



**Statement before the Senate Health, Education, Labor, and
Pensions Subcommittee on Employment and Workplace
Safety**

***“Digging Deeper: Building Our Critical
Minerals Workforce”***

A Testimony by:

Gracelin Baskaran

Director, Project on Critical Minerals Security, Center for Strategic and
International Studies

**June 12, 2024
215 Dirksen Senate Office Building**

Chairman Hickenlooper, Ranking Member Braun, and distinguished Members of the Subcommittee, I am honored to share my views with you on this important topic. CSIS does not take policy positions, so the views represented in this testimony are my own and not those of my employer. In my testimony, I would like to reflect on how the workforce became a key impediment to reducing our reliance on China for key minerals required for national, economic and energy security. I will then look at potential solutions: how the United States can make existing tools, such as the Fulbright program, National Science Foundation, and the Infrastructure Investment and Jobs Act, better fit for supporting our minerals security needs, how we can support partnerships between mining companies and universities to attract young talent, and how we can leverage our military academies to help meet our workforce needs.

My name is Dr. Gracelin Baskaran. I am the Director of the Project on Critical Minerals Security at the Center for Strategic and International Studies (CSIS). I started in the mining industry 11 years ago, when the U.S. State Department awarded me a Fulbright Fellowship. Through my Fulbright, I spent a year in South Africa's platinum belt, including time in the mines, and saw the long-term value of the sector - both economically and technologically. I went on to do a PhD at the University of Cambridge on the platinum sector and later co-authored a book on leveraging mining, oil and gas for economic transformation amidst decarbonization. My career, which has taken me from the depths of mines in South Africa, such as Twickenham and Mogalakwena, to the halls of Washington DC, began with the Fulbright.

At CSIS, I now work to increase our economic and national security by reducing vulnerability in our supply chains for critical minerals. My work informs the White House National Security Council, State Department, Department of Energy, Development Finance Corporation, US Embassies globally, and bipartisan and bicameral members of Congress. My work also takes me to resource-rich jurisdictions around the world, where I work with industry players from 8 of the biggest Western mining companies by market capitalization, government officials from the United States, Middle East, Africa and Latin America, and members of civil society to understand how we can effectively build minerals security. This has given me perspectives that reflect the realities on the ground both domestically and internationally.

Background

Minerals are important for national, economic and energy security. Their strategic value to the United States motivated an active minerals policy in the 20th century. In 1910, the United States Department of Interior created the United States Bureau of Mines with the goal of overseeing domestic mining activities and securing a sufficient mineral supply. The Bureau supported scientific studies and knowledge sharing about mineral resource extraction, processing, utilization, and health and safety standards. In 1996, Congress voted to close the Bureau and decentralize some of its responsibilities amongst several other departments. A Department of Interior report published in 2023 noted that, "At the end of the 20th century, the United States lost its position as the global leader in mining, both in terms of total production and the development of cutting-edge mining technology."¹

¹ US Department of the Interior. Recommendations to Improve Mining on Public Lands. September 2023.

Over the last three decades, China has become a dominant player in the supply chains of minerals key to national and energy security. Even if it is a marginal producer directly, China finances and imports from the rest of the world to control 65 percent to 90 percent of global supply of key metals.² This concentration is the result of decades of industrial strategy and foreign policy from Beijing. It is also a strategic challenge for the United States, given the importance of strengthening national security and meeting energy needs while geopolitical tensions between the two countries rise. China has developed a robust workforce that has allowed it to develop an absolute advantage in these supply chains.

Rare earth elements, nickel, lithium, germanium and gallium are critical inputs for defense systems, including precision guided munitions, strategic nuclear applications and several missile classes, lasers that serve as range finders and target designators, military information communication technology, modern naval missiles, weapon systems, tanks, and radar modules. They are the backbone of national security. Copper, lithium, nickel, manganese, cobalt, graphite, zinc, and rare earth elements are necessary for meeting our global decarbonization goals by manufacturing and deploying offshore and onshore wind, stationary and electric vehicle batteries, solar photovoltaics (PV), nuclear power and natural gas.

