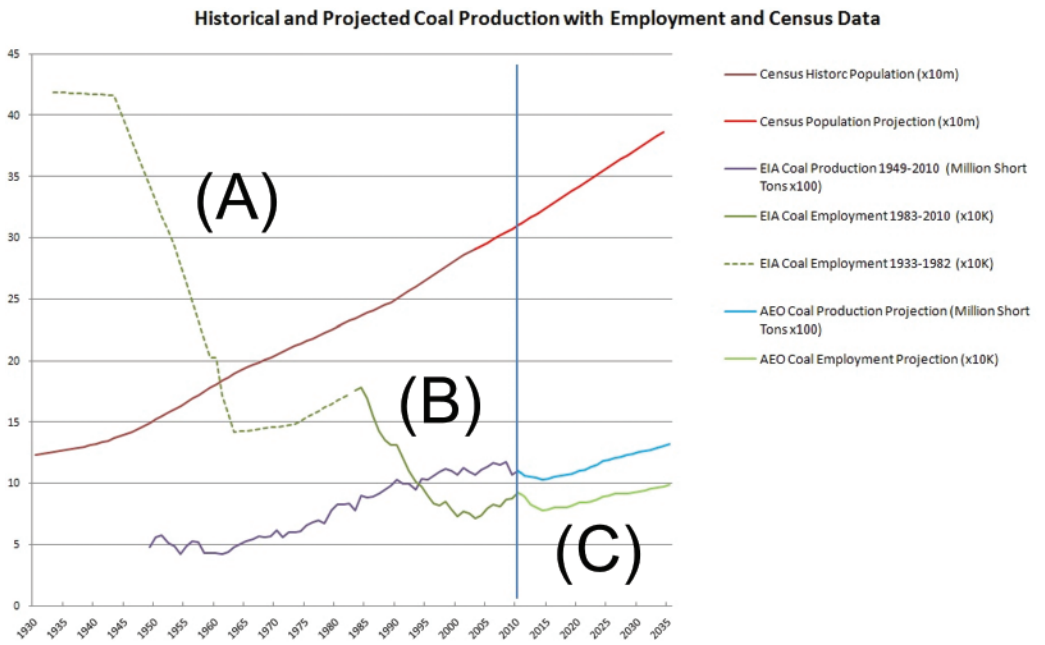


Figure 8
Employment (greens) [20][21][22], production (blues) [23][24], and population (reds) [8][9] change over time. Solid lines indicate year-to-year data. Dashed lines indicate intermittent data with extrapolation between points. Darker colors identify historic data and lighter colors indicate projections. Note: In order to project all three types of data on the same graph, the y-axis is scaleless. See the figure's explanation for the individual scales (multiplier).

Coal was chosen (Figure 8) because: (a) it is consumed by the public as energy, (b) production (blue lines) generally tends to trend in the same direction as the population (red lines) because coal consumption is a function of electricity use (currently 90 percent of coal produced is used to generate electricity), and (c) there are distinct changes in labor patterns (green lines).

It might seem that labor should increase in proportion to production. That is not necessarily the case. In Figure 8, there are three distinct inflection points in the labor headcount labeled A, B, and C. The primary reasons for the labor shifts are presented below [25]:

(A) 1943-1963: Automation in the coal industry reduced labor requirements.

(B) 1984-2003: Western open-pit coal operations dramatically increase production and labor intensive eastern underground operations were closed or consolidated.

(C) 2010-2016: Predicted labor loss as some Eastern coal mines close and coal based power plants convert to natural gas. If it happens, this would mark yet another instance whereby significant labor loss in the coal sector would be associated with production decreases driven by changes in environmental regulations.

Over the 105 year span depicted in Figure 8, almost 50 percent of that time was spent in transition to smaller labor forces for various reasons.

Each mined commodity could be charted and analyzed. Each would be unique but would likely show headcount inflections similar to those shown for coal, though the timing and explanations for changes will be different. Below is a list of factors that may drive workforce changes.

- Increased use of contractors (changes productivity)1
- Mines may close and new mines open
- Changes in the market (commodity prices, replacement, regulation, etc.)
- Technological advances
- Economies of scale in production
- Improved managerial and worker skills or effort
- Improved organization/use of resources, and
- Other efficiency improvements

1 Modified from a talk presented to NAS by Lisa Usher (BLS), July 14, 2011 [26]

Mining Workforce and Compensation

Mining tends to pay well and tends to provide stable employment. Table 2 below shows the top ten industries for average earnings and number of hours worked per week. Mining is in the top three in both lists.

Table 2.

Table 2
From 2010 BLS survey data. March 2010 benchmark revisions to all employee hours and earnings estimates for selected industries. Top ten displayed. [28]

	INDUSTRY	AVERAGE HOURS
1	Mining and logging	42.8
2	Primary metals	42.2
3	Transportation equipment	42.2
4	Textile mills	40.9
5	Machinery	40.6
6	Durable goods	40.2
7	Computer and electronic products	40.2
8	Manufacturing	39.9
9	Electrical equipment and appliances	39.9
10	Fabricated metal products	39.6

	INDUSTRY	AVERAGE EARNINGS
1	Computer and electronic products	$ 32.12
2	Transportation equipment	$ 28.56
3	Mining and logging	$ 27.34
4	Construction	$ 25.23
5	Durable goods	$ 24.72
6	Machinery	$ 24.14
7	Goods-producing	$ 23.97
8	Primary metals	$ 23.55
9	Beverages and tobacco products	$ 23.51
10	Manufacturing	$ 23.22

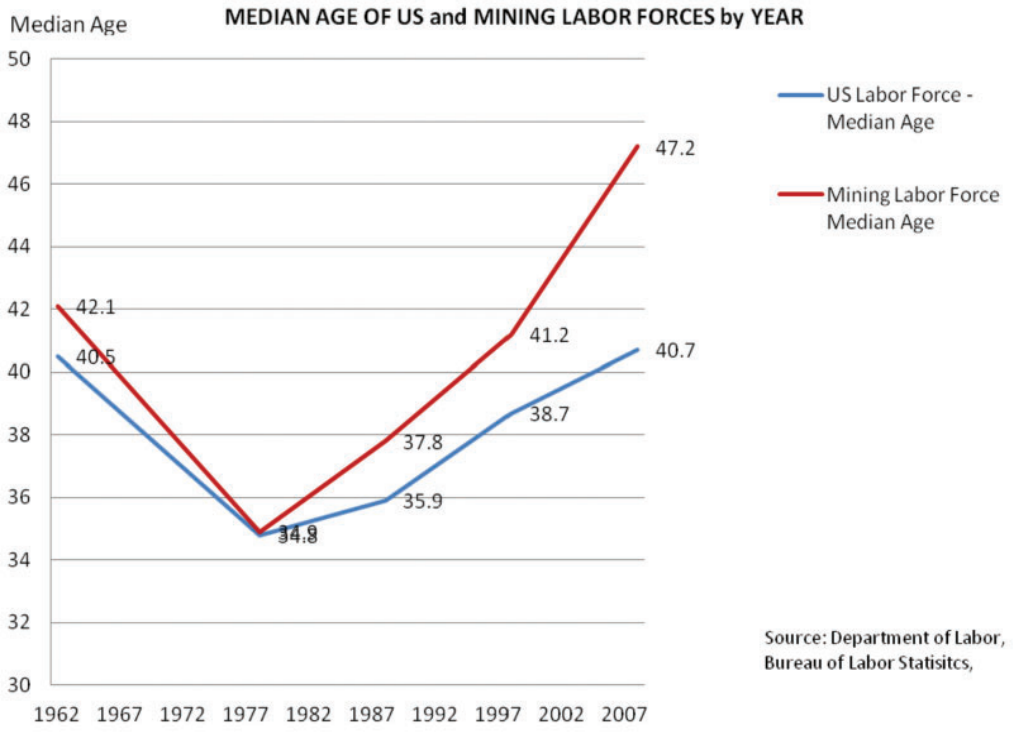
The Aging Workforce

Based on EIA projections, the U.S. mining industry is expected to grow over at least the next ten years. However, it is industry retirements that will create the more significant labor needs.

Starting in 1978, the U.S. mining workforce began to age more rapidly than the overall U.S. workforce (see Figure 9) and, by 2008, the mining workforce was 6.5 years older than the general workforce. There is no mining-specific retirement age information available for the U.S. though the average U.S. retirement age for men is currently at 64 years and 62 years for women [27]. Canada's average miner's retirement age is 59.5 [29], which may be comparable to the average U.S. miner's retirement age. If this is the case, U.S. miners in 2007 were retiring 2.5 to 4.5 years earlier than the general population.

