MINES MAGAZINE
For Colorado School of Mines Alumni and Friends ▲ Fall 2025

A MINE FOR THE FUTURE

Once exclusively a practical training site for mining engineers, the Edgar Experimental Mine now serves as a vibrant space for education, research and innovation across disciplines.

PLUS:

Mines alumni share their experiences with unique campus visits, volunteering, mentorship and more.

The Campaign for MINES@150 breaks records while paving the way for the university's next chapter.

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Graduating with an engineering degree can take you far. For George Saunders ’81, it took him to the bestseller list. Celebrated author, Booker Prize winner and *New York Times* bestselling writer of *Lincoln in the Bardo, Tenth of December* and other titles, Saunders is known for his short stories and novels on life and what it means to be human. He also holds a bachelor’s degree in geophysics from Mines. He returned to campus this fall to speak as part of the William H. Erickson Distinguished Lecture Series.

Saunders answered five questions from students during his visit. Read the questions and his answers on **minesmagazine.com**.

Follow Mines on social media for more great shots of the Mines community and to keep up with everything happening with your fellow Orediggers.

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COLORADO SCHOOL OF MINES

A MINE FOR THE FUTURE

The Edgar Experimental Mine has evolved from a hands-on home for mining engineers to a multidisciplinary hub for education, research and innovation. **18**

On the cover: Geological engineering student Lanie Smith scans a supported rock face in the Edgar Experimental Mine during field session. The students also took samples and fed the data gathered into a model to create a 3D model of the area they were mapping.

A macro view of copper, one of the critical minerals essential to technology, energy and modern life.

Many people rarely think about the materials that make modern life possible—rare earths, lithium, cobalt and other critical minerals that power smartphones, satellites, energy systems, medical devices, defense technologies and more. With global demand surging and supply chains growing increasingly complex, securing these resources—and providing a skilled workforce to address these challenges—has become an urgent priority.

Mines has been preparing for this moment for 150 years. Faculty, students and alumni are leading every step of the critical minerals supply chain, from discovery and extraction to processing and policy development, while simultaneously developing the next generation of leaders who will tackle these challenges head-on.

This issue of *Mines Magazine* touches on the many ways in which Orediggers are shaping the future of critical minerals and mining. Read about the researchers who are providing expertise on how to recover critical minerals domestically. Explore the research questions students are investigating to provide actionable insights that inform effective decision making in the global critical minerals landscape. Get an overview of how the redevelopment of the Edgar Experimental Mine is helping expand research and learning across disciplines. Then read about how alumni and faculty are helping shape national policy through expert testimony and thought leadership.

Throughout this work is the same spirit that has always defined Mines: collaboration, innovation and a commitment to solving real-world challenges. It's how Orediggers continue to lead—by solving today's problems while creating the innovations and workforce that anticipate tomorrow's needs.

→ Explore how Mines is leading innovation in critical minerals at **mines.edu/critical-minerals-research.**

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DRIVING THE CRITICAL MINERALS CONVERSATION

Orediggers are helping the nation reimagine its approach to vital resources

Critical minerals are the focus of many national discussions. They are central to energy systems, defense technologies, medical devices, consumer electronics and the broader economy. It's clear that the U.S. relies too heavily on international supplies and processing capabilities and developing supply chains with foreign allies.

To do this, the U.S needs new policies, new financial models, more cost-effective technologies—and we need to grow a specially trained engineering workforce.

Mines is actively engaged in these national conversations. We have unique expertise that spans technology, science, policy and economics. We have a history of producing the type of graduates that are needed for this type of situation, and we have a network of alumni and industry partners that cannot be matched by any other university.

As you'll read in several stories throughout this issue, Mines' expertise across geology, mining, separations, materials science, economics, policy and more makes us uniquely equipped to help the U.S. meet its need for sustainable and secure critical minerals supply chains. Just in the past few months, our faculty, students and the Payne Institute for Public Policy have identified previously unexplored sources, they have convened key stakeholder meetings, they have published valuable reports and an editorial in the national press, and they have testified before Congress.

In addition, industry and government are looking to Mines to lead in preparing the next generation of engineers, scientists and policymakers who will shape how critical minerals are sourced and used for decades to come.

Our alumni are key to accomplishing this. You are encouraging, supporting and actively engaged in these efforts. Your input on where to prioritize our efforts, the sharing of your experiences and perspectives with students and faculty, and your participation in the meetings we convene and in our academic programs is a real difference maker. You are helping ensure that Mines is positioned and viewed as a leader in national and global efforts related to critical minerals. Thank you for that. Please stay engaged. Help us stay out in front.

Go Orediggers!

Paul C. Johnson
President and Professor

GAME CHANGERS

From record-setting athletes to a trailblazing team, the Oredigger Hall of Fame's new inductees continue Mines' proud athletic tradition

Since 1998, the Harry D. Campbell Oredigger Hall of Fame has celebrated the student-athletes, coaches and teams whose talent, dedication and impact has left a lasting mark on Oredigger athletics. The Class of 2025 recognizes standouts across football, volleyball, men's basketball and women's soccer.

JOE BUTKOVICH '72 • MEN'S BASKETBALL

Mines Basketball's first All-American, Butkovich was a prolific scorer and rebounder. He graduated as the Orediggers' all-time rebounding leader with 891 and ranked third on Mines' all-time scoring list with 1,641 points. More than 50 years after graduating, he still owns Mines' career and season per-game rebounding records of 11.7 and 12.3 rebounds per game, respectively. After tryouts with the Denver Nuggets and Chicago Bulls, Butkovich played professionally in Europe before building an engineering career largely focused on dismantling chemical weapons across the United States.

JUSTIN DVORAK '16 • FOOTBALL

One of the most prolific quarterbacks in NCAA Division II history, Dvorak rewrote the Mines and RMAC record books. The 2016 Harlon Hill Trophy winner set career records with 13,466 passing yards, 134 touchdowns and 14,608 total offense. His senior season remains legendary, leading the division with 4,584 passing yards and 53 touchdowns, while guiding Mines to the RMAC title. Dvorak is now a drilling engineer with Hess Corporation and serves on Mines' Petroleum Engineering Program Advisory Board.

EMILY GARNIER '17 • WOMEN'S SOCCER

A three-time All-American, Garnier led Mines Women's Soccer through its most successful stretch, including three consecutive RMAC regular-season and tournament championship doubles and the NCAA South Central regional titles in 2014 and 2016. Mines qualified for the NCAA Tournament four times during her career. Garnier graduated as one of the most-awarded players in Mines soccer history, earning three consecutive RMAC Defensive Player of the Year Awards, the 2016 RMAC Player of the Year honor, five all-America honors and was the 2016 D2CCA Regional Player of the Year and Colorado Sportswoman of the Year for soccer. After retiring from a professional soccer career, Garnier now works as a business analyst for Epilog Laser in Golden, Colorado.

DANIELLE JOHNSON-HAZLEWOOD '16 • VOLLEYBALL

One of Mines Volleyball's most decorated student-athletes, Johnson-Hazlewood was the engine of the program's rise to prominence. A three-time All-American, she remains the only player in RMAC history to win both Setter of the Year and Player of the Year in back-to-back seasons. She helped deliver four straight RMAC regular-season titles and the program's first tournament crown, while finishing her career as Mines' all-time assists leader at 5,375. She now works as a structural engineer and architect while coaching club volleyball in Texas.

2014 WOMEN'S SOCCER TEAM

The first Mines program to reach a NCAA national semifinal in a bracketed national tournament, the 2014 women's soccer team was the program's first to win three trophies, capturing the RMAC regular-season championship, the RMAC Tournament championship, and the NCAA South Central regional crown. The team had a heart-stopping postseason with three penalty-kick advancements, including in the RMAC Tournament final, in the regional final and in the national quarterfinals. Their final national ranking of No. 4 is tied for the highest in program history.

TOP NEWS AT MINES

→ Keep up with the latest Mines news at **minesnewsroom.com**.

VILLAGE AT MINES PARK OPENS

Mines more than doubled its on-campus housing for graduate and upper-division undergraduate students with the opening of the newly redeveloped and renovated Village at Mines Park. Located off 19th Street on the west side of U.S. 6, the $151 million student housing project increases the bed count at Mines Park from 495 to 1,058.

Here's what's included in the reenvisioned apartment-style community:

- Five new apartment buildings with a mix of studio, two- and four-bedroom units
- 19 smaller apartment buildings that were renovated from top to bottom
- Café
- Fitness center
- Indoor and outdoor common spaces for gatherings and studying
- Walking paths
- Playground
- Ore Cart shuttle to the main Mines campus

"We are thrilled to welcome student residents to the Village at Mines Park. Residents will enjoy the independence of apartment living while also benefiting from the amenities and supports that the university designed specifically to meet Mines students' needs," said Braelin Pantel, vice president of student life.

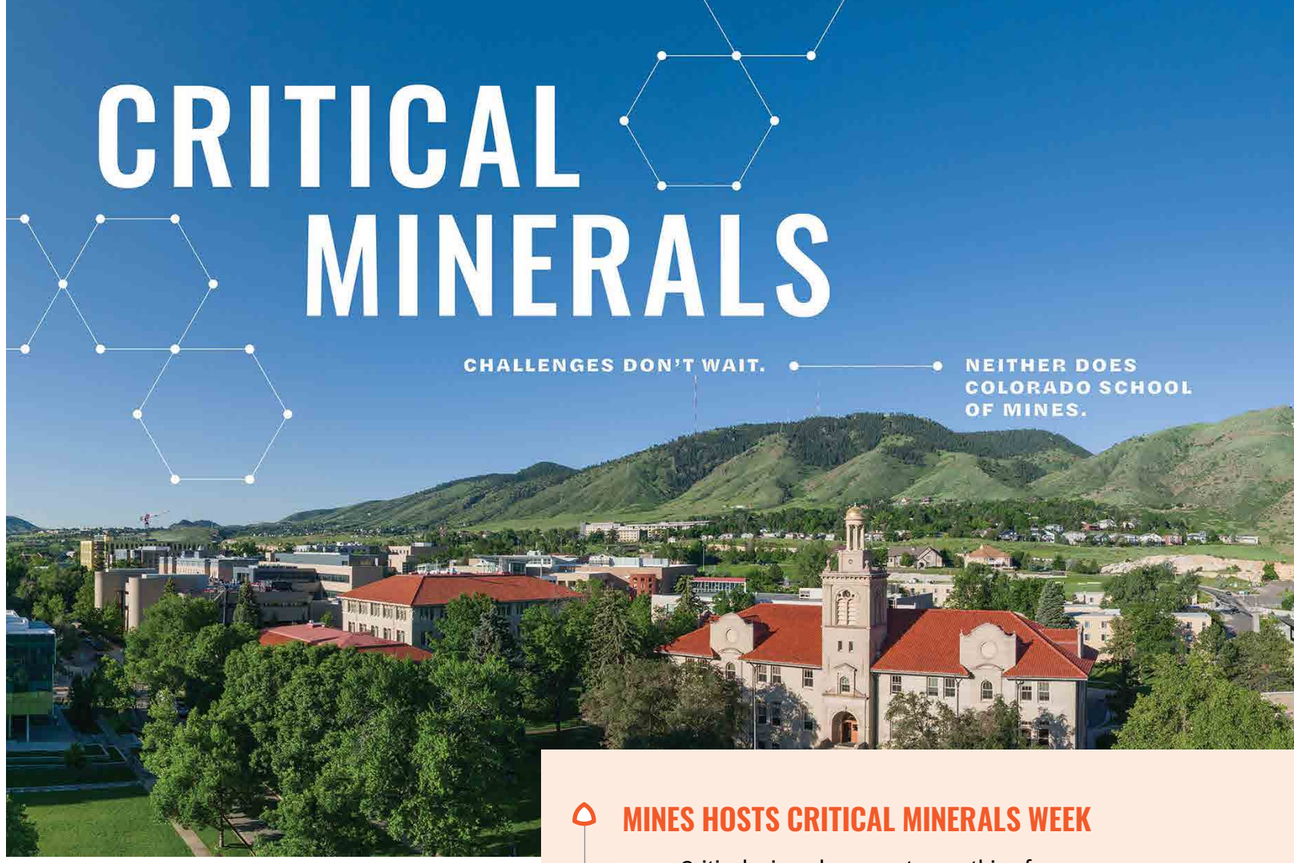
The Village at Mines Park is the first of two major investments in Mines student housing set to open over the next year. In Fall 2026, an 800-bed apartment-style building on 19th Street across from the Starzer Welcome Center will welcome its first residents, allowing Mines to house its sophomore class on campus.