The United States, and much of the globe, is most reliant on China for its critical minerals supply.³ Of the 50 minerals included in the 2022 Final List of Critical Minerals produced by the USGS, the United States had larger than a 50 percent reliance on imports for 31⁴⁵ and was wholly important reliant for 12. The United States is wholly reliant on China for 9 of them.⁶ China has already demonstrated a willingness to use export controls or quotas on critical minerals as a geopolitical tool.

The United States needs a strategy for reducing dependency and strengthening mineral supply. The last two administrations have set out to improve supply through better exploration, production, recycling, and reprocessing of critical minerals. In 2017, President Donald Trump issued Executive order 13817, to facilitate better management of critical minerals to strengthen energy security and executive prosperity. An output of this was an inter-agency report from the Secretaries of Commerce, Defense, Interior and Energy and the U.S. Trade Representative on critical minerals. One of the six calls to action in the report was to, “Enhance International Trade and Cooperation Related to Critical Minerals: [Identify] options for accessing and developing critical minerals through investment and trade with America’s allies, discusses areas for international collaboration and cooperation.”⁷ In 2021, President Biden issued Executive Order 14017 which ordered a review of vulnerability in the US critical mineral and material supply chain. Subsequently, a supply chain assessment was released by the administration that found over-reliance on foreign sources and adversarial nations for critical minerals and materials posed

² Baskaran, G. What China’s Ban on Rare Earths Processing Technology Exports Means. Center for Strategic and International Studies. January 8, 2024.

³ Stanford University. Assessing the U.S.-China Competition for Minerals Crucial to the Development of Emerging Technologies. October 1, 2023.

⁴ National Mining Association. U.S. Reaches Highest Recorded Mineral Import Reliance. January 31, 2023.

⁵ This includes 14 lanthanides, which are part of the rare earth elements group.

⁶ Department of the Interior. Recommendations to Improve Mining on Public Lands. September 2023.

⁷ US Department of Commerce. A Federal Strategy to Ensure Secure and Reliable Supplies of Critical Minerals.

national and economic security threats. The White House published its “Plan to Revitalize American Manufacturing and Secure Critical Supply Chains” in 2022, where it announced plans to increase domestic processing capacity of rare earth minerals, copper, nickel, lithium, and cobalt.

The Defense Logistics Agency (DLA) has a stockpile of 47 commodities worth more than \$1.5 billion. The stockpile was first established after World War 1. In February 2022, Congress authorized \$1 billion for the National Defense Stockpile to acquire strategic and critical materials to increase its buffer in the event of crises and disruptions in supply chains.⁸

Over the last few years, Congress also passed the Infrastructure Investment and Jobs Act (IIJA), the CHIPS and Science Act, and the Inflation Reduction Act (IRA), which authorized and provided over \$8.5 billion in funding for critical minerals activities.⁹ Specifically, the IRA seeks to prioritize domestic production of minerals. The Clean Vehicle Tax Credit and the Advanced Manufacturing Production Tax Credit of 2022 extend tax credits only to vehicles that meet threshold requirements for critical materials sourced domestically and from countries with which the United States has a free trade agreement. These tax credits and spending programs are uncoordinated and mostly focused on domestic mining and processing.

However, the domestic-only approach to critical minerals cannot work. Geologically, a significant share of the minerals we need are not located in the United States or economically recoverable here. The United States has less than 1 percent of the world’s nickel, cobalt, and graphite, 1.3 percent of the world’s rare earths, and 1.5 percent of the world’s manganese, which is a non-substitutable metal required for all steel production.