Figure 9

Figure 9
Average age of the U.S. workforce and the mining workforce. [30]



To understand what the future mining workforce will look like, a BLS age survey of mining employment (see Table 3) was "aged" in 10-year increments starting in 2009 for a 20-year period. The details of how the workforce was "aged" appear in Exhibit D.

Table 3

HISTORIC DATA (1)	2006(2)		2009(3)		3 - YEAR CHANGE	
	MINING - (CONTRACTOR)		MINING - (CONTRACTOR)		MINING - (CONTRACTOR)	
	Labor (4)	Percent %	Labor (4)	Percent %	Labor (4)	Percent %
Total 16+	**239**	**100%**	**231**	**100%**	**-8**	**-3%**
16-19 Years	2	1%	3	1%	1	50%
20-24 Years	13	5%	10	4%	-3	-23%
25-34 Years	47	20%	40	17%	-7	-15%
35-44 Years	52	22%	52	23%	0	0%
45-54 Years	78	33%	71	31%	-7	-9%
55-64 Years	44	18%	49	21%	5	11%
65+ Years	4	2%	6	3%	2	50%

(1) Labor headcount does not include contractors
(2) 2006 statistics from BLS. Median age 45.0 (weighted average by sector) [31]
(3) 2009 statistics from BLS. Median age 47.2 (weighted average by sector) [32]
(4) Average labor headcount (thousands)
Source: Department of Labor, Bureau of Labor Statistics, Current Population Survey
Updated: January 2011 [31] [32]

Table 3.
BLS mining labor employment estimates by age group for 2006 and 2009 with percent of total labor for each group and a change comparison for the three year period. Shaded areas indicate the age classes expected to exit the industry over the next 20 years.

To understand how the mining labor pool will change over time, a table was prepared that advances the age classes in ten-year increments starting with 2009. Two cases were prepared. In Case A, the labor lost is replaced so the size of the overall labor remains constant. In Case B, 10,000 new employees were added every 10 years based on the 10,000 in the existing 20-24 age group for 2009. The 16-19 and 65+ age classes were held constant. To reduce the complexity of the model it was also assumed that there were no defections or additions to the age classes over time. Figure 10 below summarizes the results for Case A and B.

Figure 10

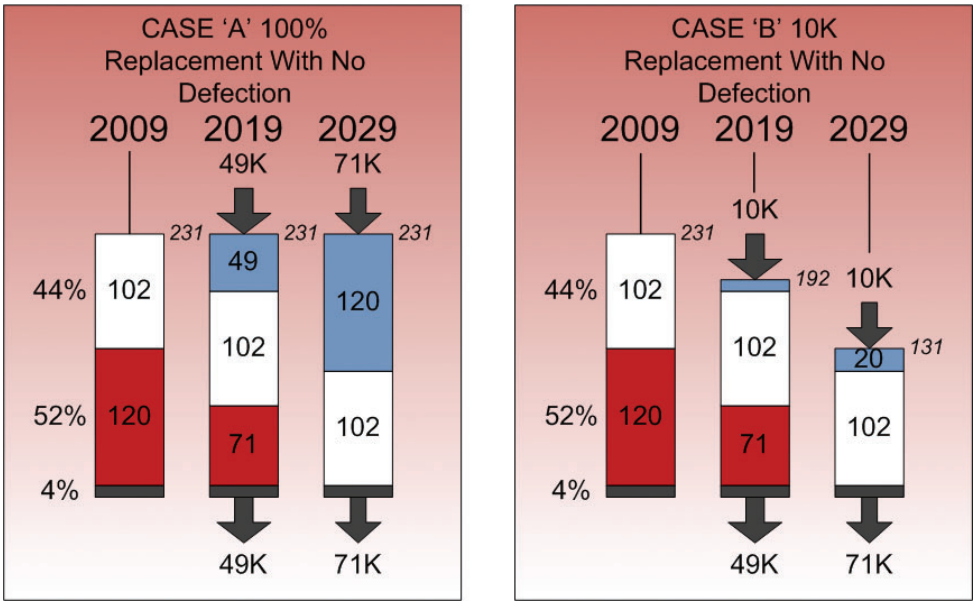


Figure 10
Comparison of labor change for Case A and Case B from 2009 to 2029. The entering workforce is shown in blue. The exiting workforce is shown in red. The white region is the workforce that is present continuously over the 20 year period. The black area represents the 16-19 year old and the 65+ age classes. See Exhibit D.

In both cases the labor exiting the system leaves at the same rate. The primary difference is the rate at which the labor pool is replaced. This change is reflected in the difference in turnover rate between the two cases at the end of 20 years (104 percent in Case A and 61 percent in Case B) as shown in Exhibit D. There is also a group of 102,000 (44 percent) of the work force that remains constant in both models.

It should be noted that the workforce was aged using the BLS labor estimates. For reasons stated in the data section of this study, these numbers are not reflective of the entire mining industry as defined by the scope of this study. However, the proportions are useful for profiling the changes in the overall workforce over time. Also, note that turnover, as the term is used here, is the sum of people entering and exiting the industry.

Given that mining headcounts are predicted to increase in the next ten years, Case A would seem to be the more likely of the two cases. Since Case A does not take into account the predicted labor increase and does not account for defection, the actual labor loss/need will likely be greater than predicted by Case A. Figure 11 shows the projected labor loss and need for the next 20 years.

Figure 11

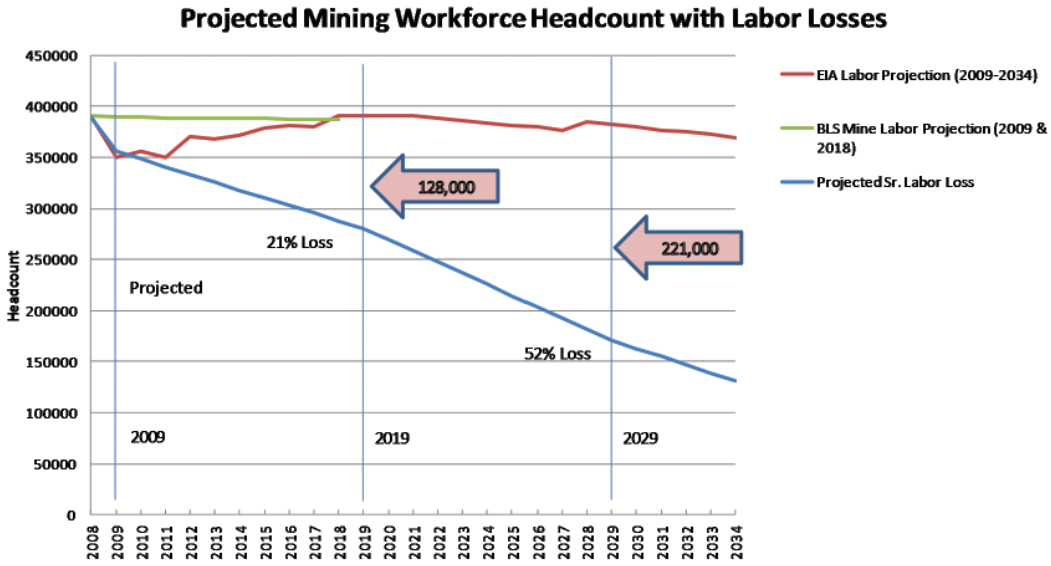


Figure 11
Workforce outlook over time showing projected labor loss (21% by 2019 and 52% by 2029). Red arrows indicate the number of positions that will need to be filled by 2019 and 2029. Green line: BLS Labor projection [33], Red line: EIA labor projection [22], Blue Line (see Exhibit D).

EIA projections have the mining industry growing by about 50,000 workers by 2019 but the industry will need 78,000 additional replacement workers due to retirement (Total of 128,000 new positions by 2019). By 2029, more than half the current workforce will be retired and replaced creating a skill and knowledge gap the industry may be challenged to accommodate.

The average rate of job addition is expected to be between 11,000 and 13,000 per year and is expected to continue into the foreseeable future. This matches the increase of 11,000 in mining employment recorded between June 2010 and June 2011[13]. The additional 17,000 support jobs added during the same period is larger than expected given the rate may reflect a rebound in the contractor sector following the recent recession (see Figure 7). The rates at which new mining jobs become available may be somewhat conservative as they do not take into account defection rates of existing skilled workers. Other factors, such as changes in technology, are not considered in this forecast.

Retention

The cases above do not consider the rate at which employees leave the industry or change roles within the industry. A table prepared by the SME Minerals Education Sustainability Committee in 2005 (Figure 12) provides some perspective on labor retention in the mining business.

Figure 12

2004 RETENTION OF 4-YEAR DEGREED MINING GRADUATES THAT MATRICULATED FROM 1976-1996

30% Attrition

30% Attrition?