MINES TEAMS RISE TO THE TOP

In just the past few months, Mines students have excelled across disciplines, showcasing their ingenuity, teamwork and leadership at national student challenges and competitions.
Here are a few highlights:

A team of Mines students, working alongside automotive technology students from Arapahoe Community College, is in the third and final year of the Battery Workforce Challenge, sponsored by the U.S. Department of Energy and global automaker Stellantis. The team is electrifying a 2024 Ram ProMaster EV van. After winning Year 1 and placing fourth out of 12 teams in Year 2, the group has moved from design to hands-on manufacturing and testing while also engaging with local youth through STEM outreach programs. The team is building technical, leadership and collaboration skills as it prepares for the challenge's final phase—integrating a fully functioning battery pack into the van next year.

Mines' surveying team clinched third place in the 2025 National Utility Engineering and Surveying Institute (UESI) Surveying Competition, part of the ASCE Civil Engineering Student Championships hosted at California Polytechnic State University from June 27 to 29. The finals drew 19 qualified teams from across the U.S., Canada, China and India. Mines also fielded teams in Concrete Canoe (placing 15th) and Sustainable Solutions (placing 19th). At the ASCE Region 7 Rocky Mountain Student Symposium, held April 10 to 12 at Colorado State University, Mines took home four first-place wins, placed second in two others and were recognized as the Overall Symposium Champions.



The Mines Rocket Club's two-stage rocket, Fever Dream, soared to 43,476 feet over the Mojave Desert this year—earning the club a place among the top ten highest flying universities worldwide with staged rockets. The rocket was part of a multi-year "Space Shot" project, which aims to send a rocket above the Kármán line at 100 kilometers using commercially available motors.

MINES HOSTS CRITICAL MINERALS WEEK

Critical minerals support everything from energy and advanced technology to national defense and healthcare. Yet every deposit presents distinct challenges—whether in discovery, extraction, processing or responsible sourcing and distribution—also complicated by economic, geopolitical and social dynamics that shape impacts on people worldwide. For more than 150 years, Mines has led the world in tackling this complexity across the full lifecycle, from exploration to policy.

This September, Mines hosted a dynamic week of events exploring the future of critical minerals, featuring industry collaboration, research presentations and thought leadership across the field.
Events included:

- CASERM fall industrial advisory board meeting
- Research and Technology Transfer-sponsored critical minerals poster session and social event
- Mineral Waste-to-Market Opportunities: Waste as a Resource Special Session, hosted by the Payne Institute for Public Policy
- Payne Institute Critical Minerals Symposium hosted by the Payne Institute for Public Policy
- Good Neighbor Agreement panelist meet and greet
- Denver Mineral Exploration Symposium, hosted at Mines

Blue Key students are responsible for managing Blaster while he's on campus, monitoring the public's interactions with him to make sure both the people and burro have a positive experience, answer any questions and take photos. They also run with him on the football field and care for him on the sidelines in between touchdowns at home games.

A CENTURY OF SERVICE AND LEADERSHIP

Mines' Blue Key chapter turns 100, celebrating a legacy of tradition and Oredigger spirit

BY ASHLEY SPURGEON

They're the Orediggers who keep the "M" on Mount Zion bright. They're the ones running down the football field alongside Blaster every time Mines scores a touchdown. They're the students who safeguard some of Mines' longest-standing traditions and keep the Oredigger spirit alive. For 100 years, Mines' chapter of Blue Key Honor Society—one of the oldest in the United States—has embodied that spirit, championing leadership, integrity and service.

Founded as an effort to boost school pride (primarily through a litany of pranks that have become university lore), Mines' Blue Key chapter has become a campus mainstay. Today, members are stewards of signature pieces of the Oredigger experience while developing leadership skills and engaging in service opportunities that extend well beyond their time at Mines. Along with maintaining the "M" and caring for Blaster when he's on campus, the group publishes the *Prospector* yearbook and sparks Oredigger pride at football tailgates and other campus events. Membership is also selective: Students must be in the top third of their class academically and have been enrolled at Mines for at least two years before they can join.

Being part of Blue Key gives students a chance to step beyond their usual circles and plug into the heart of campus life. That's one of the things Connor Dunfee, the organization's current M Chair, values most. "The work we do brings everyone together to participate in the traditions of Mines," he said. "I've met so many wonderful people outside of my major and class because of Blue Key."

For many, that sense of community is only one small part of the Blue Key experience. The leadership experiences students gain often prove to be invaluable long after they've graduated. Michelle Applegate '05 credits her time in the organization as a foundational part of her journey into public service and leadership. She has spent her career in the energy and utilities industry but also serves on the Jefferson County Public Schools Board of Education and participates in other service roles.

Blue Key members maintain the "M" on Mt. Zion, ensuring it shines bright year-round. They also help rearrange the lights into a unique design that aligns with the annual Homecoming theme. Last year, Blue Key helped arrange the lights in a design that celebrated Mines' 150th anniversary.

"When I got out of college, it helped to solidify what has meaning and impact, and it's important to continue to do acts of service, small or large, in the community," she said. "That, for me, really set me on a course of all kinds of board work and service outside of a core job. I don't think I would have done any of that had it not been for the foundation of Blue Key."

Applegate said the organization planted those seeds of service early. "The treasure of Blue Key is that it teaches you about service at an age where it's easy to serve because you're doing things like Mines Activities Council and student government. You're doing things like taking care of the M, which is a cherished symbol at that time in your life. It almost disguises service as a really fun way to do something cool and be involved and use your time, talents and treasures in ways that benefit your school," she said. "But what it's really doing is wiring you to say, this is something that is important. I'm taking care of something and I'm preserving something and I'm making sure that I'm leaving an organization better than when I entered it."

Dunfee echoes that sentiment. "Blue Key presents a lot of opportunities to practice being a leader in so many ways," he said. "For me personally, I've become much more confident. I've also better understood what style of leadership works best for me, and more importantly, how it can be channeled to best serve others."

> "WHEN I GOT OUT OF COLLEGE, IT HELPED TO SOLIDIFY WHAT HAS MEANING AND IMPACT, AND IT'S IMPORTANT TO CONTINUE TO DO ACTS OF SERVICE, SMALL OR LARGE, IN THE COMMUNITY,"
>
> -Michelle Applegate '05

"Blue Key has helped me realize how important it is to put others first," Dunfee continued. "Especially from my experience on the executive board, seeing the dedication and drive of my peers has really pushed me to work harder in all facets on my life each and every day, both at Mines and beyond."

Applegate remembers feeling that same pull as a student. "Blue Key brought people in, welcomed them in, taught them how to be leaders, what it meant to run a meeting and why it was important to keep it going and carry on the traditions but also recognizing new ideas," she said. "It was just a really great, welcoming community from a huge cross-section of the campus, and it was a lot of fun. I got sucked in by the fun and then I stayed because it felt really good."

BRINGING CRITICAL MINERALS STATESIDE

BY SARAH KUTA

Mines researchers are leading key collaborations that will help inform the United States' domestic critical minerals production

Critical minerals are in "just about everything we use," according to Elizabeth Holley, a Mines associate professor of mining engineering. From our laptops and cell phones to the transmission lines that deliver electricity to our homes, these naturally occurring compounds have become a major part of our daily lives—likely without us even realizing it.

However, many critical minerals are difficult to obtain—or could become so in the future—because they are extracted and processed in other countries. Against the backdrop of the world's ever-shifting geopolitical landscape, the nation's industry and government leaders are exploring the possibility of producing more of these minerals domestically.

Making this shift will be challenging, but Mines researchers are confident it can be done. Experts in everything from metallurgy to anthropology are teaming up to chart a path forward for critical minerals in the U.S.—work that will likely have major implications for national security, the economy and the environment.

INTERDISCIPLINARY, CROSS-CAMPUS COLLABORATION

The U.S., like many other countries, maintains a list of critical minerals—those considered essential to the nation's economy or security and at high risk of supply chain disruption. The current lineup is expansive, covering "more than half of the periodic table," said Holley, one of the Mines researchers leading the charge to help the U.S. produce more of its own critical minerals.

Mines researchers have been studying critical minerals for years. But those efforts ramped up roughly five years ago, when the university, in partnership with Fort Lewis College, was awarded a grant from the National Science Foundation's Growing Convergence Research program. Since then, this interdisciplinary team, led by Holley and Nicole Smith, a cultural anthropologist in the Mining Engineering Department, has received nearly $9 million in funding for a portfolio of related projects.

THREE PATHWAYS FOR DOMESTIC PRODUCTION

The Mines team is working on a suite of different projects to understand the issue from every possible angle.

"All of our projects examine the technical, as well as the social, environmental and policy considerations, of increased domestic production of critical minerals," said Holley. "What does responsible mineral production look like? What are some of the challenges? Where are the opportunities? Where are the bottlenecks and supply chain risks?"

They are also looking into the economics of critical mineral production, to understand whether the practice is financially viable in the U.S.—and, if not, what types of incentives might be introduced to make it so.

Their research focuses on different minerals and sites, but they all fall under three possible pathways for ramping up U.S. production: new mines, byproduct recovery and mine waste.

Some case studies relate to the development of new mines, or operations created specifically to extract critical minerals. In Idaho, for example, Mines researchers are investigating the possibility of mining cobalt by looking at the mineralogy of the deposits, where and how these elements could be recovered and how the proposed activities intersect with global supply chains and the priorities of communities and local economic development organizations.