The United States ability to build both its domestic and international capacity in mining will require a skilled workforce, which we have a significant deficit for. A recent McKinsey survey revealed that 71 percent of mining leaders stated that human capital shortages are preventing them from reaching their production targets and strategic goals.¹⁰ We need mining engineers, geologists and geoscientists, metallurgists, geophysicists, economists, and senior management that we can deploy domestically and internationally. An analysis from CSIS notes:

“More than half the current domestic mining workforce will need to be retired and replaced by 2029 (roughly 221,000 workers). This number stands in stark contrast to the total of just 327 degrees awarded in 2020 in mining and mineral engineering and a 39 percent net drop in graduations in the United States since 2016. University programs tasked with creating this workforce have also been decreasing, with the number of mining and mineral engineering programs in the United States dropping from 25 in 1982 to 15 in 2023. This is in stark contrast to China, which has over 38 mineral processing schools and upwards of 44 mining engineering programs. Central South University, China’s largest mineral

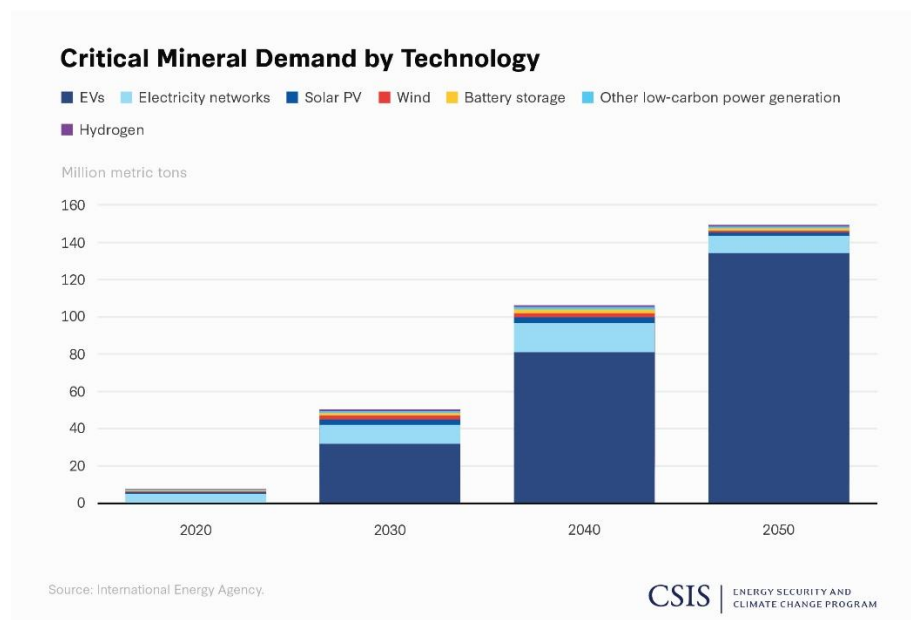
⁸ Barna, S., Hastings, A. and Pearce, M. 2023 NDAA Provides New Opportunities for Industry. National Defense Magazine. February 7, 2023.

⁹ Broberg, D. and Jacobs, J. Expanding Domestic Critical Mineral Supply Chains. Bipartisan Policy Center. March 15, 2023.

¹⁰ Has mining lost its luster? Why talent is moving elsewhere and how to bring them back. February 14, 2023.

processing program, has 1,000 undergraduates and 500 graduate students alone ready to accomplish China’s mineral ambitions.”¹¹

As the graph below shows, without this, we will not be able to meet future minerals demand, which will grow significantly over the next 30 years, largely driven by clean energy technology. In 2020, the world needed approximately 8 million metric tons of minerals for the deployment of clean energy technologies - electric vehicles, electricity networks, solar and wind technology, battery storage, low-carbon power generation and hydrogen. In 2030 – just six years from now – we will need roughly 50 million metric tons – over a six-fold increase. In 2040, this increases to about 105 million metric tons – a thirteen-fold increase from 2020. And by 2050, we will need about 150 million tons - nearly a 19-fold increase. Training a workforce to meet future demand is imperative and it requires efforts that begin as soon as possible.