EDUCATION	INDUSTRY SECTOR	GRADUATE PLACEMENT (FIRST JOB) 1976 - 1996*	RETENTION AS OF 2004**
4 YEAR PROGRAM	**PRODUCTION**	**70%**	**35%**
	Coal	35%	15%
	Precious Metals	10%	5%
	Base Metals	10%	5%
	Sand and Gravel + Stone	10%	5%
	Industrial Minerals	6%	5%
	SERVICES and SUPPLIES	**15%**	**35%**
	Consulting	5%	20%
	Equipment	5%	5%
	Supplies	5%	10%
	NON-TRADITIONAL	**13%**	**20%**
	Production in Other Industries	5%	5%
	Construction	5%	5%
	Other	3%	10%
	GOVERNMENT	**2%**	**9%**
	Federal	1%	4%
	State	1%	5%

* Percentages based on 20 years worth of graduate information from accredited programs.

** From BLS occupation statistics compiled for 2004

Figure 12. Progression of degreed professionals in the mining industry over time. [34]

Figure 12 indicates how individuals with mining related degrees were deployed across various mining industries (aggregated counts for 20 years beginning in 1976). It shows how that same group was dispersed across various industries in 2004. Notable is the high overall attrition rate of 30 percent (the portion of the workforce that has left the industry) and the 50 percent change in numbers of individuals originally employed in production. It is also interesting to note that all sectors other than production showed a two to four fold increase over the same period. Based on the changes observed, production is the functional training venue for the other employment areas.

While these numbers cannot be applied to the overall mining workforce, it does suggest there is a potential problem with production retention. Failure to address this problem will only further increase demand in a strained labor market.

The Emerging Workforce

Mining is a global business. The U.S. mining workforce is subject to many of the tidal forces that affect the industry outside U.S. borders. For instance, mine labor shortages in Australia can affect the domestic mine workforce if wages and other benefits in Australia and elsewhere exceed those in the U.S. (see Figure 13).

Figure 13

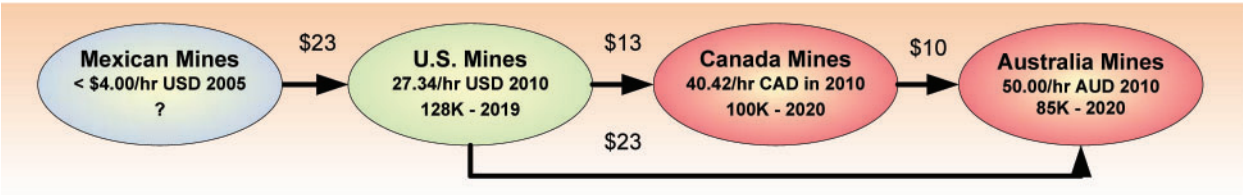


Figure 13
Average hourly rate and anticipated labor need for the next 10 years (not available for Mexico) for the mining work force by country. Hourly rates increase in the direction of the arrows. Rounded rate differences are indicated with the arrows. Note: at the time this study was prepared, U.S., Australian, and Canadian dollars had very similar values. Canada [36] [37], Australia [38], Mexico [39]

As the diagram indicates this also works the other way. Gaps in the U.S. mine workforce market may create a draw for foreign labor. Figure 14 below summarizes the sources of labor (blue) for the U.S. mine labor workforce (green) and other opportunities external to the U.S. which will draw on the U.S. mine workforce (red).

Figure 14

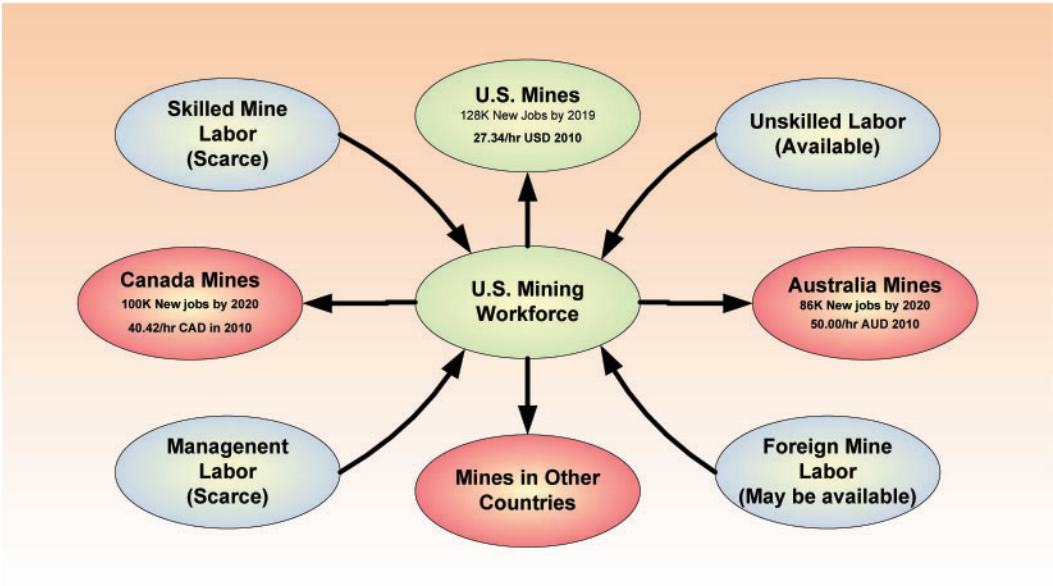


Figure 14
Internal and external drivers on the U.S. mine workforce. Canada [36] [37], Australia [38]

The U.S. mining industry workforce is relatively stable compared to that of other boom-and-bust mining countries. The industry tends to pay well, is anticipated to need skilled workers to fill jobs vacated by retiring senior labor, and may be expanding due to increased commodity demand over the next 20 years. The gap behind the retiring workers may also mean more opportunity for rapid advancement to in-fill those ranks. There are other factors that may discourage candidates from entering the mining industry or result in defection from the existing mining workforce:

- Remote: Some mines are in remote locations.
- Work: Despite increased automation, mining is still a labor-intensive industry.
- Environment: Except for underground mines, sites are located outdoors and are therefore subject to dramatic weather extremes and corresponding working conditions.
- Safety: Mining itself creates working conditions that require vigilant attention to personal safety.
- Skilled Labor: Training is required as there are few jobs that require unskilled labor.
- Generational: There is an increased focus on life/work balance by the incoming workforce.
- Boom and Bust: Certain commodities are subject to boom and bust cycles.

- Public Perception: There is a significant disconnect with the general public between the goods and services they consume and the fact that the majority of those goods are generated by mining, and
- Employment: Outside of mining communities, there is a lack of perceived opportunity for employment in this sector. The BLS *Occupational Outlook Career Guide to Industries, 2010-2011* lists as its first significant point for mining, "Employment is projected to decline in all sectors, except for coal mining." [38a].

The Mine Labor Supply

Is there, or will there be, a mining labor shortage? It turns out "shortage" can be hard to define particularly in a capitalist system where money can cure scarcity. However, there are proxies for scarcity (wages and changes in wages over time) that could be used to understand the extent of the "shortage", if it exists.

General:

- Cowan, a global mine recruiting company recently (8/1/2011) posted several blogs:

  > Dwindling talent pools in the mining sector has given way to scarcity in human resources, impacted and aggravated by an aging workforce ready for retirement. Panic is setting in as graduates are being forced to step up in their careers at a much faster progression. Leading-edge companies in the US and Europe are also turning to other countries specifically South-east Asia, Eastern Europe and Latin America to recruit high-skilled talent to sustain their innovations and growth strategies. [40]

Canada:

- In an article titled, "Canada is not Alone" (CIM Magazine - May 2011 edition) reported:

  > It is no secret that Canada's mining industry is facing a demographic challenge; an aging population means that in the next five years alone, one-third of the mining workforce will be eligible for retirement, driving the need for approximately 100,000 new workers by 2020 according to the Mining Industry Human Resources (MiHR) Council's latest labor market information report, "Canadian Mining Industry Employment and Hiring Forecasts 2010." [41]

Australia:

- The final report of the Government's National Resources Sector Employment Taskforce forecast:

  > There will be a peak of 45,000 new construction jobs in resource projects in both 2012 and 2013 and an additional 61,500 new mining sector operational jobs expected by 2015. The report forecasts shortfalls of 1,700 mining engineers and 3,000 geoscientists over the next five years. In addition, it concluded that there may be shortfall of 36,000 tradespeople by 2015. [42]

- **Reuters, July 11, 2011 reported:**

  > Chronic labour shortages in resource-rich Western Australia could put mining projects at risk, as the state struggles to plug a shortfall of skilled workers set to balloon to 150,000 by 2017, the region's jobs minister [Peter Collier] said on Monday. [43]

Mexico:

- In a Global Press Institute article dated April 5, 2011:

  > The first to bring in women to fill in the employment gaps here was Peñoles, a prominent mining company that hired 36 women to work alongside 210 men to work in Francisco I. Madero, the main zinc deposit in Latin America at the time. They turned to women to fill the void left by men, who had begun to migrate north. [44] The average Mexican miner made < $4.00/hr (USD) in 2005 [39].