Researchers are also considering byproduct recovery, or trying to get more critical minerals out of existing, active mines. New research led by Holley finds that the U.S. could drastically reduce or even eliminate most of its critical mineral imports if mining companies extracted more critical minerals from already mined ore.

"The geological endowment is there, it's just that it's not economically viable to recover these minerals—so, the next question is, what do we need to do to change that?" said Holley.

Mines PhD student Karlie Hadden MS '24 weighs out a sample of sparamine concentration to run through a RO-tap machine.

The third angle they're exploring is mine waste. This involves recovering critical minerals from tailings, or the leftover materials after a mining company has extracted its target product. For example, some Mines researchers are trying to figure out how to recover copper from a wastewater treatment plant near Idaho Springs, while others are investigating the possibility of recovering zinc and other critical minerals from tailings at active and abandoned mines across the country.

COMMUNITY SUPPORT AND SOCIAL ACCEPTANCE

Regardless of which pathways the nation chooses to pursue, community acceptance and participation will be vital. That's why the Mines team includes experts like Smith.

Through qualitative and quantitative research, Smith and her colleagues are trying to understand social dimensions of the entire critical mineral supply chain—from mining to processing to refining. In southeastern Missouri, for instance, her team is investigating community perceptions of a forthcoming cobalt mine.

"Some of the questions our group is asking include what factors influence the social acceptance—or rejection—of critical minerals development in the U.S.?" she said. "What does acceptance actually look like on the ground? In the push to secure domestic supply chains, what kinds of tradeoffs or liabilities are emerging, either here or abroad?"

Mining companies understand that community engagement is critical for the success of their projects. Does that engagement take on new urgency—or a different form—when it comes to critical minerals? That's another question Smith and her colleagues hope to eventually answer with their research.

"We're also trying to understand if the critical minerals narrative is gaining traction among local communities and the broader public and whether this, in turn, contributes to increased social acceptance of these projects," she said.

THE U.S. ALREADY HAS THE CRITICAL MINERALS IT NEEDS—BUT THEY'RE BEING THROWN AWAY

A team of Mines researchers, led by Elizabeth Holley, associate professor of mining engineering, recently published a new analysis in Science stating that all the critical minerals the U.S. needs annually for energy, defense and technology applications are already being mined at existing U.S. facilities. The challenge lies in recovery.

To conduct the analysis, Holley and her team built a database of annual production from federally permitted metal mines in the U.S. They used a statistical resampling technique to pair these data with the geochemical concentrations of critical minerals in ores, recently compiled by the U.S. Geological Survey, Geoscience Australia and the Geologic Survey of Canada.

Using this approach, Holley's team was able to estimate the quantities of critical minerals being mined and processed every year at U.S. metal mines but not being recovered. Instead, these valuable minerals are ending up as discarded tailings that must be stored and monitored to prevent environmental contamination.

The analysis in *Science* looks at a total of 70 elements and shows that unrecovered byproducts from other U.S. mines could meet the demand for all but two—platinum and palladium.

→ Read more about the analysis and what it could mean for domestic production of critical minerals at **mines.edu/mineral-analysis**

ASKING THE RIGHT QUESTIONS—AND FINDING THE BEST ANSWERS

Mineral and Energy Economics students are delving into research projects that are shaping the future of critical minerals

Addressing the complex challenges surrounding critical minerals requires an approach that spans economics, geopolitics and sustainable development.

Mines student researchers in the Mineral and Energy Economics program—the only graduate program of its kind in the U.S.—are investigating key questions to provide actionable insights that inform policies and strategies that promote responsible sourcing, transparency and stability in the global critical minerals landscape. Here are some of the research questions they're exploring.

Q: HOW IMPORTANT ARE SMALL-SCALE AND ARTISANAL MINERS TO ZAMBIA'S PRODUCTION OF KEY MINERALS (MAINLY COPPER, COBALT AND MANGANESE), AND HOW CAN THIS BE QUANTIFIED AMID POOR REPORTING?

The research: Mines student researchers, such as graduate student Grace Akinyi, are focusing on Zambia's underreported production levels of artisanal and small-scale mining (ASM) of copper, manganese and cobalt and their role in national critical mineral output. Using secondary government data and estimation techniques, they aim to quantify ASM's contribution and produce an open data model.

The impact: The project addresses a key blind spot in Zambia's critical minerals approach. In 2022, ASM formally contributed only 3.8 percent of copper despite representing a high proportion of mining rights. Unlocking ASM's value chain is essential for diversifying and securing global energy transition supply chains, attracting investment through improved traceability and formalization, and facilitating inclusive growth by mainstreaming ASM in national development plans.

Q: HOW DO GEOPOLITICAL TENSIONS AND TRADE DEPENDENCIES AFFECT THE RESILIENCE OF GLOBAL MINERAL SUPPLY CHAINS, AND WHAT POLICIES CAN HELP MITIGATE THESE VULNERABILITIES?

The research: Elif Bozkurt and other Mines graduate students are exploring the geopolitical risks and economic implications of critical mineral supply chains. As part of the Critical Materials Innovation Hub and in collaboration with Argonne National Laboratory, the project examines how international trade dynamics and policy shifts impact the accessibility and affordability of critical minerals essential to alternative energy technologies.

The impact: The project builds an understanding of supply risks and offers policy-relevant insights to guide more resilient sourcing, extraction and recycling strategies vital to the sustainable development of clean energy infrastructure and national resource security.

Q: WHAT IS THE LONG-TERM AVAILABILITY OF CRITICAL MINERALS, WHAT ARE THE POTENTIAL IMPACTS OF SUPPLY CHAIN DISRUPTIONS ON KEY ECONOMIC SECTORS AND LOCAL COMMUNITIES, AND TO WHAT EXTENT ARE DOMINANT PLAYERS EXERCISING MARKET POWER OVER SELECT MATERIALS?

The research: Researchers such as PhD candidate Sangita Gayatri Kannan work through the Critical Minerals Innovation Hub on projects evaluating the long-term availability of lithium, regional differences and strategies to address critical mineral supply chain risks, and local economic effects of mining in the United States, among others.

The impact: This work intersects mineral economics, public policy and critical minerals manufacturing. The insights gained from this research can inform public policy to build more resilient critical mineral supply chains.

Q: WHY IS SOURCING SOME CRITICAL MINERALS—SUCH AS CHROMIUM, TANTALITE, TIN AND TUNGSTEN—OFTEN OPAQUE AND UNSTABLE, AND WHAT DOES THIS REVEAL ABOUT THE NEED FOR RESPONSIBLE SOURCING AND SUPPLY CHAIN STABILITY?

The research: PhD researchers like Clarkson Kamurai are conducting research coordinated by Mines' Mineral and Energy Economics program and the Payne Institute for Public Policy—supported by the Quadrature Climate Foundation—that studies critical mineral supply in resource-rich countries. Their work explores socioeconomic impacts of extraction and processing, identifies policy and regulatory challenges and considers how Western Hemisphere demand can support responsible sourcing and more sustainable, transparent supply chains.

The impact: Illicit trade and opaque markets disrupt supply chains, especially for newer or niche minerals, hindering transparency and fair trade. This work helps inform policy and regulation decisions to mitigate these challenges.

Q: WHAT IS THE ECONOMIC IMPACT OF ARTISANAL MINERS?

The research: Mines student researchers like Christian Briones study the economic impact of artisanal miners in countries such as Chile, Zambia and Indonesia. Each country has its own unique context, and this research aims to better understand how artisanal mining—often involving critical minerals like copper—contributes to the local and national economies.

The impact: Artisanal miners play a meaningful role in society. This research provides a deeper understanding of the often underappreciated economic contributions and impact of their work.

→ Learn more about the Mineral and Energy Economics program at **mines.edu/mineral-energy-economics**.

Every year, Colorado's Climax Mines, pictured here, produces approximately 30 million pounds of molybdenum, a critical mineral essential for manufacturing the high-strength steel used in many modern technologies.

TURNING WASTE INTO WORTH

Mine waste offers new path to sourcing critical minerals and sustainable construction materials

BY ASHLEY SPURGEON

Mining companies face a tough balancing act: meeting the surging demand for critical minerals—such as lithium, cobalt and rare earth elements vital to energy, communication, medical and defense technologies—while managing the environmental and financial costs of mine waste.

Mine tailings—the material left over from everyday mining operations—are often seen as waste and a growing environmental concern. But Reza Hedayat, associate professor of civil and environmental engineering at Mines, sees them as an opportunity to both scale up the extraction of essential minerals and develop more sustainable construction materials.

Hedayat's research team is developing scalable processes to turn mine tailings into high-value construction materials, such as geopolymer bricks, lightweight aggregates and ceramic tiles. These materials are designed to meet strict performance standards while reducing the mining industry's environmental footprint. And while the primary focus is on reuse, the extraction of critical minerals is closely tied to the process.

It's a practical solution to a demanding challenge.

MAKING WASTE WORK HARDER

Rethinking what happens to mine waste by transforming it into something useful could unlock significant opportunities for both critical mineral supply and sustainable materials.

"Imagine you have an ore body, and within that ore body, you have certain traces of critical minerals that are economically viable to extract. Eventually, in many cases, over 90 percent of the original ore body will end up in the form of finely ground residue that is not economically viable for processing, and that type of waste is deposited in a landfill or deposition areas," Hedayat explained. "This non-critical component, though economically deficient, may still have valuable components in that they can be converted via fairly inexpensive methods to become sustainable, durable construction materials."

This dual-use vision—recover what you can, reuse what you can't—could be vital for strengthening domestic critical mineral supplies while advancing sustainable construction. Creating marketable materials from tailings also opens new revenue streams, helping mining companies offset costs and ride out market volatility.

"Our goal is to create a sustainable, economical and scalable pathway for reusing mine waste, while supporting the critical minerals and material supply chain and promoting a circular economy," Hedayat said.

SUPPORTING A CIRCULAR ECONOMY

That circular mindset reframes tailings not as a burden to manage but as raw input for the next generation of building materials. The approach reduces demand for raw materials, cuts carbon emissions and extends the lifecycle of extracted resources.

"Our work directly advances a circular economy model in mining by transforming mine tailings into valuable, durable and sustainable construction materials, thereby closing key resource loops and extending the lifecycle of extracted materials," Hedayat said.

And the benefits are multifaceted. Instead of stockpiling or disposing of tailings, Hedayat's technologies, when adopted at large scale, can convert them into valuable materials. And by replacing natural resources like clay, shale and stone with mine tailings, the technologies can decrease the need for additional mining and quarrying, reducing resource depletion, carbon emissions and land disturbance.

Hedayat also envisions the deployment of bench-scale—and eventually pilot-scale—facilities near mine sites that would promote the localized reuse of waste, reducing transportation impacts and generating regional economic activity.

"Our work aims to shift mine tailings from end-of-life waste to new beginnings as feedstock, exemplifying how mining byproducts can fuel sustainable construction and contribute to a low-waste, low-emission future," Hedayat explained.