Addressing the Workforce Shortage

Repurposing Existing Instruments to Build the Mining Workforce

The Department of Interior report published in 2023 noted that, “A lack of educational programs for building expertise in mining and mining oversight and a lack of interest in mining among the cohort of students who will become the managers of tomorrow compound a shortage of properly trained workers.”¹²

My dad is the Chair of the Geology Department at Wayne State University in Detroit. As I’ve built my own career in the mining industry, we have discussed how geology, environmental

¹¹ Hale, T. The United States Needs More than Mining Engineers to Solve Its Critical Mineral Challenges. May 8, 2023.

¹² US Department of the Interior. Recommendations to Improve Mining on Public Lands. September 2023.

science and engineering graduates in the United States are not moving to the mining sector. The United States needs to support embedding mining workstreams into geology and engineering programs. The need to build a mining workforce is a more recent priority – so few programs have historical depth here. Catching up in this area will require a significant increase in capacity building and financing. This is for two reasons. First, academic programs largely succeed or fail based on available funding – particularly for research and scholarships. Second, there is often a lack of expertise to build these programs. This will require bringing in both skilled industry experts and faculty from mining programs around the world to cross-pollinate knowledge and build these programs – in particular Australia and Canada have deep academic expertise in the mining sector. The 2024 QS World University Rankings for mineral and mineral engineering show that one out of the top 12 programs in the world are American – Colorado School of Mines. Of the other 11, there are four in Australia and Canada and one in Russia, Chile and Saudi Arabia.¹³

A key solution to achieving these two goals is to make existing mechanisms better fit for mining workforce development. With that in mind, I can make three suggestions:

The first is creating a dedicated Fulbright program for mining, minerals processing, and recycling. There are already a number of Fulbright programs – the Fulbright Arctic Initiative, the Fulbright Hays Program for K-14 teachers and administrators, Fulbright United States Scholar program for United States scholars and artists, Fulbright European Union Scholar-in-Residence (EUSIR) Program to strengthen United States expertise in European Affairs, and Fulbright Specialist Program to send U.S. faculty abroad to serve as expert consults and do faculty development, amongst others. A Fulbright program for mining to bring mining experts and faculty to the United States and send undergraduate and graduate students to top mining institutions abroad offers a real opportunity to both establish and expand mining programs in the United States and allow our students, particularly in STEM-related mining fields, to develop the necessary skills and knowledge to enter the modern minerals workforce.

The second is increasing targeted funding to the National Science Foundation (NSF) for mining-related research and capacity building. The NSF is an independent federal agency that supports science and engineering in all 50 U.S. states and U.S. territories. In 2023, the NSF’s enacted budget was \$9.9 billion, and they supported over 2,000 organizations in every state and US territory.

- The NSF has 15 focus areas – ranging from the arctic and Antarctic to astronomy and biology. Chemicals and materials are perhaps the closest to the mining sector – but it’s still not fit to building mining expertise. The objective of this effort is “breakthroughs in chemistry and materials science that enhance nearly every aspect of daily life, from pharmaceuticals to plastics, environmental cleanup to battling pandemics.” Mining is notably absent.¹⁴

¹³ QS World University Rankings by Subject 2024: Mineral & Mining Engineering.
<https://www.topuniversities.com/university-subject-rankings/mineral-mining-engineering>

¹⁴ The full list of focus areas include the arctic and Antarctic to astronomy and chemistry and materials, computing, diversity in STEM, earth and environment, education and training, engineering, facilities and infrastructure, mathematics, people and society, physics, research partnerships and interdisciplinary convergence and transformative research.