Automation:

- At a 2011 SME meeting Preston Chiaro, Group Executive of Rio Tinto's Technology and Innovation Division, gave a speech entitled, "The Mine of the Future":

  > Mr. Chiaro indicated that labor costs in places like the Pilbara, Australia are driving Rio Tinto to consider advanced automated solutions [51]. Some of the all-in costs absorbed by the company (housing, transportation, etc.) quoted by Mr. Chiaro ($120,000 – Janitor, $600,000 – Jumbo Operator AUD) make consideration of high-tech solutions seem very reasonable and prudent. [45]

Given the downsides to mining, will people show up to fill the available positions? Given the current level of unemployment in the U.S. and the wage rates, the most likely answer is yes. The more important question is: Will they show up with the right skill sets and experience?

Fungible Labor

How easy is it for labor to move between mining sectors? How easy is it for labor to move between mines within a sector (the same or different commodities)? How easy is it for an individual to move into different positions within a mine? How fungible is the mining workforce?

Merriam-Webster defines "fungible" as: 1. Being of such a nature that one part or quantity may be replaced by another equal part or quantity in the satisfaction of an obligation, 2. Interchangeable, or 3. Flexible.

Labor reductions in stone, sand and gravel over the last three years have been linked to the downturn in construction which, in turn, has been linked to the U.S. recession. Can the employees who lost their jobs in this sector find jobs in another mining sector where jobs are available?

There is not much literature available on fungible labor in mining. Personal experience suggests that, at present, there is limited movement of people between mining sectors and, within a sector, sometimes limited mobility between commodities. The ability to move from position to position within the mine environment is more dependent on mine policy. There may, however, be more flexibility in the contractor environment.

Kowalski and others [46] observed of millennial cohorts, "These young people [under 24] have concluded that employment does not mean job security. Their only sense of security is what they know how to do." If this is the case, fungibility within a mine could be important for retention.

The concept of fungibility is usually applied to commodities. Individuals have a natural resistance to being thought of as commodities. What is being considered here is not the fungibility of any specific individual. The question being asked is, "How flexible is the mining workforce?" There currently is not a good answer to this.

Education

There is a fair amount of information available on degreed mining-related programs in the U.S. and globally. The information on community colleges, trade schools, apprentice programs and other mining training and education programs is spotty at best. Information on unskilled labor at mines was also lacking though, from conversations with recruiters and personal experience, there are few if any mining jobs that do not require training. What follows focuses on the degreed programs in mining.

Will there be enough degreed and skilled labor to meet the current and anticipated demand? The an-

swer to this question is unclear because current demand is not known. Discussions with recruiters that specialize in the mining industry indicate that, generally speaking, there is currently not enough skilled labor to meet the demand although demand varies depending on location and position. There are however, numerous current news articles (U.S. and foreign) that suggest there is a mine labor shortage. [47]

There has been a steady decline in the number of mining and mineral engineering programs at U.S. colleges and universities. The programs have decreased from a high of 25 in 1982 to 14 (12 accredited) by 2007, according to an article by McCarter in the September 2007 issue of *Mining Engineering* magazine [48]. There also has been a corresponding decline in U.S. faculty (~120 in 1984 to ~ 70 in 2007) in these programs as well as a shortage of qualified candidates to fill these faculty vacancies.

Figure 15 shows a steep decline in mining engineering graduates following the mining "bust" period in the 1980s and another drop after 1999 to levels not seen since 1990 [34]. As the industry began to pickup in about 2004, so did the graduate count. We are now close to levels of graduates that have not been seen since 1974. It is not clear if the graduation ramp-up rates seen in the mid- to late 1970s could be reproduced as there are currently fewer mining engineering programs and as well as qualified faculty.

Figure 15

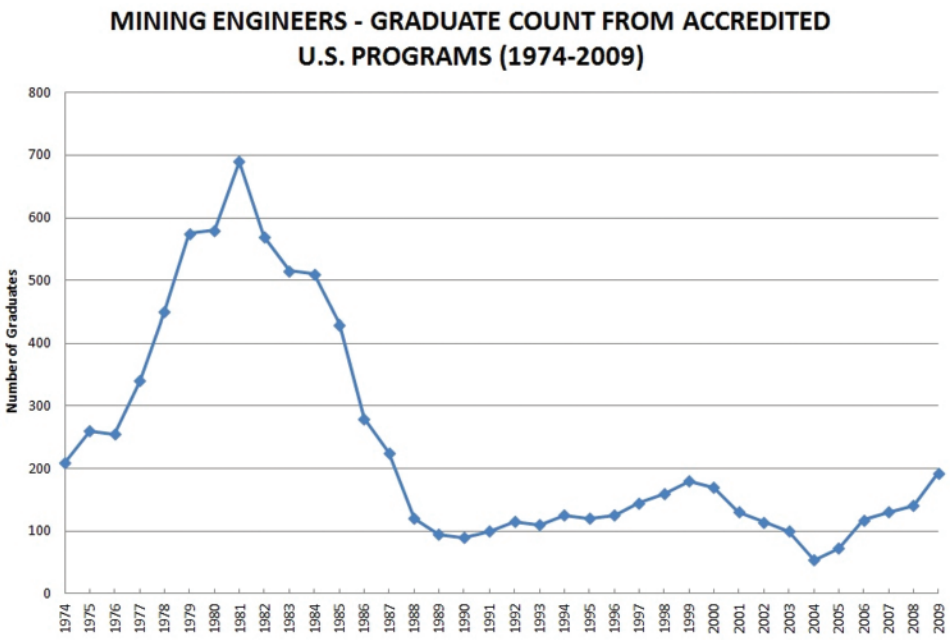


Figure 15
Number of B.S. mine engineering graduate students each year from 1974 through 2009 (35 years). [34] [35]

There are community colleges and trade schools throughout the country with mining and mining related programs usually in close proximity to mining operations. Little information has been compiled on these programs as a whole and those who have completed these programs...

If the demand for mining and mineral engineering programs were to increase beyond current educational capacity due to market needs, schools would have to expand their programs, hire new faculty, develop their programs, and enroll new students. Given the "boom" in mining globally and the lag in degreed academic program response, it is speculative if schools can meet the demand at least in the near future.

Health and Safety

Mining and mine employment has a long history of booms and busts. A boom in the 1970s resulted in a dramatic increase in hiring. The subsequent "bust" in the 1980s and a slow increase in the 1990s have resulted in a labor gap just behind the "boom" workforce that has begun retiring. At the same time, the mining industry has likely entered another hiring boom cycle. This rapid shift in the workforce demand may present additional health, safety and training issues.

The National Research Council report, *Toward Safer Underground Coal Mines,* found that, "...the age of workers is seen to be strongly correlated to disabling injury rates, with younger miners (ages 18 to 24) having a much higher disabling injury rate than older miners" [49.] This is borne out to some degree by a study of experience and injury and illness for metal and nonmetal workers (see Figure 16). This assumes younger workers also are going to be at the low experience end of the graph. Note that the charts for metal/nonmetal and coal contractors are similar but federal agency information for coal employees shows an unexpected shift to the middle of the range of experience.