It's a vision that resonates with policymakers and industry alike. Hedayat's research was already selected as part of the U.S. Department of Energy's efforts to increase the efficiency of domestic critical minerals production through the co-manufacture of value-added products. But turning that vision into reality will take more than lab success.

Hedayat points to the need for broad collaboration—with mining companies, universities and government agencies—to ensure site-specific adaptability and scalable solutions. Policy support will also be essential, from funding pilot projects to streamlining approvals for integrated recovery and reuse operations.

In other words, sustainable materials and critical mineral supply chains don't have to be separate goals. With the right technology and partnerships, they can support each other—and help reshape the mining and construction industries into a more resource-efficient cornerstone of the U.S. and global economies.

→ Watch a video to dive deeper into the construction materials Hedayat's team is working on at **mines.edu/tailings-construction-materials.**

Edgar Experimental Mine has expanded from a hands-on home for mining engineers into a multidisciplinary hub for learning, research and innovation.

A MINE FOR THE FUTURE

BY JENN FIELDS

Back-to-school may evoke memories of rushing to class across campus for some, but for mining engineering majors, a different tradition prevails. For these literal Orediggers, going to class often meant donning a hard hat and heading underground to the classroom in the Edgar Experimental Mine.

For more than a century, Edgar Mine in Idaho Springs has been a place where mining students can get hands-on experience that few other universities offer. Now, a generous $1 million gift from Freeport-McMoRan Foundation—the company's second gift to Edgar over the last decade—has enabled a revitalization of the mine that will let it continue to offer exciting opportunities in the future. New infrastructure being built at Edgar, often by Mines students, is keeping the mine at the forefront of applied education focused on best industry practices and maximizing learning experiences. It's also opening brand-new doors to innovative cross-disciplinary research and partnerships—giving Mines a leg up on the other 14 U.S. universities that have mining engineering degree programs.

"The Edgar's really the crown jewel of our program," said Hugh Miller '86, MS '91, PhD '96, an associate professor of mining engineering and research director of the Energy, Mining, and Construction Industry Safety (EMCIS) Program, which provides mine safety training for industry professionals. "The environment it provides to conduct novel educational and learning activities is second to none."

As part of the geology field session, geological engineering students Rick Lu and Lanie Smith took samples from a supported rock face in Edgar Mine.

Freeport-McMoRan Foundation's initial gift to Edgar upgraded the mine's electrical infrastructure. The latest gift will make the mine more accessible and comfortable for visitors: A new bathhouse will have facilities for the Mines community as well as Mine Rescue Training Course attendees, industry and government partners and members of the public touring the mine. A new multipurpose room, excavated by students and faculty, will serve as a learning space for up to 30 people. Potable water, sewer and airflow systems will also get an upgrade.

"The mining department has done a good job of building out a vision of what it can be, and we recognize the importance of it to the entire Mines community and support it as an organization," said Josh Olmsted '92, president and chief operating officer-Americas at Freeport-McMoRan.

The mine's revitalization also means that the opportunities at Edgar are evolving. The unique setting offers students and researchers experiences for education and experimentation across a surprising number of disciplines. Industry and government partners are working with Mines on projects ranging from explosives research to hydrology to petroleum geology and quantum physics.

"Ten years ago, it was very much a mine—it was dusty, it was not in the shape that it's in today," said Kyle Leach, professor of physics and science director of the Colorado Underground Research Institute (CURIE) housed within Edgar. "Over the past 8 to 10 years, it has evolved from a teaching tool for the Mining Department to a real research resource across campus."

A HISTORY OF LEARNING

Edgar Mine's story goes all the way back to Colorado's gold and silver rush. In its early days, the mine primarily produced silver, lead, zinc and small quantities of gold.

Over the years, ownership of Edgar Mine changed hands many times before the Big Five Mining Company, facing bankruptcy, leased it to Mines for educational and research purposes in 1921.

The university eventually acquired the property and developed extensive facilities at the site, including an aboveground area designated for explosives research.

In the mine's current era, students attend class in a classroom inside the mine, but they also gain working knowledge of rock structures and equipment. They learn how to excavate rock, construct ground support systems and operate drills, rock-bolters, haul trucks and muckers. They also learn how to use explosives and acquire fundamental safety skills and ethics they'll use at any jobsite. They get real-life design experiences, like planning a new space with modern infrastructure—ventilation, lighting, waste management, communications, road construction and piping networks. They learn to consider the economic viability of what they've planned and then actually develop it out of the rock.

The mine's revitalization is also letting the university build in new capabilities. Mining engineering students have already carved out new spaces for an underground X-ray laboratory and experiments in quantum physics, and more projects are underway.

THE EDGAR EXPERIENCE

Alexandra Nickle, a senior in mining engineering, was drawn to Mines in part by Edgar. She comes from an engineering family, and growing up, her family's vacations sometimes included a mine tour.

"What I love about being underground is that it's not somewhere that humans are meant to be," she said. "The challenges you have to overcome are interesting—ventilation, water, rock support. I'm an engineer, so I love solving problems."

Nickle now works as a "shifter" at Edgar while pursuing her degree. It's a leadership role that has her managing crews during the lab period, leading tours of the mine, teaching fellow students how to operate equipment and handling a number of other tasks underground. It also gives her the opportunity to meet and learn from industry professionals that come to the mine, whether for research, a tour or safety and emergency rescue training.

While the chance to get your hands on equipment can't be overlooked, the leadership skills required to be an effective shifter are essential for any current role in the mining industry, Olmsted said. He was a shifter, and he said he used the management lessons he learned in Edgar at his first job in the mining industry.

"Being a shifter is a way to grow and gain leadership skills that students might not have otherwise," Olmsted said. "You might not realize how important those experiences are in the moment, but you look back and say, 'That was formative.'"

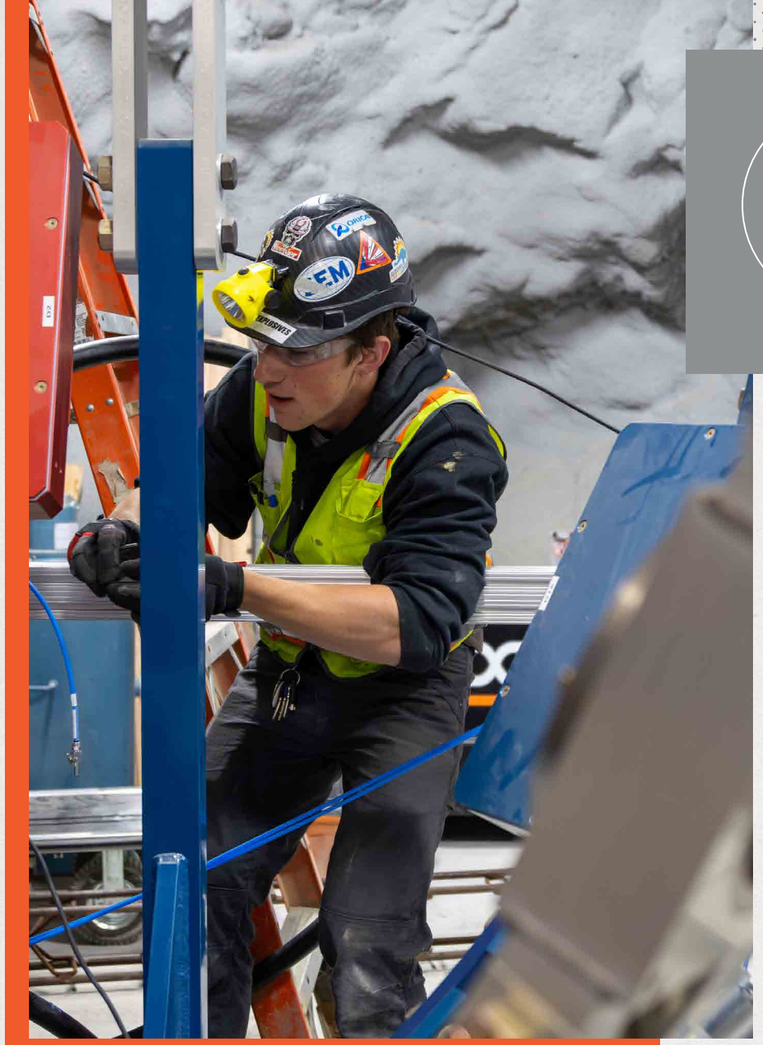
SAFETY FIRST

There are other skills to pick up at Edgar, and safety is an important one.

In addition to the skills gained through the EMCIS program, graduate students who work with Veronica Eliasson, an associate professor of mechanical engineering and director of the Mines Explosives Research Laboratory (ERL), gain additional and highly specialized training in explosives. Their research group works closely with the U.S. Departments of Defense and Energy and their industry partners.

"When these labs come out and they say, 'Where are your technicians?' I point to the students," Eliasson said. "The students get a full-on experience. For us, it's about training the students in using the safety protocols as well as diagnostics, so if students want to go work for them, they don't need to spend two years working from scratch on safety training."

Edgar Mine serves as the training ground where collegiate mine-rescue teams from around the world—including the Mines team—test their skills in rigorous rescue competitions.



PhD candidate Finnegan Wilson ’22, MS ’24 works on a three-ring flash X-ray system inside Edgar Mine that was designed and built at the Lawrence Livermore National Lab. The system is used to study explosive events.

The safety requirements are intense: Students don’t handle explosives on their own at first, and everything is closely supervised. In addition to the steep training requirements, they’re gaining experience on current research projects ranging from advanced diagnostics and 3D-printed formulations to new techniques for disposing of unexploded ordinance.

Inside Edgar, Eliasson recently guided undergraduate students through the design and development an X-ray facility in the Sunburst drift, which the students expanded. “You can use this to study detonation waves,” Eliasson said of the technique that will be used there. “You can reconstruct it into a 3D movie, sort of like what you get from a CT scan.”

Their research group is also often at the outdoor range, if weather allows. “Up there we have all the cool equipment: high speed cameras, all kinds of sensors, high-fidelity diagnostics,” Eliasson said. “It’s a big space, so we have enough space to be safe and be far enough away.”

A LOW-BACKGROUND QUANTUM ENVIRONMENT

With the revitalization, Edgar Mine has become a space that’s interesting to researchers outside of mining engineering.

“As Edgar evolved, for those of us who do subatomic physics, we started thinking more and more about how can we use it to search for extremely rare events in the universe?” Leach said.

As mines go, Edgar isn’t as deep as some. But there’s enough rock above to block most of the cosmic radiation that hits Earth’s surface, making it an ideal environment for studying the origins of the universe, said Wouter Van De Pontseele, an assistant professor of physics. He cited an example from his group’s preparatory research in Edgar on subatomic particles called muons. Aboveground, the constant cascade of muons gets in the way of spotting neutrinos—rare, hard-to-detect particles that physicists believe hold the keys to understanding how the universe formed. In the room in Edgar dubbed the Subatomic Particle Hideout, the cascade of muons is more like a trickle.

