

MINES MAGAZINE

For Colorado School of Mines Alumni and Friends • Fall 2023

INDUSTRY 4.0:

SHAPING THE NEXT TECHNOLOGICAL LANDSCAPE

As companies increasingly shift to cyber-physical tools and systems across industries, Mines graduates are well-prepared for the new challenges.

PLUS:

Mines celebrates two decades of the Humanitarian Engineering program and its influence on Mines students and communities around the world.

Mines alumni pursue businesses that bring their passions and artistry to the forefront.

MINES.EDU

Mines' football helmets got a bit of an upgrade this year, featuring the same classic look but with some new details. The helmets showcase updated Mines branding, custom straps and revamped academic decals, such as a Marv Kay memorial sticker.

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

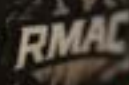


Revamped Academic Decal



MECHANICAL ENGINEERING

Marv Kay Memorial Sticker



New Mines Athletics Font



Conference Decal



Classic Blaster



Addition of Colorado Red

Custom Straps

Pick and Pike Cup

CONTENTS



FEATURE

INDUSTRY 4.0: SHAPING THE NEXT TECHNOLOGICAL LANDSCAPE

The Fourth Industrial Revolution is bringing about an increased shift to cyber-physical tools and systems for many industries, and Mines graduates are well-prepared for new challenges. **18**

INSIDE MINES



Top news at Mines **8**

Mines' vice president of research testifies before U.S. House committee

Men's cross country team honored at White House

Challenge Bridge Program receives Inspiring Programs in STEM award

A new professorship to spur innovation in business education



Mines celebrates 20 years of humanitarian engineering education. **7**



A historic gift funds scholarships for student-athletes and track and field and cross country facility improvements. **10**

BIG IDEAS



Mines students and communities co-create sustainable recycling solutions in Colombia. **12**



An interdisciplinary research initiative will address the treatment and characterization of forever chemicals. **14**



Mines and collaborators were awarded funding to develop a carbon storage hub. **16**

ALUMNI NETWORK

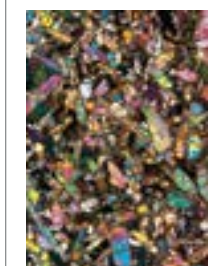


Leslie Collins '98 empowers workers and protects the environment in Meta's supply chain. **24**



Paul Anderson '85 embraces challenges in the aerospace industry. **28**

SKILL SET



Teresa Johnson '10, MS '15 discusses developing products to showcase the geologic artistry found under a microscope. **30**

On the cover: Traditional industries, such as mining, are turning to the latest cyber-physical technologies to continue to meet demand and advance in new ways.



New Degree Bridges a Gap in the Construction Industry

Recruiters looking for civil engineers with construction management training are flooding Mines' Career Days.

In Fall 2023, companies representing civil/construction engineering and building trades dominated all other industries—25 percent. Last year, Mines even added an industry-focused event to accommodate all of them.

At Mines, 18 percent of graduates go to work for these types of companies—second only to aerospace.

“There is a massive shortage of construction and civil engineers in our country,” said David Zanetell '87, president of Kraemer North America, a heavy civil contractor. “People in this industry know that Mines students are smart, hardworking and can hit the ground running on day one.”

Annual demand far outweighs the number of graduates from U.S. construction engineering schools.

18%
of Mines graduates work in the civil/construction engineering and building trades industry.

This fall, Mines launched a **bachelor's degree in construction engineering**.

The program will prepare graduates for design, oversight, inspection and planning careers in infrastructure and commercial and residential construction. The program combines:

- Rigorous courses in data, science, math and civil engineering.
- Classes on running the business of building projects, like scheduling, cost loading, project management and communication.
- A framework of global, economic, environmental, sustainability and societal contexts.

Combine this curriculum with the Mines way of education, and our construction engineering graduates will be primed to **lead the industry into the future**.

Kiewit Corporation, one of the largest construction and engineering firms in North America, hires about 1,000 engineers a year, said Bruce Grewcock '76, executive chairman of the company board.

“Our business is booming, and the market looks strong as far as the eye can see,” Grewcock said. **“Kiewit will hire every one of this program's graduates.”**

INTRODUCING THE ORE CART

A new free transit option to serve the Mines and Golden community

A new-and-improved campus shuttle launched this summer, called the Ore Cart. The free transit shuttle connects the Mines campus, downtown Golden and beyond.