Figure 16

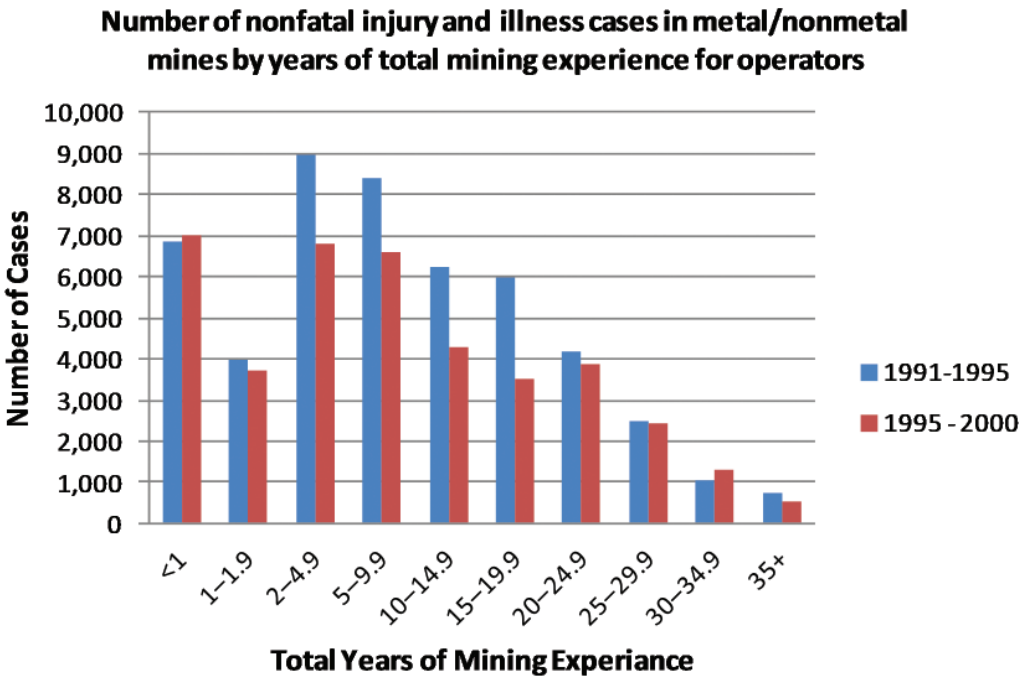


Figure 16
Nonfatal injury counts for 1991-1995 and 1995-2000 in U.S. metals/nonmetals mines based on experience. [38]

Aging Workforce Risks

A 2000 NIOSH study, *The Aging Workforce: An Emerging Issue in the Mining Industry,* for the period 1988 to 1998 indicated an increase in time lost by injured or ill older workers (45+)[30]. While this trend varied by commodity, occupation, and mine type (open pit and underground) it suggests that, given the average age of the U.S. miner and that the median number of days lost due to injury or illness was higher for older workers than for younger workers, this could have an impact on productivity as the mine workforce continues to age.

Together these studies suggest, with the exception of coal, more experienced mine workers have fewer injuries and illnesses. However, when injuries or illness do occur in these older workers, it tends to result in more lost time.

Training

Generational differences in the workforce have always existed and will doubtlessly persist into the future. However, the differences in the current generations within the workforce make training and communication of knowledge somewhat more challenging. Kowalski and others in their 2010 paper, *The Evolving Mining Workforce: Training Issues,* covered the challenges of training the current workforce. [46]

There is one potential bright spot. Considering the number of senior people exiting the mining workforce over the next 20 years, it might be worth exploring the possibility of tapping this resource's deep industry knowledge and experience and using it to train and instruct the incoming workforce. Some of the issues that may affect mine safety and health and must be confronted in the near future include:

(1) A rapidly aging workforce that is taking its knowledge base with it as it retires;
(2) A young, inexperienced and possibly foreign workforce that will be backfilling the knowledge gap as senior labor retires;
(3) A thinly spread residual layer of mid-level skilled labor destined in short order to be the senior staff; and
(4) Generational, communication, and training challenges.

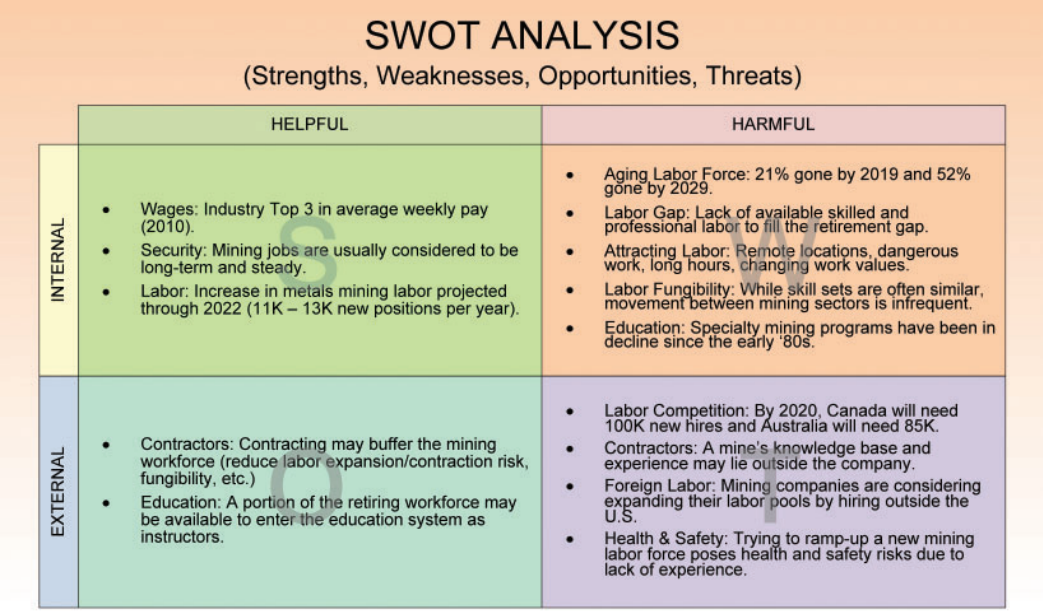
Summary and Conclusions

Mining will be one of a handful of sectors that will add jobs at a fairly constant rate (11,000 to 13,000 per year) over the next 20 years driven by retirement of the current workforce and projected increase in demand for resource production. These will tend to be well-paying, relatively long-term jobs. On the downside, the U.S. may not presently have the skilled labor base to meet the current resource demand and the skilled labor that does exist may well be lured to places promising higher wages (Australia, Canada, etc.). This does not mean people will not be found to fill U.S. mining positions. The questions are: How skilled will this new, young workforce be? From where will they come? Will the U.S. change its immigration policies to expand the mine labor pool? How will mining companies respond? Will companies increase wages and other benefits? Will companies implement new mining and processing technologies? What does this portend for health and safety of the employees at these mines?

A Strengths, Weakness, Opportunity and Threat (SWOT) analysis summarizes the major workforce points raised in this study.

Figure 17
SWOT analysis of the mining workforce.

Figure 17



The phrase "Perfect Storm" is a bit overused so some caution should be exercised in its application. Having said that however, the situation with mining in the U.S. and its workforce is at a historic juncture.

The mining industry is entering a global commodity boom cycle for metals and certain minerals that are being driven by a rising global middle class that "wants what we [the U.S.] have" [45]. The U.S. may shortly find itself competing for its share of commodities due to increased competition, trade and mineral production policies and mineral nationalism. This is presently being mitigated by the sluggish U.S. and world economy.

Closer to home, the aggregates and industrial minerals industries, which experienced labor reductions as road construction and housing faltered during the recession, also have an aging workforce and may have challenges finding skilled labor that would be needed to quickly ramp up production in response to a sudden increase in demand.

Within this world framework, U.S. mining finds itself with a predominantly senior workforce and an expanding need for labor to meet the increasing resource demand. As a result, the U.S. may, in the short term, be challenged to process its mineral resources and would therefore be strategically exposed due to its dependence on foreign raw materials.

EXHIBIT A

The National Academies
Division on Earth and Life Studies
Policy and Global Affairs Division
Board on Earth Sciences and Resources
Committee on Earth Resources
Board on Higher Education and Workforce

EMERGING WORKFORCE TRENDS IN THE U.S. ENERGY AND MINING INDUSTRIES

STATEMENT OF TASK

An ad hoc committee will conduct a study of the availability of skilled workers to meet the energy and mineral security requirements of the United States.

This study will include an analysis of:

(1) The need for and availability of workers for the oil, natural gas, coal, geologic carbon sequestration, nuclear, geothermal, solar, wind, and non-fuel minerals industries;
(2) The availability of skilled labor at both entry level and more senior levels; and
(3) Recommendations for actions needed to meet future labor requirements.

Specifically, this study will, to the extent possible given available data:

(1) Provide historic and current trends in the size, growth, and demographics of the workforce in these industries, disaggregating for each industry and sector (business, government, and academia) and identifying the main worker groups by sector and occupation.
(2) Examine key labor market characteristics of the workforce in each industry, including sectoral workplace practices and any labor market impediments, constraints, and failures.
(3) Discuss future demand for and supply of workers in these industries, sectors, and occupations.
(4) Describe current and projected education and training programs for these groups at community and technical colleges and universities or through other on-the-job or job-specific training and re-training initiatives.
(5) Discuss the potential for skilled foreign labor meeting projected sectoral labor requirements.
(6) Assess potential job health and safety impacts and national security of a long-term (more than three years) workforce shortage or surplus.
(7) Describe and evaluate data sources available, federal data collection and coordination, and possible research initiatives for future decision making on workforce issues.