“A student in our group has been leading the experiments to characterize how many muons there are underground, and there are 700 times less,” Van De Pontseele said. “We used to see a background event once every second, and now we see one once every 15 minutes, just by going 200 meters underground.”

Aside from the radiation-blocking rock overhead, the mine’s constant temperature of 54 degrees Fahrenheit provides a stable environment for sensitive equipment used in particle physics and quantum computing. “Qubits can become unstable in 0.1 milliseconds, and that is partially affected by cosmic radiation, temperature variations and surrounding noise introduced by various sources such as cell phones,” Van De Pontseele explained. “All of these things affect the building blocks of quantum computers.”

There are only a handful of underground labs for this kind of experimentation in the U.S., and because they do not offer horizontal access or are not owned by universities, they’re much less accessible, he said. For Van De Pontseele and Leach, who both have joint appointments at the National Institute of Standards and Technology (NIST) and are partners in the U.S. Economic Development Administration’s Elevate Quantum tech hub, Mines’ ownership of Edgar creates unique opportunities for partnerships in quantum research. “What the Edgar Mine brings to the table is being able to collaborate with scientists and industry while being very nimble in tackling novel challenges quantum technology is facing, Van De Pontseele said.

While the characterization work at the Subatomic Particle Hangout continues, the physics and mining engineering departments are collaborating on the design of the next two quantum-focused labs in the mine. The first, which they’re calling Cryolab 1, will have an ultra-cold refrigerator inside a clean room when it’s up and running—but it’s already providing a hands-on experience for mining engineering and physics students alike.

“When we toured the space that will be Cryolab 1, the mining engineering students who excavated it were fascinated to learn what we were trying to do and wanted to know how they could get involved,” Leach said.

“There’s real cross-pollination between really different areas of science, and that’s a real strength of Mines.”

→ Watch a video about how Mines is shaping the future of mining on **Mines’ YouTube channel.**

Physics PhD candidate Dakota Keblbeck works in the Subatomic Particle Hideout in Edgar Mine, where the underground space provides a stable environment for sensitive equipment used in particle physics and quantum computing.

LEADING AN UNCONVENTIONAL LIFE

Across oceans and continents, Peter Consalvi ’17 has built a life defined by exploration, endurance and connection

BY SARAH KUTA

Peter Consalvi ’17 has always wanted to live an unconventional life.

That desire has taken him on adventures across the globe, from serving on U.S. Navy warships to cycling thousands of miles across multiple continents.

“I don’t want to do the same things that everybody else does,” he said. “I wanted to branch out and learn about myself, learn about the world and just see what’s out there.”

It all started after high school, when Consalvi left his home in Maryland and moved across the country to study physics at Mines. As a student, Consalvi got his first bike—which he named “Oredigger”—and developed a passion for long-distance cycling. He also discovered his love of travel, visiting far-flung destinations like Costa Rica, Cuba, Nepal, Iceland and Greenland during summers and school breaks. “I was super fortunate to have amazing friends who were interested in exploring and going places and trying new things and spending time outdoors,” he said.

As a Mines sophomore, Consalvi enlisted in the U.S. Navy’s Nuclear Propulsion Officer Candidate (NUPOC) Program. The Navy paid him while he was in school and, in return, he agreed to spend at least five years working on ships and submarines after graduation.

While on active duty, Consalvi worked as a nuclear surface warfare officer in Spain, Japan and South Carolina, supervising the sailors who operate the nuclear reactors on naval vessels. He also got into ultrarunning, testing his mettle by completing three separate 100-mile runs.

When he got out of the Navy, Consalvi wanted to keep exploring the world. With savings he’d accrued while he was in the military, Consalvi decided to embark on an 18-month, self-supported bike journey. “I wanted to take a big chunk of time off after getting out, and I wanted to do something different,” he explained.

In the end, he pedaled 15,000 miles across four continents, riding from Mongolia to Spain—with a brief jaunt through Egypt—followed by Miami to Maryland. He carried everything he needed with him, from a tent and sleeping bag to food, water and cooking gear, a style of travel known as “bikepacking.” Consalvi, who was sponsored by the outdoor gear company Big Agnes for the trip, also raised more than $7,000 for Juniper Fund, an organization supporting the families of Sherpas who die while working in the Himalayas.

Though he was alone on his bike most of the time, the endeavor also opened his eyes to the power of human connection. “I met so many people on the road,” he said. “You might not speak the same language as someone, you might come from a completely different walk of life, but you can still relate. I spent a night with camel herders in Saudi Arabia, and in the morning when I left, these guys had tears in their eyes. And I felt it, too. We had shared this really special experience.”

Near the end of his bicycle trek, Consalvi heard about a group of military veterans who were attempting to run across the country while carrying an American flag, an initiative called the Old Glory Ultra Relay. It seemed like the perfect challenge to try next.

Consalvi was selected to join the 12-person team but was later sidelined by an injury. So, instead of running, he became the team’s crew chief.

“It sounds like a simple thing, but it was actually quite complex because the flag never stopped moving,” he explained. “It was 24/7, all through the night, coordinating the locations where the teams would meet and exchange the flag, where people were sleeping at night, where we were going to get food and water.”

The group successfully completed the 3,000-mile, coast-to-coast relay in 16 days in May 2025. They also raised more than $1 million for Team Red, White & Blue, a nonprofit dedicated to helping veterans lead healthier lives. For Consalvi, those fundraising results were just as important—if not more so—as the team finishing the relay. “Something both trips really reaffirmed about myself is that I want to give back—I want to live a life of service,” he said.

Looking ahead, Consalvi isn’t quite sure what the future holds. For now, he’s focused on recovering from major hip surgery and writing his first book, a biography of a Sherpa who summited Mount Everest 16 times. He’s also using this time to reflect on his journey so far—an unorthodox path he hopes might serve as a source of inspiration to others.

THE CAMPAIGN FOR MINES@150 BREAKS RECORDS

Mines community support makes history and sets up a bright future for the university

Capping off Mines' 150th anniversary, the Campaign for MINES@150 celebration highlighted the most successful fundraising effort in the university's history and the success Orediggers can achieve together. The impact of this momentous campaign will be felt for generations, empowering students, advancing faculty and research and expanding opportunities for innovation and leadership. Together, donors and partners ensured Mines is poised to lead for the next 150 years and beyond. Here are some highlights of what the Mines community achieved.

Visit **campaign.mines.edu/impact-report** to explore how Mines has transformed thanks to the generosity and strength of our alumni community.

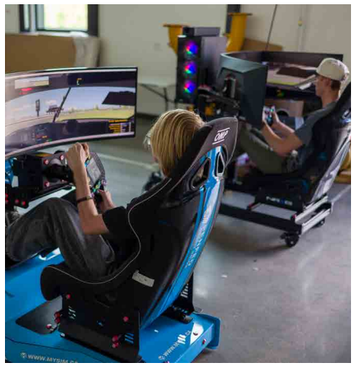
$589M	TOTAL RAISED
31K	TOTAL DONORS
77K	TOTAL NUMBER OF GIFTS MADE
86%	GIFTS MADE UNDER $1,000
$225M	INVESTED IN STUDENTS, INCLUDING 264 NEW UNDERGRADUATE SCHOLARSHIPS AND 26 NEW GRADUATE FELLOWSHIPS
$55M	ENHANCED THE MINES SIGNATURE STUDENT EXPERIENCE, INCLUDING NEW-AND-IMPROVED ATHLETIC FACILITIES, HONORS PROGRAM SUPPORT AND NEW PROFESSIONAL DEVELOPMENT AND LEADERSHIP OPPORTUNITIES
$33M	ADVANCED ENTREPRENEURSHIP AND INNOVATION WITH 100,000 SQUARE FEET OF NEW FACILITIES, INCLUDING THE LABRIOLA INNOVATION HUB, ARAMCO XWORKS INNOVATION SPACE, MCNEIL CENTER FOR ENTREPRENEURSHIP AND INNOVATION AND THE BECK VENTURE CENTER
$103M	STRENGTHENED MINES' EXCELLENCE AND DISTINCTION THROUGH RESEARCH AND FACULTY SUPPORT

Jim White '64 (left) established the Jim and Lee White Scholarship in 2022, and current mining engineering student Jack Maring (right) became the scholarship's first recipient in 2023.

IN THE DRIVER'S SEAT

Sabré Cook '17 put Orediggers behind the wheel—literally and figuratively—during her return to campus

Sabré Cook '17—professional racecar driver and mechanical engineer—returned to campus this fall for two high-octane days of events. Cook shared her experiences and career lessons in a lecture and Q&A, networked with fellow Orediggers in a lunch and learn with the Society of Women Engineers and even gave students (and President Johnson) a glimpse into her Porsche racecar. Students were even able to try out their skills in a racing simulator. Here are some of our favorite moments from her visit.



GUIDED INTO ORBIT

From mentee to mentor, Libby Booton ’16 pays it forward to help other Orediggers find their passion

BY CYNTHIA BARNES

Libby Booton ’16 had been on a path to Mines since a second-grade field trip, but it was a chance encounter during her first year that set her on a course toward space.

“We were at Mines to see the Geology Museum,” she recalled. “And my second-grade teacher said, ‘You really like math and science, and you’re really good at it. You should go to Mines someday.’ And that just stuck.”

“Mines just kind of reappeared, throughout my life,” she said. Both an uncle and a childhood friend’s father were Mines alumni, and Booton had spent time on campus in high school while participating in the Science Olympiad. She was accepted into Mines with a scholarship just before Christmas as a high school senior. But then she had to decide where her path would lead from there.

“How I got into aerospace is probably my favorite story ever,” said Booton. “I was in my differential equations class freshman year, and a classmate announced, ‘I need a girl that wants an all-expense-paid trip to Huntsville, Alabama.’” The trip was to compete in the NASA Great Moonbuggy Race, where Booton was introduced to Mines alum Penny Pettigrew ’92, who was working at NASA.

“She came running up to us at the finish line and said, ‘Oh my gosh, you're the Mines team. I’m a Mines alum. Here’s ice cold water. You did great. Let's talk about how we can improve your moonbuggy for tomorrow’s race,” Booton said.

Pettigrew took the team to dinner with other Mines alumni and inspired Booton to set her sights on aerospace. “She's the payload communications manager, which means she talks to astronauts all day on the space station and helps them with their science,” said Booton. “That was just super cool to me. She became one of my mentors and helped me see myself in a career at NASA or another space company. That single weekend changed my entire career structure. Prior to that, I had no idea what I wanted to do. But having role models like Pettigrew and alumni volunteers helped me find my way, and the connections I’ve made have really made my career succeed. That leads me to want to continue to volunteer with students in every capacity that I possibly can find.”

Although Mines doesn’t offer a formal aerospace degree, Booton’s engineering physics degree nonetheless opened doors and internships, including at Northrop Grumman. She eventually landed a full-time role at Lockheed Martin.