Operated as a partnership between Mines, the City of Golden and West Line Corridor Collaborative, the Ore Cart is free for all riders, ADA accessible and designed to complement and expand access to existing transit options in the Golden area. Two main routes serve the Mines campus:

- **Silver Route:** Connects Mines Park apartment complex to central Mines campus
- **Tungsten Route:** Connects Mines campus and downtown Golden to the RTD W Line's Jeffco Government Center Station

Mines operates the Silver and Tungsten routes, but all routes are open and free to all community members, visitors, students and faculty.

“Ever since we launched the Mines Rover pilot in 2021, we have heard loud and clear from the Mines community that they want more transit options to get to and from campus,” said Jason Slowinski, associate vice president of infrastructure and operations at Mines. “With a free and convenient connection between the W Line and campus, students and employees who live in Denver, Lakewood and beyond can get to campus without a car, reducing both the car trips to and from Golden and the parking required on campus. We're excited to launch the expanded Ore Cart service to help meet the mobility needs of our campus and the broader Golden community.”

➔ Additional details and FAQs about the Ore Cart can be found at guidinggolden.com/transit.



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What else are industry leaders saying about our construction engineering degree? Find out here. ➔





A YEAR FOR THE HISTORY BOOKS

A lot to look forward to this school year as we head into Mines' 150th anniversary

There is always a special kind of energy and excitement on campus at the start of the school year. You can feel it walking across campus and see it on the faces of the new and returning students, faculty and staff. That's especially true as we start the school year that will lead us into 2024 and Mines' 150th anniversary celebrations.

The beginning of the school year is also a good time to reflect on last year's accomplishments and this year's goals as we continue to position Mines for even more success and impact in the next 150 years. Some more visible changes you'll see underway in 2023-24 include:

- Opening of the Beck Venture Center and Labriola Innovation Hub
- Launch of two new undergraduate degree programs in construction engineering and ceramic engineering
- Groundbreaking for the federally funded U.S. Geological Survey/Mines Energy and Minerals Research Facility
- A new free transit service featuring Ore Cart shuttles that connect campus and Golden
- Construction of Mines' second combined classroom building and parking garage facility
- Upgrades and new additions to Mines Park upperclass and graduate student housing

- Construction of our on-campus early childhood education center
- Celebration of the 20th anniversary of Mines' Humanitarian Engineering Program, the first curricular program of its kind in the U.S. (read more on page 7)

Our alumni have been central to Mines' successes through the years. From helping build our reputation with industry to leading innovation and progress in those industries, our alumni always have been at the forefront of Mines' success and where we're headed. (Check out page 18 for more on the work Mines and our alumni have been leading with the Fourth Industrial Revolution.)

I hope you'll continue to be involved and join us in our celebrations starting now and continuing through early 2025. Come back to campus for events or to share your talents and experiences with our students and programs. Check out one of our new professional and graduate degree programs and expand your skills. Meet up with other proud Orediggers in your local area or join one of our strategically focused alumni interest groups.

I look forward to seeing you on campus or at one of your local events. Let's have a helluva 2023-24 school year and 150th anniversary.

Go Orediggers!

Paul C. Johnson
President and Professor

➔ Follow our progress at weare.mines.edu/150.

TWO DECADES OF TRANSFORMATIVE IMPACT

Celebrating 20 years of humanitarian engineering at Mines

In the past two decades, Mines' Humanitarian Engineering (HE) program has taught scientists and engineers how to best partner with communities around the world and take a sociotechnical approach to making a difference in the world. Through a variety of education, research, outreach and engagement programs, the program has encouraged and developed leadership in sustainability and social responsibility that has allowed Mines graduates to remain at the forefront of innovation and progress.

This year, the Humanitarian Engineering program celebrates its 20th anniversary and is reflecting on how the program has evolved and grown since its inception in 2003, the more than 150 students who have graduated with a Humanitarian Engineering minor, the 20 students who have received a master's degree or graduate certificate since 2020 and the many research projects that have strengthened Mines' reputation in the U.S. and around the world.