EXHIBIT B

The sections below describe the data sets as well as differences between the data sets. This section also describes how the data sets are used in the analysis that follows.

Data Set Comparison

It might seem that a headcount of employees engaged in the U.S. mining industry would be straight forward and that the employment estimates from various public sources should be consistent. This is not necessarily the case as shown in table B1 below which summarizes 2008 employee head count by mining sector of seven data sets from publically available sources.

Table B1.

Table B1
Comparison of mining labor numbers from select sources.

EMPLOYMENT SOURCE DATA COMPARISON - 2008							
2008	Coal	Sand & Gravel	Crushed Stone	Non-Metal	Metal	Contractor Support*	**Total**
PwC (1)	154,020			322,290	88,090		**564,400**
MSHA (2)	90,055	42,307	78,975	23,033	39,126	119,223	**392,719**
BLS (3)	81,095	34,223	47,005	20,671	40,156	13,893	**237,043**
BLS-AGE (4)							**231,000**
BLS (5)	80,600			107,200	39,900		**227,700**
EIA (6)	80,000	46,000			44,000		**170,000**

[1] Price Waterhouse Coopers report to NMA (for 2008). Includes mining operation and transportation of minerals from mines to their customers.
[2] MSHA data compiled by the National Institutes of Occupational Safety and Health (NIOSH). Includes all employees and contractors in the benefaction processes.
[3] BLS breakdown by NAICS codes. Provided by Dixie Sommers (BLS).
[4] BLS Mine Labor - Breakdown by age group (2009).
[5] From BLS Employment Labor Projections. Table 2.7 Employment and output contract by industry 1998, 2008, and projected 2018.
[6] EIA mining industry projections. BLS data used for projections. Values are rounded.

* MSHA Contractors work at but are not employed by the mine. BLS Support is office support.
The data from 2008 was primarily used in this comparison because it is one of the few years where there is reported labor data from each of the public sources. It is not known if the differences in data sets for 2008 are representative of all years (past and future). Note that the sources are arranged by total headcount, highest to lowest.

The differences between sources have to do with what is being counted and what is being reported for headcount by each public data source. Each of the data sets is described below along with how the information is collected, its limitations, and how it is used in this study

PwC Data [1]
The PricewaterhouseCoopers 2008 report (PwC) commissioned by NMA indicates a large percentage difference in all the sectors though it is likely that the nonmetals sector actually includes sand and gravel with stone. The PricewaterhouseCoopers report uses BLS, MSHA, and the USGS data as its information sources. The overall large percentage differences however are due to the fact that PricewaterhouseCoopers also included mined material transportation headcounts in their numbers.

Because transportation is included in their numbers, the PricewaterhouseCoopers report overstates mining labor with respect to the labor constraints of this study.

The PricewaterhouseCoopers report is included here for two reasons. First, since MSHA mine labor numbers may be somewhat understated. It is likely that the actual numbers are somewhere between the MSHA and the PwC numbers. Second, the PwC labor count demonstrates the downstream impact of mining on the economy before mined products reach the first point where additional value is added to the mined products.

MSHA Data [2]
As part of its mission, MSHA collects information on each site where mineral benefaction takes place. All of MSHA's data is collected on activities and labor within the MSHA defined 'footprint' of the operation. MSHA classifies labor count within the footprint by labor type and other measurers. Sites are also classified by commodity and sector (coal, metal, non-metal, sand and gravel, crushed stone, and contractor). A combination of site visits and mandatory reporting are the source for the MSHA data. MSHA has specific jurisdictional boundaries for each site.

To be included in the head count for a mine, an individual has to work in the benefaction process within the mine footprint. This includes contractors and mine employees; basically, anyone at risk from the benefaction process.

If a worker contributes to the mine process, but is located outside the footprint of the mine they are not counted (engineering, near-mine exploration, corporate, etc.). MSHA also does not include state and federal government run operations (Yucca Mountain, Homestake – DUSEL, public works borrow pits, etc.). MSHA also may not count many smaller sand and gravel operations.

Relative to the stated goals of the study, MSHA may undercount the mine labor force because it does not count individuals who support the mining process but are outside the mine footprint. MSHA may over- count in some cases where contractors support multiple mines.

One of the objectives of this study is to understand how many people are in the mine labor force and to project how the labor force is anticipated to change over the next twenty years. MSHA labor counts are the closest match to the objectives though they are likely somewhat understated and therefore conservative.

BLS Data [3-5]
The Bureau of Labor statistics (BLS) collects and analyzes data from the U.S. population in the form of a census taken every four years, household surveys (intermittent studies from a population sample) and employment statistics collected as part of government mandated company reporting.

The BLS employment count is very precise. In the case of the census, it collects actual information about the population rather than estimations from a sampling of the population. In the case of mining, it is important to understand how the industry is counted by the BLS.

To be included in the mining headcount an individual has to work for a mining company that self-identifies by NAICS code [7] as a mining company. The NAICS code system is hierarchal with two branches that apply to mining: 212 (mining), and 213 (mining support). Table B2 below identifies the NAICS codes that apply to mining for the sectors in this study.

Table B2.

Table B2
NAICS Codes for the various mining sectors [3].

Coal	Sand & Gravel*	Stone**	Non-Metal, except Sand & Gravel and Crushed stone	Metal	Support (excluding Drilling oil and gas wells and Support services to oil and gas extraction)
2121	212321 and 212322	21231	2123, except 21231, 212321, and 212322	2122	213, except 213111 and 213112

*NAICS 21232 Sand, Gravel, Clay, and Ceramic and Refractory Minerals Mining and Quarrying, includes some industries producing output other than sand and gravel. The BLS data here include only those two detailed industries.
**MSHA report, where the employment number shown is published, uses "Stone." NAICS 21231 Stone Mining and Quarrying includes one detailed industry where the stone is not crushed (212311 Dimension stone). This slide uses the broader definition, i.e., NAICS 21231.

There are several different sets of BLS numbers used in this study:

(3) This is a breakdown of labor by sector specific NAICS codes.
(4) The BLS age data (from surveys) is not broken down by sector and is only provided in aggregate.
(5) This BLS data is from the occupational employment guide published by the BLS. It does not break out the sand and gravel or stone sectors but combines them in the nonmetals sector.

Relative to the goals of the study, the BLS may over-count employees with respect to administrative staff and others employed by a mining company but not necessarily present at a mine. It may under-count individuals working in the mine benefaction process because it does not count contractors that do not identify themselves with a NAICS mining code.

We know from the MSHA data that contractors currently compose about 30% of the mining workforce. The BLS employment estimates for 'support' are significantly less than the MSHA estimates for contractors. This may have to do with the subtle difference between what a company does verses where it operates. An example of this problem is presented below.

> Example: A truck maintenance company is contracted to operate and run a mine's truck shop. More than likely, such a company may manage a number of truck shops for other companies at other facilities (trucking, construction, etc.). A company such as this would describe themselves as a repair service for trucks (NAICS code 811 – what they do) and not a mine service company (NAICS code 213 –where they work).

One way to investigate the differences between the MSHA contractor numbers and the BLS support numbers would be to match MSHA contractors with BLS companies and then evaluate the NAICS codes associated with the BLS vendors.

The BLS publishes the *Occupational Outlook Guide* which is used by people entering the job market for the first time as well as recruiters. The most recent edition of the guide states, "Employment is projected to decline in all sectors except coal mining." The arguments put forward in this study indicate that this is probably not the case.

BLS numbers provide a significant dimension to this study. The BLS Labor projections for future labor needs and how the labor force ages is important for understanding the mine labor workforce of the future.

EIA Data [6]

Energy Information Administration (EIA) employment reports and projections are largely derived from BLS data and thus have the same constraints as the BLS data. EIA is included as one of the key data sets because the EIA projects mine employment through 2035. Note that the EIA projections are generated from an EIA model and the numbers are rounded. The projections also do not account for stone or non-metals and are therefore understated on headcount with respect to the study constraints.

EIA does project labor needs for metals, nonmetals, and coal through 2034 [6]. This projection is based on BLS data modeled by EIA. Though rounded, this is the only year-by-year estimate of mine labor identified. The EIA mine labor projections for the sectors mentioned have been aggregated to create a projection of the labor needs through 2034.

Data Source Differences

There are apparent differences between MSHA, BLS, and EIA totals for 2008. These differences are summarized as percent differences relative to MSHA data in Table B3.

Table B3

Table B3
Percent difference in employment estimates relative to MSHA headcounts. Cells with > 10% differences are highlighted.