“I started as a quality engineer working on antennas.” said Booton. “One thing I really loved about that job and what got me so hooked on the industry, was getting to be on a production floor, building hardware that was going to space. Then, ultimately, I had a GPS satellite that I’d been working on as a quality engineer that many years later made it to the launchpad. Just understanding how GPS works—it runs our maps, it helps our military and it’s also helping farmers plant their crops. It’s putting things into space, but it’s also helping people on Earth.”

> “THAT SINGLE WEEKEND CHANGED MY ENTIRE CAREER STRUCTURE. PRIOR TO THAT, I HAD NO IDEA WHAT I WANTED TO DO. BUT HAVING ROLE MODELS LIKE PETTIGREW AND ALUMNI VOLUNTEERS HELPED ME FIND MY WAY, AND THE CONNECTIONS I’VE MADE HAVE REALLY MADE MY CAREER SUCCEED.”
>
> -Libby Booton ’16

Booton is now an ardent volunteer for Mines, intent on “paying forward” the mentoring and support she received while a student. She volunteers as an advisor for the Mines chapter of Sigma Kappa sorority, gives career talks and participates in Physics Department panels. She's also volunteered at events like Commencement and Oredigger Camp, where she loves being around the students, and been involved with panels for prospective students and their parents.

“That one's super fun, too,” she said. “Parents ask, ‘What should my kid’s major be?’ And I say, engineering anything. It doesn't actually matter. Every industry needs every type of engineer. So whatever they enjoy doing the most is what they should probably major in. It doesn’t need to be an aerospace degree to be working in aerospace. We need mechanical engineers, electrical engineers, software engineers. We need everything."

TEAMMATES FOR LIFE

Inside the alumni networks and friendships formed through Mines athletics and club sports

BY JASMINE LEONAS

Jennifer Kendall ’18 knew that playing soccer at Mines meant she would gain a group of teammates. What she didn’t know was that she would also gain lifelong best friends.

While at Mines, Kendall’s teammates supported each other, both on and off the field. They helped Kendall decide which classes to take, and older team members guided her through her mechanical engineering degree, a major many of them shared. And now that she works as a propulsion systems engineer, Kendall still gets advice and support from her Mines soccer teammates, who often understand what it’s like to be a woman working in a male-dominated field.

“Just like on the soccer fields, we might be competing for the same position, but at the end of the day, we all just want the same goal, which is to win and be our best,” she said. “And as we transitioned through life, every time I see my soccer friends, I still want them to be the best they can be, whether that’s having children, getting married, we’re always there for each other.”

Kendall’s experience is not a rare one. Orediggers from different generations regularly stay in touch with their teammates, whether they continue playing the sport they love or because their experiences at Mines bonded them together.

Justin Dvorak ’16 was on the football team all four years he was at Mines. He started as quarterback for three of those years and was team captain for two. A standout on the field, he received the Harlon Hill Trophy, given to the individual selected as the most valuable player in NCAA Division II. He said being a student-athlete was a challenging but rewarding experience.

“At many times it was overwhelming,” Dvorak said. “However, I had some of the greatest times of my life while at Mines. There is no better place if you want to study engineering and be successful on the field. I am a better person in every aspect for having went to Mines and being a student-athlete.”

That connection is one he didn’t want to lose, even after graduating and wanted other student-athletes to be able to find that same connection. Dvorak, who is originally from Tomball, Texas, now lives in Houston and works as a drilling engineer. One of the ways he stays connected to Mines football is through the Lone Star Scholarship, which he established in 2019. He reached out to some of his Oredigger teammates who also hail from his home state to help give financial support to Mines football student-athletes from Texas.

Along with helping a fellow Texan, creating the award was a way to establish a link between his former teammates and the current team. Dvorak said he follows the on-field careers of the award winners and regularly comes back to campus for alumni and homecoming weekends. He also attends Mines-sponsored events in Houston as often as he can to keep that bond with his teammates going.

“I don’t get to see old teammates as much as I’d like, but when we are back together, we don’t skip a beat,” he said.

For Shaun Bevers ’05, a sport he didn’t know how to play helped him bond with friends. As an undergraduate, his roommate, Bob Ratzi, dragged Bevers and some friends to play on an intramural ultimate frisbee team.

“I knew nothing about the sport, and neither did any of my friends. Essentially, we were terrible, but it was nice to do something that me and my roommates could share,” he said. “I didn’t know it at the time, but that connection would actually extend after school.”

Now a couple decades after their undergraduate years at Mines, Bevers said that he, Ratzi and several other Mines alumni still play in a competitive ultimate league every summer in the Denver area.

“I wasn’t sure if I was going to keep playing [after Mines], but I have,” he said. “Playing ultimate recreationally is essentially how we could stay connected and meet other Mines people. So many Mines alumni live in the south and west sides of Denver that a lot of people who play club ultimate at Mines end up finding their way to this league after they get out of school.”

It might be for a couple of months each year, but Bevers said it’s been essential to keeping his college friendships going as he and his teammates have gotten older and life milestones interfere.

“Bob is my best friend, but since he has two kids now, I see him more sparingly than I did before. Outside of ultimate, it’s hard to catch up sometimes,” Bevers said. “Having a defined activity with a schedule makes it easier to stay in touch.”

Because Bevers stayed in the Denver area and still plays ultimate—in addition to returning to Mines for graduate school in 2018—it felt like he’d never truly left Mines. He’s been back to campus for sporting events, both to watch Oredigger teams and the professional ultimate team in Denver, which plays games at Marv Kay Stadium. And by interacting with so many alumni in this way, his Mines connection has stayed strong.

“It’s always nice to run into Mines alumni, either by seeing a sticker or a hat or something like that,” he said. “We all share a commonality, whether it’s the M Climb or suffering through Physics 2. There’s a lot of shared experiences at Mines that make it really easy to connect with people.”

IN THE ROOM WHERE IT HAPPENS

Orediggers experts are driving innovation and helping guide policy that will help secure and strengthen the U.S.'s most critical assets

When Congress and federal agencies grapple with how to secure and strengthen critical mineral supply chains, meet increasing energy demands, build new and repair existing infrastructure and more, they are increasingly turning to Mines for trusted expertise and actionable, data-driven solutions. Mines faculty and alumni are advancing research and innovation in these key areas while also providing testimony that informs national policy.

Three recent examples—all related to critical minerals and mining challenges—show how Orediggers are both driving innovation and helping guide policies that define the future of energy, infrastructure, defense and the environment.

A VISION FOR THE "MINING OF THE FUTURE"

Elizabeth Holley, associate professor of mining engineering, appeared before the House Select Committee on the Chinese Communist Party's Critical Minerals Policy Working Group in September 2024 to explore the need to develop a skilled domestic workforce to support U.S. economic, energy and national security through the responsible sourcing of critical minerals. With low enrollments in mining engineering programs and nearly 50 percent of the U.S. mining workforce—about 220,000 professionals—expected to retire by the end of the decade, the current talent pipeline is insufficient to meet the growing demand for minerals.

"Achieving increased domestic mineral production that is both environmentally sustainable and socially responsible will require innovation across the entire mining value chain," Holley said. "To meet this challenge, we must develop an interdisciplinary workforce capable of designing and implementing new approaches to mineral exploration, mine production, processing, and reclamation."

Holley leads a National Science Foundation-funded interdisciplinary research team dedicated to the responsible development of critical minerals in the U.S. Through partnerships with industry, government and community stakeholders, her team brings unique insights to domestic mineral and mining challenges, including the need for an innovative minerals workforce.

In her testimony, Holley discussed Mines' vision for the "mining of the future," which aligns with students' interest in environmental stewardship, innovation and social impact. She emphasized the need for increased investment in mining and mineral R&D to address complex engineering and social challenges, as well the need for greater coordination among academia, industry and government to meet the strategic critical mineral objectives of the United States.

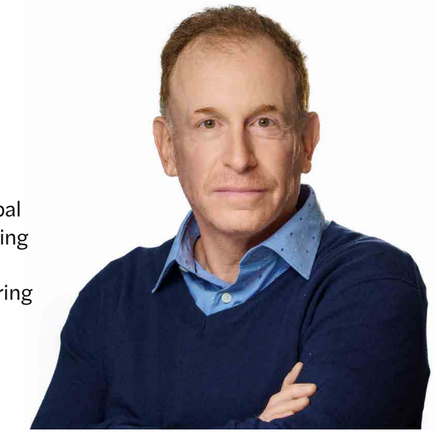
LINKING CRITICAL MINERALS, NATIONAL SECURITY AND ECONOMIC STABILITY

Where Holley emphasized the workforce, Morgan Bazilian, director of Mines' Payne Institute for Public Policy, drew the connection between domestic mining, national security and economic stability. Testifying before the U.S. House Natural Resources Subcommittee on Energy & Minerals in February 2025, Bazilian explained that minerals are "foundational across the modern economy" and increasingly indispensable to American defense, prosperity and energy security.

Bazilian urged lawmakers to take strategic steps to shore up supply chains, including expanding the critical mineral stockpile, streamlining the permitting process, supporting the mining workforce, enhancing mineral supply chain transparency in government procurement and reviving the U.S. Bureau of Mines.

"These actions are not only feasible but would also be effective in bolstering mineral supply chains for goods that are critical to U.S. national security," he said.

Bazilian's expertise and recommendations arrived at a pivotal moment. Intensifying global competition for resources and rising geopolitical uncertainties have underscored the urgency of securing critical minerals. Appearing alongside industry and academic peers, Bazilian reinforced Mines' reputation as a trusted source of data-driven policy analysis. Through the Payne Institute, Mines offers thought leadership at the intersection of technology, economics, energy transition and national security—helping Congress and federal agencies understand not only where minerals come from but also how policy choices ripple through supply chains and markets.



INVESTING IN THE NEXT GENERATION OF MINING LEADERS

For Bill Zisch '79, J. Steven Whisler Head of Mining Engineering at Mines, the most important critical resource in the mining industry is its people. In June 2024, he testified before the U.S. Senate Health, Education, Labor and Pensions Subcommittee on Employment and Workplace Safety on how to strategically build the critical minerals workforce.

As energy goals and advanced technologies drive unprecedented demand for critical minerals, Zisch warned that the U.S. cannot achieve its objectives without investing in the next generation of mining professionals.

"When it comes to minerals and their role in our modern world, our most critical resource is our people—skilled professionals equipped to responsibly manage our Earth's resources and solve complex engineering and social challenges," he told senators.