"HE is an amazing program—truly a signature student experience at Mines," said Kevin Moore, executive director of the Humanitarian Engineering program. "It provides distinctive programming that contributes to skill-building and lifelong learning, attracts highly qualified students from diverse backgrounds, responds to societal challenges and produces differentiated and highly desired STEM-educated leaders."

We asked Mines alumni for their favorite memories from the Humanitarian Engineering program. Here's a selection of what they shared.



"I am grateful to the Mines HE program for facilitating my appreciation and understanding for different engineering cultures, which has helped me work the most collaboratively with my colleagues and clients across the world."

—Heidi Bauer '04, MS '06

"The HE program influenced how I approach problems as an engineer. It taught me to look beyond the question and consider the full problem and those it ultimately affects."

—Julia Brown '21

"The HE program taught me that good intentions with an engineering degree are not enough—community engagement and multi-stakeholder dialogue are needed, too."

—Nicole Hanson '14

"HE continues to influence how I approach my job (and which jobs I look for) and encourages me to always consider the people my job affects—to look at the bigger picture. It gave me a broad mindset for approaching projects, encourages me to always keep the user in mind and challenges me to always consider the stakeholders involved at all phases of a project."

—Franco Pilone '20

"It was exciting to learn concepts, theories and methods from the social sciences that I have never explored before, which are essential for community development. I got better at asking questions, choosing methods and interacting with various stakeholders so that the project aims correspond with the community's interests."

—Sofía Schlezak '23

➔ Learn more about the Humanitarian Engineering program at humanitarian.mines.edu and then read more about how Humanitarian Engineering students have been working with international communities on sociotechnical engineering projects on page 12.

Humanitarian Engineering students listen to community members during a problem-identification focus group in Guatemala, learning how to engage with local communities and take a sociotechnical approach to engineering challenges.

Photo courtesy of the Mines Humanitarian Engineering program



MINES VICE PRESIDENT FOR RESEARCH AND TECHNOLOGY TRANSFER TESTIFIES BEFORE U.S. HOUSE COMMITTEE

Walter Copan spoke on behalf of proposed Mining Schools Act

Walter Copan, vice president for research and technology transfer at Mines, testified before the U.S. House Natural Resources Subcommittee on Energy & Mineral Resources on June 14, 2023, in Washington, D.C. on behalf of the proposed Mining Schools Act.

The Mining Schools Act would establish a grant program for mining schools to recruit students and support programs in relevant mining and mineral fields. The energy sector and many other parts of the economy rely on critical minerals and materials, and the U.S. has a substantial need for a well-educated workforce in these essential fields.

“I am proud that this university is an authoritative and trusted resource to Congress and policymakers on a broad range of topics connected with Science, Technology, Engineering and Mathematics,” Copan told the committee. “Mines is addressing all aspects of the mining and materials lifecycle—from initial community engagement, exploration, mineral economics, and mining—to minerals processing and extractive metallurgy, to metals and alloys processing and products—to closing the loop of the circular economy by product recycling. No other university in the world has this technology breadth.”

\$1M GIFT FOR PROFESSORSHIPS WILL SPUR INNOVATION IN BUSINESS EDUCATION

Andy Swiger '78 and his wife, Sherry, made a \$1 million endowed gift to support Mines' growing business education programming, creating the Andy and Sherry Swiger Professorship for Business Excellence. A separate \$40,000 gift will provide immediate startup funding. Mines faculty will compete for funding and the prestigious title through a proposal process.

“We are supporting faculty who represent the cutting edge of business education with ideas to provide all Mines students the business acumen that's necessary from day one of their first jobs,” Andy Swiger said. “We believe this gift will assist faculty in fast-tracking innovation.”

“Increasing the business acumen of our graduates is a key goal of our MINES@150 strategic plan, and the Swigers' gift is going to accelerate our path to that goal,” said President Paul C. Johnson. “It will encourage and support faculty engaged in innovating and expanding business education opportunities at Mines.”

Scott Houser, Economics and Business department head, said faculty have great ideas for improving Mines business education offerings. “The professorship provides resources that will support faculty to move beyond improving the teaching we do in the classroom and to look for ways to impact the whole campus,” Houser said. “It will certainly inspire new ideas and excitement.”