PERCENT EMPLOYMENT SOURCE DATA COMPARISON - 2008						
2008	Coal % Dif with MSHA	S&G % Dif with MSHA	Stone % Dif with MSHA	NM % Dif with MSHA	Metal % Dif with MSHA	% Dif with MSHA
PwC (1)	-71%	NA	NA	-1299%	-125%	-44%
MSHA (2)	--	--	--	--	--	--
BLS (3)	10%	19%	40%	10%	-3%	40%
BLS-AGE (4)	NA	NA	NA	NA	NA	41%
BLS (5)	10%	NA	NA	-365%	-2%	42%
EIA (6)	11%	-9%	NA	NA	-12%	57%

Differences in BLS and EIA headcounts as compared to MSHA headcounts are primarily due to exclusion of various mining sectors. Where data exists and headcounts can be compared (e.g. coal) the employee estimates are relatively close. Differences within a mining sector may reflect how employees are counted. BLS counts employees and support identified by select mining NAICS codes. Others that may work at a mine will not be counted if they have a NAICS code other than that of a mine. Contractors and administration (office labor) are represented in the MSHA headcounts so, as expected, MSHA's headcounts tend to be larger for most sectors. There is an exception in the BLS non-metals employee headcount as compared to MSHA non-metals. This may be explained if the BLS counted all or a portion of crushed stone employment as non-metal.

Because of the completeness of the information set, the MSHA data is used primarily in this study's analysis. The employment headcounts in this study should be considered a conservative estimate of employment for the mining industry.

Adjusting Projections

Given the scope of this study, MSHA labor numbers provide the best approximation of the mining workforce. However, labor projections are only available from the BLS and EIA. To project future mine labor needs, both the BLS and EIA data were adjusted to meet the MSHA values (see Figure B1). This adjustment was accomplished by adding the difference between the MSHA labor values and the EIA projection for 2009 for each EIA point. The same was done to the BLS projection.

Figure B1

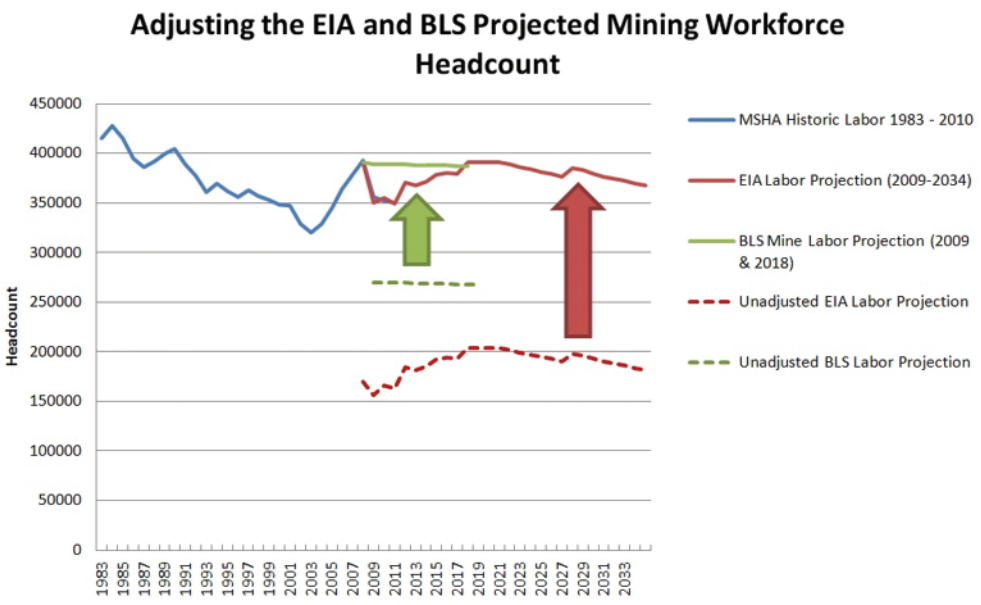


Figure B1
Adjusted BLS and EIS mining labor projections.

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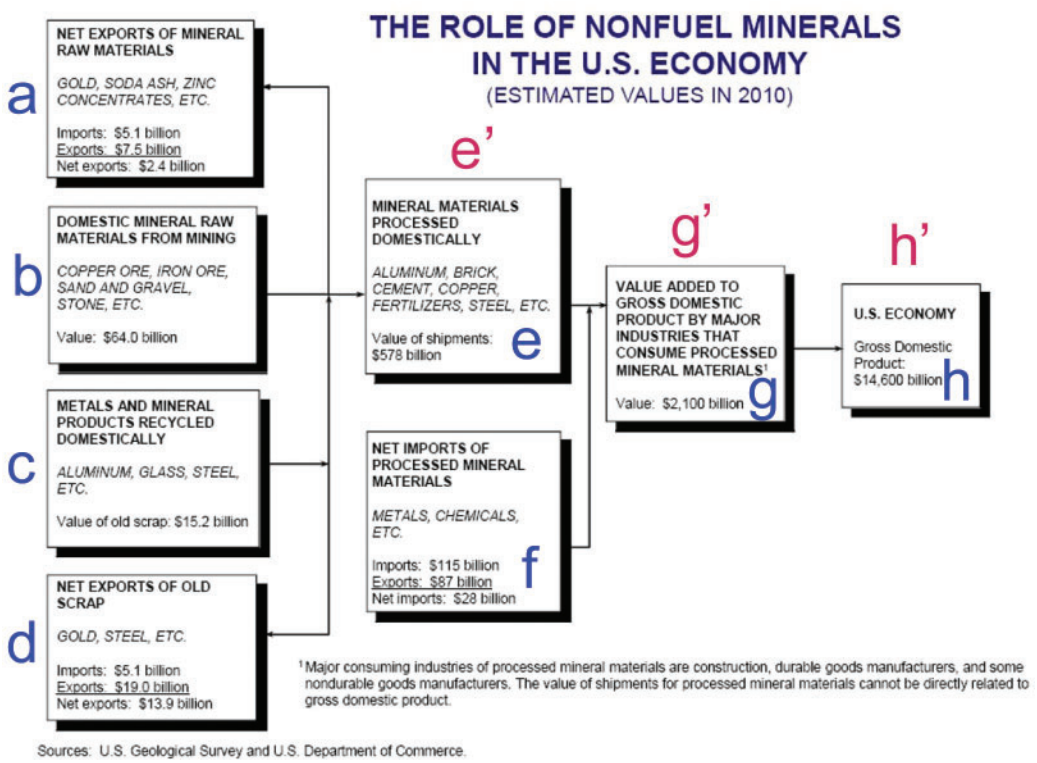
EXHIBIT C

Below is a mineral value flow diagram for 2010 produced by the U.S. Geological Survey as part of the Mineral Commodities Summary publication (published annually). Value flow diagrams are available for previous years and those from 2006 through 2010 were compiled to create the table "Domestic Mining's Impact on the U.S. Economy" [1] in the body of this paper.

Figure C1

Figure C1
2010 value chain for mining in the U.S. Economy. From the 2010 USGS Mineral Commodities Summary, annotated to identify components used in calculations.



As the study was interested in U.S. labor and production; recycled, scrap, and imported materials were excluded from the calculations and coal was added since it is considered to be within the study scope. Figure C1 was redrawn and recalculated (Figure C2)

Figure C2

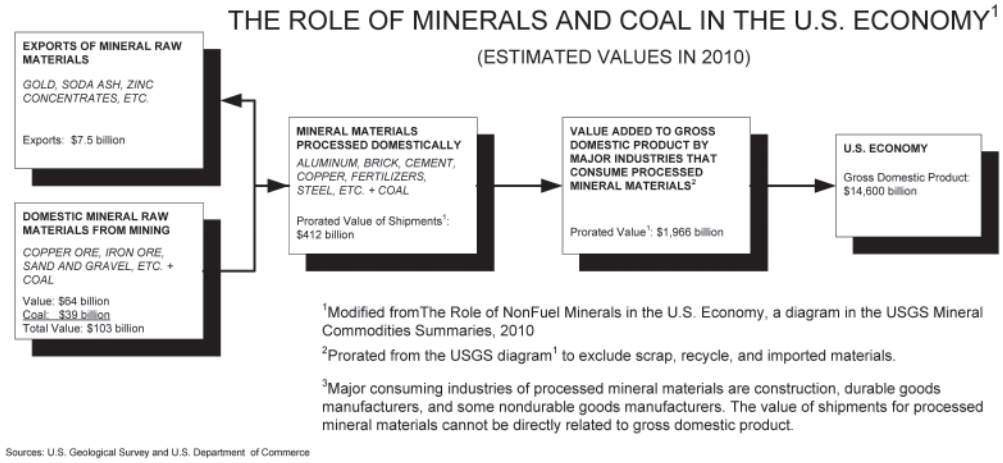


Figure C2
2010 value chain for mining in the U.S. Economy. Derived from the 2010 USGS Mineral Commodities Summary [1].