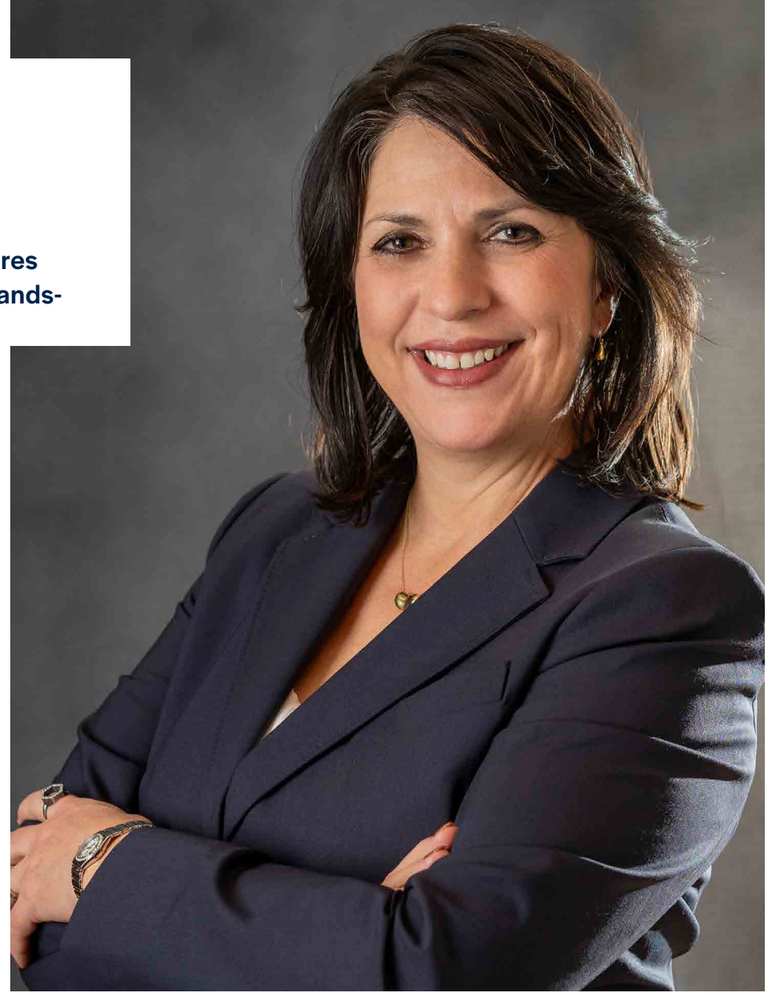
Zisch outlined a vision for mining education and research that responds to the scientific, social and environmental challenges facing the sector and integrates innovation, advanced technologies and sustainable practices to optimize resource utilization, increase productivity and minimize environmental impact.

"At Mines, we are working to educate and prepare students for the essential link between mining, minerals, responsible resource management and sustainable energy," he said. "The opportunity before us is to engage and inspire the next generation of mining and mineral leaders with a passion for impactful careers in a sector innovating to support our economic, energy and security future."

His message reinforced what sets Mines apart: an unmatched ability to provide expertise that spans the entire mining and mineral lifecycle—from exploration and production to community engagement, economics, finance and public policy. That comprehensive perspective positions Mines as the go-to source for lawmakers shaping the workforce and technologies that will power the nation's future.

BUILDING A PIPELINE TO LEADERSHIP

Tallgrass COO Crystal Heter '99 shares her thoughts on how ot move from hands-on engineer to C-suite executive



When Crystal Heter ’99 began her engineering career with KN Energy, she wasn’t focused on leading thousands of people or overseeing billion-dollar projects. She simply wanted to put her degree to work. As the company evolved, first becoming Kinder Morgan and later Tallgrass, Heter’s role grew right along with it.

Over 26 years, she has advanced from mapping and drafting, to risk and project management, up to account director and then to president of the gas transportation segment of Tallgrass’ operations. Now, as the company’s executive vice president and chief operating officer, Heter has come full circle, bringing her operations and commercial experiences together. This year, she was also named one of Oil and Gas Investor’s Influential Women in Energy.

We asked Heter about what it’s like to grow with an evolving organization and her thoughts on navigating a shift into a leadership role. Here is what she had to say.

MINES MAGAZINE: YOU’VE SPENT TIME IN ROLES THAT SPAN NEARLY EVERY ASPECT OF THE NATURAL GAS BUSINESS AND HAVE LED SOME SIGNIFICANT PROJECTS, LIKE THE ROCKIES EXPRESS PIPELINE. WHAT INTERESTS YOU ABOUT WORKING IN THE ENERGY INDUSTRY?

Crystal Heter: On the outside, people talk about these projects on a macro scale. Take the Rockies Express Pipeline, for example. Most folks focus on the 1,700-mile, large-diameter pipeline stretching across nearly the entire country. But what fascinates me is that it’s not a massive monolithic structure—it’s a system-built inch by inch, landowner by landowner, community by community. In the process, you come to understand what matters most to people, whether it’s working the land, raising cattle or creating income through leasing. That perspective has stayed with me.

And now, as a leader, I’ve come to appreciate not only the individual priorities of landowners and communities but also the broader quality of life that energy brings to all of us. While we’re committed to leading clean energy solutions, we also recognize that the reliability of today’s energy sources is essential to sustaining that quality of life.

MM: WHAT HAS IT BEEN LIKE TO GROW ALONGSIDE A COMPANY IN THIS FIELD, AND WHAT MOMENTS STAND OUT TO YOU?

Heter: One of my biggest revelations was understanding that while I could build pipelines, and design compressor stations, I didn’t understand how we’re making money doing it. I had this deficit in my professional experience, so I asked if I could have an opportunity to see the business side of the shop and spent the next 10 years working my way from an account director up to president of the gas transportation segment. It was phenomenal for progressing my career and gaining a broader, more holistic understanding of the industry.

MM: HOW DO YOU BUILD STRONG AND RESILIENT TEAMS WHEN MANAGING COMPLEX PROJECTS AND MEETING TODAY’S ENERGY DEMANDS?

Heter: I’ve found that success really starts with clear communication and a commitment to collaboration. My leadership philosophy is grounded in the idea that I don’t have all the answers—in fact, I have very few. That’s why I prioritize listening to input from across my team, then making the decision that needs to be made, embracing the responsibility that comes with it and circling back to explain the “why.”

It’s unrealistic to expect people to pull in the same direction if they don’t understand the reason behind the decision. Even if someone disagrees, giving them the opportunity to understand why the decision was made allows them to respect it, embrace it and move forward with the team.

MM: WHAT ADVICE WOULD YOU GIVE SOMEONE WHO’S NAVIGATING THE TRANSITION FROM BEING AN EXPERT IN THEIR FIELD TO BECOMING A LEADER OF PEOPLE OR STRATEGY?

Heter: Learning to delegate is one of the hardest transitions, especially for strong performers. You have to let go of the instinct and the satisfaction that comes from producing the work yourself. Early in your career, you can point to a report, analysis or model and say, “I did that.” As a leader, the work becomes less tangible. You don’t get that same sense of closure from finishing a task.

Instead, the shift is about asking, “How can I help my team achieve their best?” Doing the work for them isn’t the answer. Leading requires being intentional about giving people the runway to grow, develop and succeed on their own.

MM: WHY DO YOU THINK MINES GRADUATES ARE TYPICALLY WELL-SUITED FOR LEADERSHIP ROLES IN INDUSTRY?

Heter: I think the greatest skills Mines taught me are attention to detail and resiliency. The workload is intense, and the expectations are precise, forcing you to juggle multiple deliverables at once. That experience shapes not only strong performers but also future leaders. We’re fortunate to be so close to Mines where we can actively recruit talent, and we are proud to have many Mines alumni within our organization.

CLASS NOTES

Accomplishments | Activities | Updates

In 1993, **Raul Lema '98** hiked up to the M on Mt. Zion carrying a 10-pound rock from his hometown as a first-year student at Mines. He was even prominently featured in a Denver Post article about the M Climb tradition that year. When Raul graduated from Mines, he retrieved his rock from the M and kept it with him in the years since. This year, 32 years after Raul's M Climb, his son Apollo completed his own M Climb and returned that same rock to the M, marking the start of his Mines journey.

Also pictured in the Denver Post article is Roxann **Mackenzie Hayes '95**.

COLORADO SCHOOL OF MINES

We're proud of Mines alumni. We want to cheer you on and celebrate your accomplishments. Tell us about your recent wedding, a new baby or your new job. Share a personal or professional accomplishment, volunteer activity or your favorite Mines memories. Stay connected to the Oredigger family.

→ Submit a class note at **minesmagazine.com/classnote**.

1970s

Tony Kenck '75 recently published a book titled *Strategic Business Portfolio Management.*

Gary Prost MS '75, PhD '86 recently published two books: the fourth edition of *Remote Sensing for Geoscientists – Image Analysis* and *Integration* and *Rocks and Riches – Exploring California's Stunning Geology.*

1980s

Tom Jorden '80, MS '87 was named to the Board of Tulane in June 2025.

Greg Piper '86 was named to World Kinect Corporation's board of directors in July 2025.

1990s

Quinton Hennigh MS '93, PhD '96 was appointed as chairman of Westward Gold's board of directors in May 2025.

Leo Kalikstein '94 was hired as a director in HKA's forensic engineering practice in Denver, Colorado in July 2025.

Greg Bazar '98 was appointed to Sanuwave Health's board of directors in May 2025.

Mohan B. Dangi '99, MS '02 received the 2025 Steven K. Dentel AEESP Award for Global Outreach from the Association of Environmental Engineering and Science Professors Foundation on May 22, 2025.

2000s

Adam Noelck '07 was promoted to operations manager at Hensel Phelps in Guam in August 2025.

2010s

Erin Bouchet '13 and her husband, Chris, welcomed another baby girl to their family. Rosie arrived in the beginning of January 2025, joining her big sister Lucy (3).

Zahra Ghanbari MS '14, PhD '17 was awarded a patent in August 2025 for the development of hermetic electrical feedthroughs utilizing precious metal alloy pins.

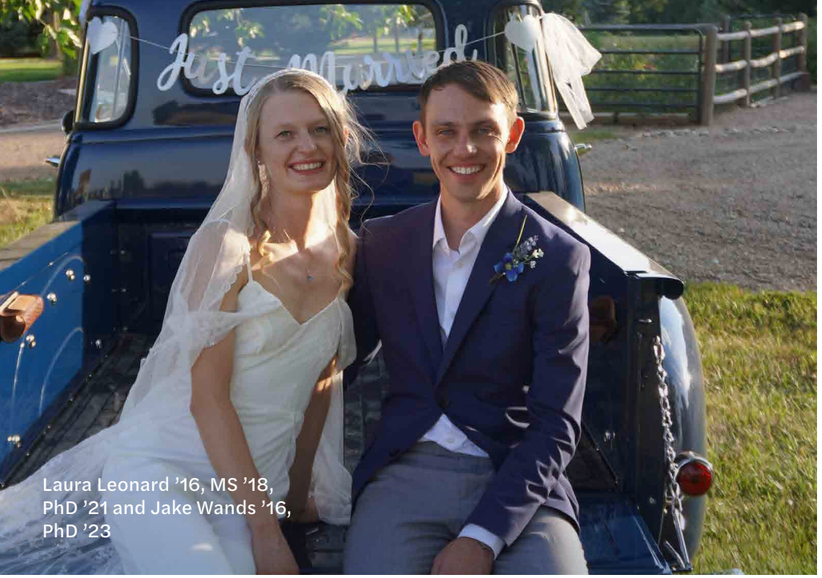
Raymond Puckett '14 was awarded his fourth patent in August 2025 for advancements in additive manufacturing of ultra-high strength, multiphase high-entropy alloys.