Swiger said he hopes the professorship will stimulate critical thinking about how to integrate business education



across the curriculum Mines students pursue in their technical education. “At the end of the day, if we can answer this challenge, Mines will continue to produce graduates that every company wants to hire,” he said.



SUMMER BRIDGE PROGRAM RECEIVES INSIGHT INTO DIVERSITY MAGAZINE'S 2023 INSPIRING PROGRAMS IN STEM AWARD

Mines' Challenge Summer Bridge Program received the 2023 Inspiring Programs in STEM Award from *INSIGHT Into Diversity* magazine, the largest and oldest diversity and inclusion publication in higher education. The Inspiring Programs in STEM Award honors colleges and universities that encourage and assist students from underrepresented groups to enter the fields of science, technology, engineering and mathematics.

Hosted by Mines' Multicultural Engineering Program, Challenge is a free four-week summer transitional program for incoming first-year students with diverse identities to prepare for the academic rigors of Mines while also building a strong social network of support. Challenge scholars get a preview of courses at Mines through pre-Calculus I, pre-Chemistry I and Engineering

Design, build academic skills through pre-collegiate workshops and grow their community through exciting weekly activities.

“The Multicultural Engineering Program serves those who are underrepresented and first-generation to college, and our Challenge Summer Bridge Program is designed to give students a head start toward a successful college experience,” said Stepheny Beauchamp, director of the Multicultural Engineering Program at Mines. “We grow a community of support and strength for students in Challenge so that college is an inclusive adventure among those who share similar lived experiences. We also prepare students to be OK with failure and provide the tools necessary to persist in the face of adversity. Lastly, we normalize breaking out of the traditional dichotomy of having a STEM identity or a diverse identity and

rather embrace the coexistence of both so students are empowered to show up authentically in all that they do.

“College can be an isolating experience, particularly for those from minoritized communities, so Challenge looks to break down barriers that might otherwise interrupt student's academic and professional pathways while surrounding them with a core community of support. Overall, Challenge seeks to help students thrive in college, not just survive it.”

Inspiring Programs in STEM Award winners were selected by *INSIGHT Into Diversity* based on efforts to inspire and encourage a new generation of young people to consider careers in STEM through mentoring, teaching, research and successful programs and initiatives.

→ For more information about the 2023 Inspiring Programs in STEM Award and *INSIGHT Into Diversity* magazine, visit insightintodiversity.com.



MINES MEN'S CROSS COUNTRY TEAM HONORED AT WHITE HOUSE

The men's cross country team was among national champions from across college sports honored at the White House on June 12, 2023, as part of College Athlete Day.

Vice President Kamala Harris and NCAA president Charlie Baker hosted the ceremony on the White House's South Lawn. Individual national champion Dillon Powell

represented Mines on stage at the event, which recognized champions from NCAA Divisions I, II, and III across all sports. They are the first Mines team to visit the White House as national champions.

→ Read more about the historic 2022 Oredigger team at minesathletics.com.



INVESTING IN OREDIGGER ATHLETES

\$6.5M gift to Mines Athletics will fund scholarships and improve facilities

BY LYNN CLARK

Mines received an anonymous \$6.5 million gift to fund scholarships for student-athletes in Olympic sports and to improve track and field and cross country facilities. It's one of the largest gifts to support athletics in the university's history.

"This gift comes from donors who have strong affinity for student-athletes, have great pride in Mines and know first-hand how involvement in athletics can lead to success in the classroom and beyond," said Mines President Paul C. Johnson. "These donors want to ensure that all our student-athletes have opportunities for scholarships. They have also seen the impact that facilities investments can have on individual and team success. I'm excited by the large number of new scholarships this gift creates, the opportunity to upgrade our existing track and field facilities and the creation of an on-campus loop for our nationally renowned and three-time national champion cross-country teams. We are incredibly grateful for this investment in our students."

\$440,000 A YEAR FOR SCHOLARSHIPS IN OLYMPIC SPORTS

Mines, like most NCAA Division II schools, offers athletes partial scholarships. Smaller scholarship budgets often

hamper Olympic sports programs' recruiting and retention efforts, including:

- Men's and women's cross country, soccer, swimming and track and field
- Women's basketball and volleyball
- Men's wrestling and golf

The gift's \$5 million scholarship fund will provide about \$440,000 each year for scholarships across these teams for the next 20 years. That total includes the initial gift plus investment income.