In order to complete the calculations, the 'Minerals Materials Processed Domestically' value of shipments was prorated using the sum of the 'Net Exports of Mineral Raw Materials' and the 'Domestic Mineral Raw Materials from Mining' over the total exported, mined, recycled, and scrap materials.

$$e'=e*((a+b)/(a+b+c+d))]$$

Similarly, the 'Value Added to Gross Domestic Product by Major Industries that Consume Processed Mineral Materials' value was prorated by the 'Minerals Materials Processed Domestically' over the sum of the processed materials and the imported processed materials.

$$g'=g*(e'/(e'+f))$$

To determine the GDP contribution, a ratio of the 'Value Added to Gross Domestic Product by Major Industries that Consume Processed Mineral Materials' to the 'U.S. Economy GDP' was calculated and applied to the calculated value of the 'Value Added to Gross Domestic Product by Major Industries that Consume Processed Mineral Materials'.

$$h'=g'*(g/h)$$

These calculations were performed for each year from 2006 through 2010 and are presented along with mining headcount and U.S. GDP in table 1 (main body of the study).

[1] 2006-2010 Mineral Commodities Summary, U.S. Geological Survey, p. 5 http://minerals.usgs.gov/minerals/pubs/mcs/2011/mcs2011.pdf

EXHIBIT D

The details of how the mine labor workforce was aged over a 20-year period appear below.

Table D1 below shows the results from BLS aging surveys for 2006 and 2009. For reasons noted in the data evaluation section of this paper, total labor, as counted by the BLS is significantly less than that calculated by MSHA (2006: 363,497 and 2009: 355,720) though the -2% change is similar to the -3% change in the BLS numbers over the same period.

There are two other notable points in table D1: the entry point for labor appears to be from 20 to 24 years and the exit point for labor is between 55 to 65 years. The shaded areas identify the classes of labor that will be exiting mining over the next 20 years.

Table 4

Table 4
BLS mining labor employment estimates by age group for 2006 and 2009 with percent of total labor for each group and a change comparison for the three year period. Shaded areas indicate the age classes expected to exit the industry over the next 20 years.

HISTORIC DATA (1)	2006(2)		2009(3)		3 YEAR CHANGE	
	MINING - (CONTRACTOR)		MINING - (CONTRACTOR)		MINING - (CONTRACTOR)	
	Labor (4)	Percent %	Labor (4)	Percent %	Labor (4)	Percent %
Total 16+	**239**	**100%**	**231**	**100%**	**-8**	**-3%**
16-19 Years	2	1%	3	1%	1	50%
20-24 Years	13	5%	10	4%	-3	-23%
25-34 Years	47	20%	40	17%	-7	-15%
35-44 Years	52	22%	52	23%	0	0%
45-54 Years	78	33%	71	31%	-7	-9%
55-64 Years	44	18%	49	21%	5	11%
65+ Years	4	2%	6	3%	2	50%

(1) Labor headcount does not include contractors
(2) 2006 statistics from BLS. Median age 45.0 (weighted average by sector) [1]
(3) 2009 statistics from BLS. Median age 47.2 (weighted average by sector) [2]
(4) Average labor headcount (thousands)
Source: Department of Labor, Bureau of Labor Statistics, Current Population Survey
Updated: January 2011 [1] [2]

General Case: The aging population and industry growth projections.

To understand how the mining labor pool will change over time, a table was prepared that advances the age classes in ten year increments starting with 2009 (Table D2). Two cases were prepared. In Case A, the labor lost is replaced so the overall labor remains the same. In Case B (Table D3), 10,000 new employees are added each 10 years based on the 10,000 in the existing 20-24 age class for 2009. The 16-19 and 65+ age classes were held constant. To reduce the complexity of the model it was also assumed that there were no defections or additions to the age classes over time.

It should be noted that "turnover", as it is used here, is the sum of people entering and exiting the industry.

Table D2

CASE 'A' (100% REPLACEMENT)	2009 (1) MINING - (CONTRACTOR) Labor (2)	Percent %	2019 (1) MINING - (CONTRACTOR) Labor (2)	Percent %	2029 (1) MINING - (CONTRACTOR) Labor (2)	Percent %
Total 16+	**231**	**100%**	**231**	**100%**	**231**	**100%**
16-19 Years	3	1%	3	1%	3	1%
20-24 Years	10	4%	49	21%	71	31%
25-34 Years	40	17%	10	4%	49	21%
35-44 Years	52	23%	40	17%	10	4%
45-54 Years	71	31%	52	23%	40	17%
55-64 Years	49	21%	71	31%	52	23%
65+ Years	6	3%	6	3%	6	3%

Labor by the end of:	2019		2029	
(a) Period Net Gain:	49		71	
(b) Period Net Loss:	49		71	
Balance (a-b)	0		0	
(d) Cumulative Labor Gain:	49	21%	120	52%
(e) Cumulative Labor Loss:	49	21%	120	52%
Balance (d-e)	0		0	
Period Senior Labor Loss	49	21%	71	31%
Cumulative Senior Labor Loss	49	21%	120	52%
Period Turnover (a+b)	98	42%	142	61%
Cumulative Turnover	98	**42%**	240	**104%**

(1) Labor headcount does not include Contractors
(2) Average miner headcount (thousands)

In Case A, the total labor force stays constant as 49,000 are added as 49,000 exits between 2009 and 2019. Another 71,000 are added as 71,000 exits between 2019 and 2029.

Table D2
Case A is a model with 100% replacement and no defection.

Table D3.
Case B is a model with 10,000 employees replaced and no defection.

Table D3.

CASE 'B' (LOW REPLACEMENT)	2009 MINING - (CONTRACTOR) Labor (2)	2009 Percent %	2019 MINING - (CONTRACTOR) Labor (2)	2019 Percent %	2029 MINING - (CONTRACTOR) Labor (2)	2029 Percent %
Total 16+	**231**	**100%**	**192**	**100%**	**131**	**100%**
16-19 Years	3	1%	3	2%	3	2%
20-24 Years	10	4%	10	5%	10	8%
25-34 Years	40	17%	10	5%	10	8%
35-44 Years	52	23%	40	21%	10	8%
45-54 Years	71	31%	52	27%	40	31%
55-64 Years	49	21%	71	37%	52	40%
65+ Years	6	3%	6	3%	6	5%

Labor loss by the end of:	2019		2029	
(a) Period Net Gain:	10		10	
(b) Period Net Loss:	49		71	
Balance (a-b)	-39		-61	
(d) Cumulative Labor Gain:	10	4%	20	9%
(e) Cumulative Labor Loss:	49	**21%**	120	**52%**
Balance (d-e)	-39		-100	
Period Senior Labor Loss	49	21%	71	31%
Cumulative Senior Labor Loss	49	21%	120	52%
Period Turnover (a+b)	59	26%	81	35%
Cumulative Turnover	59	**26%**	140	**61%**

(1) Labor headcount does not include Contractors
(2) Average labor headcount (thousands)

In Case B, the labor force shrinks when 10,000 employees are added as 49,000 exits between 2009 and 2019. Another 10,000 are added as 71,000 exits between 2019 and 2029. The 10,000 number was based on the number of people in the 20-24 age class in 2009.

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Note: Many references have associated internet addresses that were functional when this paper was published. Over time these addresses may change and no longer be accessible.

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Mr. Brandon is the President of Automated Systems Alliance, Inc. and has served in that position since 1989. In 2010 he led the acquisition of the ACIS® Business Development software system from Coemergence, Inc. In early 2009 he released the Open data Warehouse Model (ODWM) and an instance of the model for Project Control (PCDW). Mr. Brandon has also produced commercial products for Mineral Land Management (LIMS – Land Information Management), Drill Hole information Management and Document Control (ARS – Automated Retrieval System). Mr. Brandon has enjoyed many long term technology related engagements with Fortune 500/global 1000 companies including Rio Tinto, Kennecott Utah Copper, Newmont, and Agnico-Eagle Mining. Mr. Brandon began his career with Anaconda Minerals working as a field geologist exploring for precious and base metals.

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Society for Mining, Metallurgy, and Exploration
12999 E. Adam Aircraft Circle
Englewood, CO 80112

Toll Free: 1-800-763-3132 • Main Number: 303-948-4250
www.smenet.org

National Mining Association
101 Constitution Avenue, NW, Suite 500 East
Washington, DC 20001
202-463-2600

Industrial Minerals Association – North America
2011 Pennsylvania Avenue NW, Suite 301
Washington, DC 20006
202-457-0200

National Stone, Sand and Gravel Association
1605 King Street
Alexandria, VA 22314
703-525-8788