- The NSF also has 11 technology focus areas – ranging from artificial intelligence to biotechnology and cyberinfrastructure.¹⁵ Advanced materials are closest to the mining industry and the institution notes that “NSF invests in the discovery of new materials and processing methods that can unlock innovations across a wide range of sectors — such as medicine, agriculture, electronics, manufacturing, energy and national security.” Mining is inadequate in this program.
- Mining remains vastly underfunded by the NSF – just 9 of 815 – or 1.1 percent of active grant opportunities are for minerals.

The CHIPS Act of 2022 (Section 10359) authorized funds for the NSF to increase its work on critical minerals mining and development.¹⁶ It includes provisions for institutions of higher education or nonprofits to offer training and research opportunities to undergraduate and graduate students, preparing the next generation of mining engineers and researchers. Funding for these programs has not been appropriated and could be included in the appropriations legislation for fiscal year 2025.

And third, widen the sectoral scope of section 40211 of the IJA which mandated that the Department of Energy create a 21st Century Energy Workforce Advisory Board to evaluate the requirements of the domestic energy workforce. The Board has also been mandated to develop strategies to provide opportunities for students to qualify to work in the energy sector and identify avenues for the Department of Energy to work with federal agencies and nongovernmental organizations to drive.¹⁷ It is crucial for this program to go beyond an energy workforce and examine the needs of the mining workforce since the mining sector is essential for the implementation of nearly all new energy technologies. Without upstream support, the downstream renewable energy development will be impossible.

Partnerships Between Mining Companies and Universities

According to the Bureau of Labor Statistics, the median age of a worker in the United States mining industry is 42, which underscores the need to attract younger generations.¹⁸ There needs to be a fundamental rebranding of the mining industry. The report published by the United States Department of the Interior - Recommendations to Improve Mining on Public Lands - in 2023 notes that “The mining industry is having difficulty attracting young professionals and building a workforce. One major obstacle appears to be the negative public perception of the industry.”¹⁹ There are two key areas for rebranding.

The first is that the industry is that the industry is tech-based. The modern mining industry is no longer one that uses picks and wheelbarrows – it runs on satellite imaging, artificial intelligence,

¹⁵ The full list of the NSF’s 11 technology focus areas is advanced manufacturing, advanced materials, artificial intelligence, biotechnology, communications and wireless, cyberinfrastructure and advanced computing, cybersecurity, disaster risk and resilience, energy technology, quantum information science and technology, semiconductors and microcolonies

¹⁶ H.R.4346 - Chips and Science Act. <https://www.congress.gov/bill/117th-congress/house-bill/4346>

¹⁷ Energy and Minerals Provisions in the Infrastructure Investment and Jobs Act (P.L. 117-58). Congressional Research Service. <https://crsreports.congress.gov/product/pdf/R/R47034>

¹⁸ Labor Force Statistics from the Current Population Survey. <https://www.bls.gov/cps/cpsaat18b.htm>

¹⁹ United States Department of the Interior. Recommendations to Improve Mining on Public Lands. September 2023.

advanced analytics, automation, robotics, and manufacturing 4.0. I've been to various mines that are entirely run out of what resembles a mission control room – blasting, production, and transportation of minerals.

Second, significant advances have been made in further improving the environmental and social impacts of mining. Responsible mining is a core focus area for nearly all Western companies. The mining industry has a goal of zero fatalities and zero injuries, amongst a range of other Environmental, Social and Governance targets. In the United States, injuries in mines have been reduced by 58 percent over the last 15 years while fatalities have decreased by 55 percent during that same time window.²⁰ Globally, institutions like the International Council of Minerals and Metals (ICMM), a key industry association for responsible mining, have worked with their members to improve human rights, health and safety, environmental performance, conservation of biodiversity, and social performance. Earlier this year, the ICMM, Mining Association of Canada, World Gold Council and Copper Mark launched a process to create a consolidated global standard for responsible mining.