"Mines has one of the highest costs of attendance in DII, with tuition, housing, food and supplies costing about \$40,000 for in-state students and \$62,000 for out-of-state students," said David Hansburg, Mines' athletic director. "We work hard to attract scholarship funds to make Mines an appealing and financially viable option for the unique student-athletes that can be successful in the classroom and in athletics at Mines."

\$1.2 MILLION FOR TRACK AND FIELD UPDATES, FIRST CROSS COUNTRY TRAINING COURSE

The gift's remaining \$1.2 million will pay for long-needed updates at Mines' outdoor track and field facility, including replacing the track surface and other equipment that has reached the end of its lifetime, as well as bringing field event areas up to collegiate standards.

"These facility improvements will reflect the quality of our championship-contending athletes and let Mines host more track meets," Hansburg said. "That will cut our travel costs and, most importantly, keep students in class."

Mines will also begin building a cross country training facility in the coming months, featuring 3K and 2K loops with varied, challenging terrain. The 50-member men's and women's teams currently train in Jeffco Open Space parks, such as Crown Hill Park's 2.5K loop. Commutes can take 45 minutes round trip.

Cross Country Coach Chris Siemers said the new facility will give Mines a distinct advantage.

"We'll be one of the few schools in the country with an on-campus training course," he said. "We'll be able to jog up the hill instead of getting on a bus, which means we can train five days a week, including recovery days. The students who look at Mines for cross country are also considering Division I schools that can offer bigger scholarships. I believe that when we show a recruit the course, they'll understand how invested we are in their potential and in continuing to be a national contender in this sport."

➔ For more on Mines Athletics, visit minesathletics.com.

PETE STERBICK NAMED NEW MINES FOOTBALL HEAD COACH

BY TIM FLYNN

After former coach Brandon Moore's departure from Mines in early 2023, the search for the Orediggers' next head football coach didn't take long.

Pete Sterbick served as the team's offensive coordinator since January 2019 and was a key driver of some of the nation's most explosive offenses since then, helping Mines to consecutive regional titles and an appearance in the 2022 NCAA Division II national championship game.

"I am honored and excited to take over as head football coach here at Mines," Sterbick said. "This is a very unique and special place. The tradition here started well before I arrived in 2019 as offensive coordinator, and we've been fortunate enough to take our program to an elite level. We aim to stay on a championship track and are hungry for more. Our players are and will always be priority number one, and I am grateful to be their coach."

"Pete has done an exceptional job in his time at Mines as our offensive coordinator, and he will continue to lead our program as we continue to pursue a national championship," said Director of Athletics David Hansburg. "The exuberant reaction of the team when I told them says it all about what Pete has accomplished and what our players feel about him."

Sterbick was the 2022 FootballScoop D-II Coordinator of the Year and has perfected one of the nation's most explosive and versatile offenses since arriving as offensive coordinator in 2019. This past season, Mines had a prolific offense that led the nation in scoring (44.6 ppg) and red zone offense (97 percent) while ranking in the top 10 nationally in total offense, passing offense, fourth down conversion percentage and turnover margin. At Mines, Sterbick has worked with numerous all-Americans and all-conference student-athletes, most notably mentoring the development of quarterback John Matocha from a true freshman starter in 2019 to Harlon Hill Award winner in 2022.



URBAN RECYCLING: CO-CREATING TOGETHER

Mines students learn the value of socio-technical projects by working with local communities around the world

BY ERIC BUTTERMAN

Many college students spend their spring break relaxing on sunny beaches or engaging in activities far from an academic atmosphere. But for Mines' Humanitarian Engineering students, they opt for a week of community-led projects to shore up their technical and social engineering skills.

Humanitarian Engineering students have opportunities to work with local communities around the world to identify and solve engineering challenges. But the students don't go in with fix-it-fast ideas or a "we know it all" attitude. Instead, they partner with local stakeholders to find practical, sustainable solutions that empower and respect the affected communities. Students are not only able to practice technical skills but are also able to learn from the communities they are supporting and understand the value of engaging local stakeholders in these projects.

Take, for instance, the e-waste recycling project in Bogotá, Colombia a Mines team helped with in March 2023. Instead of simply visiting with a local community during the week-long trip, Mines students actually worked with community members long before they ever set foot in the country.