Evan Halpern '18 and **Hannah (Thomas) Halpern '18** welcomed their first baby, Nora Louise, in February 2025.

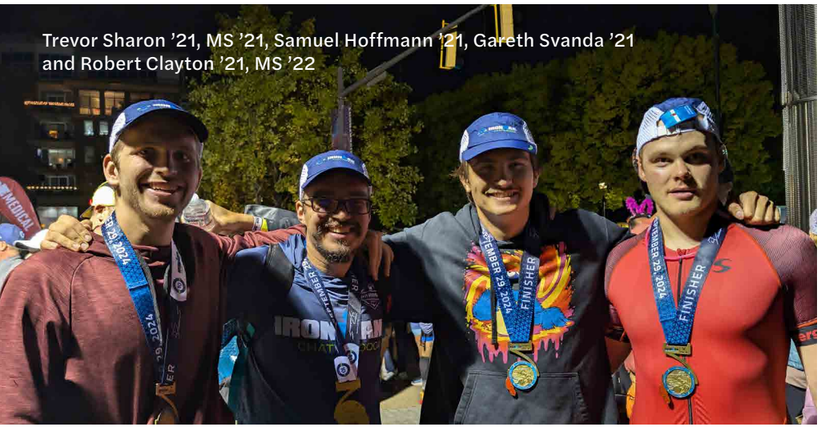

Rosie Bouchet


Nora Louise Halpern

Raymond Puckett '14



Laura Leonard ’16, MS ’18, PhD ’21 and Jake Wands ’16, PhD ’23



Trevor Sharon ’21, MS ’21, Samuel Hoffmann ’21, Gareth Svanda ’21 and Robert Clayton ’21, MS ’22

2010s cont.

Following a proposal outside Guggenheim Hall at their usual meeting spot, **Laura Leonard ’16, MS ’18, PhD ’21** and **Jake Wands ’16, PhD ’23** were married on August 21, 2025, in Windsor, Colorado. The couple met through the Mines Cycling Team and have been riding together ever since.

2020s

Trevor Sharon ’21, MS ’21, Samuel Hoffmann ’21, Gareth Svanda ’21 and **Robert Clayton ’21, MS ’22** took on the IRONMAN Chattanooga together. Originally a fitness goal among friends, the challenge turned into a shared commitment that pushed the group to accomplish something beyond what any of them thought possible. Hoffmann credits every athletic and health milestone since—including finishing IRONMAN 70.3 Boulder—to the support, training and friendship he has gained from his fellow Orediggers.

Steven Goldy MS ’23 won the 19th Denver Colfax Marathon on May 18, 2025, running a 2:24:20 in his first-ever marathon race.

Chase Taylor-Robins MS ’23 joined K2 Gold Corporation as a new board member in June 2025.

After Rachael Lamman ’21, MS ’22 graduated from Mines, she worked as a geothermal engineer in Duluth, Minnesota for two years before she felt like she needed a change. Last year, she was hired by, SAHAS Nepal, a local non-governmental organization, to research groundwater wells in marginalized communities.

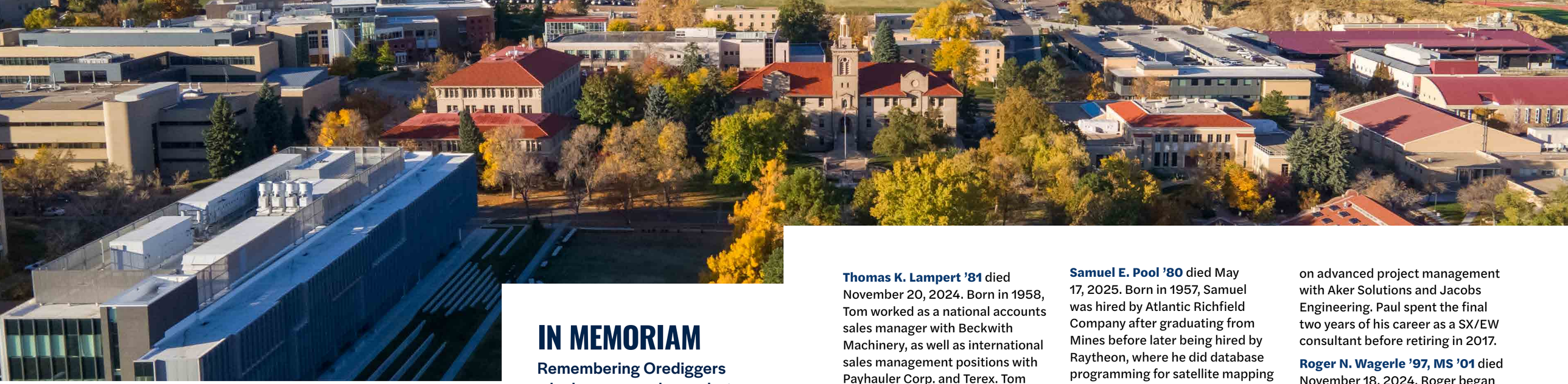
Although she’s based in Kathmandu, her project area is near Biratnagar, along the India border. In this area, arsenic is naturally released through the native geology, jeopardizing groundwater quality. Lamman takes field visits to the project area to understand the geology and collect water samples.

“The people are welcoming, curious, and always excited to give me tea. There are cute animals outside every home and beautiful sunsets,” Lamman said. “I feel quite lucky to have gotten the opportunity to visit and work with these communities.”

Lauren Guido ’20, MS ’23 and **Leland Spangler ’19** may have had the most Mines wedding and honeymoon ever.

The pair tied the knot at 12,000 feet elevation, with a backcountry wedding on July 7, 2025. More than 20 Mines alumni were among the guests who either hiked, biked or scrounged for rides up the trail to Carner’s Cabin in Leadville, Colorado. Mary Carr, geology and geological engineering research assistant professor and Lauren’s longtime friend and mentor, officiated the wedding.

While honeymooning in Grindavik, Iceland, the two geologists got to experience an incredible show of Earth’s power, witnessing a volcanic eruption. Coincidentally, an Associated Press journalist happened to be watching the eruption as well and produced a video story about their geologically exciting honeymoon.



IN MEMORIAM

Remembering Orediggers who have passed away but will always remain part of the Mines community

John "Jack" H. Brunel '48 died May 3, 2025. Born in 1924, Jack joined the U.S. Navy during World War II before beginning a career in oil and gas, first with TriGood Oil Company as a petroleum geologist. After the company changed hands a couple of times, Jack began a second career as a wildcatter in the Denver Basin and Piceance Basin, in addition to cattle ranching. Jack and his wife, Catherine, also built an alternative care facility in Arvada, Colorado, to support individuals with Alzheimer's disease and other aging-related needs.

James "Jim" W. Calvin '71 died January 23, 2025. Jim was born in 1944 and spent 34 years working as a petroleum engineer for Amoco. He retired from Amoco in 1998 and joined Nations Energy. In the role of chief operating officer, he helped the company build orphanages, support hospitals, build a technopark and support communities in Kazakhstan and Azerbaijan before retiring again in 2007.

Thomas K. Lampert '81 died November 20, 2024. Born in 1958, Tom worked as a national accounts sales manager with Beckwith Machinery, as well as international sales management positions with Payhauler Corp. and Terex. Tom retired in 2017.

David B. Marshall '83 died January 31, 2025. Dave was born in 1960 and worked for Idaho National Laboratory in the Naval Nuclear Propulsion Program before roles with Trident Data Systems and Vitesse Semiconductor. The final years of his career were spent as a systems engineer with Oracle.

Susan M. Arnold Mitchell died April 29, 2025. Sue was married to George Mitchell '53, a Mines alum and former director of the Mines Alumni Association. Sue also eventually worked for Mines, helping students find jobs after graduation, before moving to an Admissions role.

Donald D. Ott '63 died February 13, 2025. Don was born in 1941 and served in the U.S. Army after graduating with a degree in geophysical engineering. His military assignments included one year in Korea, where he was a platoon leader, and Vietnam as a 1st Lieutenant Army combat engineer. After the military, Don worked for Amoco Production. He also worked as a manufacturer's representative and adjunct instructor for various schools.

Samuel E. Pool '80 died May 17, 2025. Born in 1957, Samuel was hired by Atlantic Richfield Company after graduating from Mines before later being hired by Raytheon, where he did database programming for satellite mapping and mapping the ocean floor.

David B. Richards MS '63 died May 22, 2025. David was born in 1934 and started his career with the U.S. Geological Survey. He was then assigned to the federal flood insurance program in Lawrence, Kansas before eventually ending up as the sub-district chief and supervisory hydrologist for the USGS Water Resources Division in Pittsburgh. He retired in 1996 after 30 years of service.

Scott E. Shipley '82, MS '89 died June 4, 2025. While a petroleum engineer by profession, Scott's true passion was geology. A rockhound at heart, he found joy in sharing his collection and knowledge with others.

Paul E. Thompsen '71 died September 9, 2025. Born in 1949, he spent 45 years working in the mining and metals industry. Paul began his career with Hazen Research, before working as a metallurgist with Cities Service Company's Pinto Valley Mine. Then, he became a design engineer specializing in hydrometallurgy and solvent extraction and electrowinning (SX/EW) for various firms and then focused on advanced project management with Aker Solutions and Jacobs Engineering. Paul spent the final two years of his career as a SX/EW consultant before retiring in 2017.

Roger N. Wagerle '97, MS '01 died November 18, 2024. Roger began his career as an electrician before earning his Mines degrees and then spent his career as a sedimentologist and stratigrapher.

John J. Zeman '56 died May 14, 2023. Born in 1934, John's professional career spanned 25 years with Monsanto. He later became a financial advisor with Equitable. One of John's favorite memories at Mines was his 50th reunion when he received a gold-engraved diploma and his granddaughter, Sarah Alsbrooks Cisper '06 received her silver-plated diploma.

→ To submit an obituary for publication in *Mines Magazine*, visit **minesmagazine.com/obituary**.

→ Memorial gifts to the Colorado School of Mines Foundation are a meaningful way to honor the legacy of friends and colleagues while communicating your support to survivors. For more information, call **303-273-3275** or visit **weare.mines.edu/givingguide**.

FRESH PERSPECTIVES

A snapshot of the Class of 2029

1,769 NEW FIRST-YEAR AND TRANSFER STUDENTS

3.87 MEDIAN HIGH SCHOOL GPA (ON AN UNWEIGHTED 4.0 SCALE)

1400 MEDIAN SAT COMPOSITE SCORE

2% INTERNATIONAL STUDENTS

17% FIRST-GENERATION COLLEGE STUDENTS

TOP 3 U.S. STATES OUTSIDE COLORADO: TEXAS, CALIFORNIA & WASHINGTON

27 COUNTRIES REPRESENTED

48 STATES REPRESENTED

32 MEDIAN ACT SCORE

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