This means that mining is more technology-based and responsible than ever before. From a financial perspective, there is incentive for young people to go into mining. The average annual salary for a miner in 2023 was \$94,848 – which is well above the United States average wage of \$72,609. This means that the average worker in the mining industry makes 31 percent more than the national average.²¹ Furthermore, as the shortage of workforce grows, supply and demand dynamics should drive wages up further.

It is in the interest of mining companies to build their workforce, particularly with young people. Establishing a federal program to coordinate collaboration between mining companies and universities to strengthen the development of the mining workforce, particularly in STEM fields, enhance research and promote innovation in the industry.

Mining companies can provide curriculum support to reflect the latest industry trends and technological advancements and experts working in the mining sector can deliver guest lectures and conduct workshops to give students field experience and share practical knowledge. Mining firms can also provide internships and co-op programs so students can get paid hands-on experience ahead of graduation, for an easier and more experienced transition to the workforce.

Another key avenue of support for the mining sector is by providing scholarships to students. This has long been used in other mining jurisdictions. For example, in South Africa, where I worked for seven years, companies like Anglo American have financed many students over the years on the condition that they come back and work for the company after graduation. This is particularly useful to encourage socioeconomically disadvantaged students – who are often underrepresented in the industry – to enter the field, thereby supporting diversity efforts.

Leveraging U.S. Military Academies to Build Tomorrow's Leaders

The primary purpose of U.S. military institutions including the United States Military Academy, United States Naval Academy, United States Air Force Academy, and United States Coast

²⁰ National Mining Association. Improving Mine Safety and Health. <https://nma.org/category/safety-and-health/>

²¹ National Mining Association. Annual Mining Wages vs. All Industries, 2023. https://nma.org/wp-content/uploads/2023/06/annual_mining_wages_state_23-1.pdf

Guard, amongst other institutions is to build future military leaders. Academy-trained engineers built the railroads and bridges for westwards expansion and were instrumental in the Industrial Revolution. It's time to enable them to answer the call for another national security challenge.

I was privileged to speak at West Point on critical minerals in February 2024. Lieutenant General Jonathan Braga – who is serving as the commanding general of the United States Army Special Operations Command – provided the keynote for the event. The interest from cadets afterward was clear. They are our future leaders – they will go on to be political leaders, cabinet members, ambassadors, and even mining executives that can advance United States mineral interests.

Mining executives have a key role to play in advancing strategic mining objectives, including talent development and pursuing national security goals. They require an understanding of engineering, diplomacy and strategy. There is a clear need to develop a workforce that is capable of leading mining companies. There are only two American CEOs of large market cap mining companies that I'm aware of – Richard Adkerson at Freeport McMoRan and Bob Wilt, an American West Point graduate and Army veteran from the Gulf War. After a long career at Alcoa, an American company, Bob is now the CEO at Ma'aden, one of the fastest growing mining companies in the world. The experience he gained in engineering, diplomacy and strategy at both West Point and his subsequent military career has been valuable. Scaling up the number of American mining executives is critical if we are to build U.S. leadership in the mining sector – and our military academies are an excellent place to do this.

At CSIS, we are planning the first national security and critical minerals summit, which will be held in October. Our speakers will include many West Point alumni - former U.S. cabinet members, ambassadors and a mining executive. Our goals are two-fold. The first is to give cadets much needed exposure to the importance of critical minerals and what careers in the mining industry look like. The second is to give faculty more exposure to critical minerals issues, which the United States has disregarded for the last 30 years. Upscaling support to initiatives like this is key.

Conclusion

The future of meeting American minerals security needs will require both domestic and international mining given the distribution of resources. In my conversations with industry, workforce shortages are universally cited as limitation. The United States may have closed its Bureau of Mines in 1996 – but investing in workforce development must be a priority to reduce our reliance on China. Without an adequate supply of mining engineers, geologists and geoscientists, metallurgists, geophysicists, economists, and senior management that we can deploy domestically and internationally, China will continue to have the upper hand, leaving our national, economic and energy security highly vulnerable to disruption.