"A community-supporting organization in Colombia called DIVERSA connected us to people who were recycling electronic waste to earn a living," said Juan Lucena, director of the Humanitarian Engineering undergraduate program at Mines. "This relationship with students and community members began long before they were ever going to make a trip to Colombia. Months before, they started regularly engaging in calls to hear from the community about the challenges to their work, how they live and understanding where they are coming from in terms of why they are doing this. By the time students met them in person, there was a real connection. This is one of the central tenets of our program: learn as much about the people you are serving before you even define the problem."

Emily Robinson '23, who worked on the project as a student, explained that they were focused on two key goals: understanding the technical challenges of e-waste recycling and understanding the people behind the work.

"We had on our list to do some prototyping and experimenting and meet with people who collected plastic sources to break down from electronic waste for computer monitors and keyboards," she said. "Another goal was to spend a lot of time asking questions and making sure we understood their processes and whether the strategies we mentioned would be useful for them to implement into their process. We spent probably two-thirds of our time that week just talking to people and asking questions to understand their process from start to finish: from when electronic waste entered their warehouse to when the buyers decided what they wanted to buy and how they broke it all down."

Robinson's experience reflects another key feature of humanitarian engineering: deep listening to understand how technology fits in people's lives.

Robinson said the experience was incredibly helpful to her team, and they were surprised by how much they learned in just a few days after a whole semester of meeting virtually with the recyclers. "It was a very valuable information exchange, and we also made sure to do prototyping with some of the recyclers to give them firsthand experience if those tests were going to be used and where they could give us feedback on that," she said.

Humanitarian Engineering graduate student Jaime Styer also worked in Colombia to create a workshop on recycling construction and demolition waste in 2023. She said engagement with the community you are working with is critical, as engineering solutions missing this are often unsustainable and can even cause harm.



Humanitarian Engineering students learned about e-waste recycling in community-led design projects with Puerta de Oro, an association of recyclers in Bogotá, Colombia.

Photo courtesy of the Humanitarian Engineering Program

"The community doesn't feel any ownership in the solution without engagement," Styer said. "They have been isolated instead of being partnered with. It makes it that much harder for the next engineers who would like to come in and work together with them."

Styer's workshop embodies yet another principle of humanitarian engineering: empowering communities by giving them voice and a seat at the table as they have much to offer to make projects sustainable in the long term.

Lucena saw eye-opening results for students in many ways from the project. "In the U.S., we're used to private, for-profit recycling trucks picking up our garbage," he said. "In Colombia, it's individual trash collectors who are picking up those used monitors and keyboards to help get money to eat. Most of these people are 'invisible' to society. It was important for

students to learn how they live and work and the struggles they face on a daily basis."

Lucena said the communities Mines partners with, in part, co-create and are empowered through shared problem-definition and problem-solving with Mines engineers. And at the end, the solution is more socially just because it came from two sides that respected the other's way of life and two groups who wanted to truly learn from each other.

"I think the biggest thing I learned from the Colombia work was the importance of building trust," Robinson said. "You could see we had a chance to contribute to make their situation better and hopefully will make it easier for them to feel good about future partnerships like ours. For me, it even improved my communications skills that much more. I'm grateful for them being open and being willing to teach me."

TAKING THE FIGHT TO FOREVER CHEMICALS

A new interdisciplinary research initiative focuses on PFAS-site treatment strategies and characterizing human exposure

BY EMILIE RUSCH

Mines launched a broad-based research initiative earlier this year to advance scientific understanding of per- and polyfluoroalkyl substances, or PFASs, and develop practical engineering solutions to address these so-called “forever chemicals,” one of the largest-scale environmental and public health challenges facing the U.S. today.

Researchers at Mines have been working on all aspects of the PFAS problem for many years, from fundamental science and how the substances move once they’ve contaminated water and soil to human exposure routes to environmental remediation and destruction, taking an interdisciplinary and solution-focused approach to the chemicals.

The PFAS@Mines initiative will bring together all PFAS researchers at Mines, from multiple departments and disciplines, to focus the university’s experience and expertise on two core challenges: the development of treatment strategies for the most challenging PFAS-contaminated sites, and the creation of improved tools for assessing all sites, known and emerging, that have been impacted by PFAS. Fundamental research and improved methods and approaches to characterize human exposure to PFAS will also be included.

Initial funding for PFAS@Mines comes from a \$2.9 million grant from the U.S. Army Corps of Engineers and is part of an established partnership with the Engineer Research and Development Center (ERDC). PFAS contamination is a growing challenge for the U.S. Department of Defense—hundreds of DoD installations around the nation have groundwater with PFAS levels well above both existing and proposed



Researchers at Mines—including University Distinguished Professor Chris Higgins, right—have been working on all aspects of the PFAS problem for many years, taking an interdisciplinary and solution-focused approach to the chemicals.

federal limits, due to the extensive use of firefighting foams, called Aqueous Film Forming Foam (AFFF), containing these substances.

“After climate change, PFAS poses one of the biggest challenges for a generation of environmental scientists and engineers,” said Christopher Higgins, University Distinguished Professor of Civil and Environmental Engineering and lead investigator of the new initiative. “Addressing this nationwide challenge, though, is currently hamstrung by critical barriers and knowledge gaps—gaps that PFAS@Mines will help bridge by adopting an interdisciplinary, solutions-based approach.”

PFAS have been widely used for decades in firefighting foams and household products such as non-stick cookware, waterproof clothing, pizza boxes, cosmetics and more. The same properties that make them useful in those applications also keep them from breaking down when they enter the environment, and a growing body of research shows that human exposure to PFAS can cause cancer and developmental, endocrine, renal and metabolic problems.

The U.S. Environmental Protection Agency recently proposed the first federal limits in drinking water for two PFAS, called PFOA and PFOS—at four parts per trillion, the lowest level that can be reliably measured.

At Mines, researchers have been involved in the issue on a local and national level. Since 2016, Mines has partnered with the Colorado Department of Public Health and Environment to measure and evaluate human exposures to PFAS, particularly in impacted communities south of Colorado Springs. From measuring PFAS in drinking water and blood to assisting water utilities in identifying optimal treatment technologies, researchers at Mines have been extensively engaged in the local communities. Much of the work near Colorado Springs has been done in collaboration with the University of Colorado Anschutz Medical Campus, and this work has also extended to communities as far away as North Carolina and Michigan.

Frequently funded by the U.S. Department of Defense through the Strategic Environmental Research and Development Program (SERDP) and the Environmental Security Technology Certification Program (ESTCP), Mines has also been working on DoD PFAS issues related to transport and treatment of AFFF-impacted soils and water for more than a decade. Current projects include efforts to better clean firetrucks that have used PFAS-based AFFF, identifying PFAS sources through chemical forensics, optimizing PFAS treatment trains and assessing the leaching of PFAS out of impacted concrete.

In addition, a group of Mines researchers led by Timothy Strathmann, professor of civil and environmental engineering, has developed one of the most promising solutions for the destruction of PFAS. Hydrothermal alkaline treatment, or HALT, has been proven in scientific studies to completely destroy all types of PFAS, and was recently patented and licensed to a cleantech startup interested in scaling up the Mines technology for commercial use.

“Mines faculty researchers are go-to experts for all aspects of the PFAS crisis—from assessing contamination to water treatment, PFAS destruction and site remediation,” said Walter Copan, vice president for research and technology transfer at Mines. “PFAS@Mines represents the critical translation of interdisciplinary science and engineering into real-world solutions, which is the hallmark of impact-driven research at Mines.”

At the outset, PFAS@Mines will focus on four interdisciplinary efforts aimed at the development of more cost-effective and sustainable technologies for remediating PFAS-contaminated water and soil, as well as better tools for assessing and predicting the impacts and risk of contaminated sites across diverse hydrogeologic and biogeochemical conditions:

- Development of remediation and treatment strategies for difficult-to-treat environments, such as soils and wastewater
- Evaluation of the fate and transport of PFAS associated with AFFF-impacted sites
- Investigation of PFAS interactions with biological systems
- Modeling of PFAS behavior at the molecular scale

“With PFAS, nature doesn’t know how to make them, so nature also doesn’t know how to break them,” said Shubham Vyas, associate professor of chemistry. “Fundamental research is the key to understanding how to break down these chemicals. PFAS@Mines will help accelerate important fundamental research—work that, when combined with the applied engineering, will inform how to capture and break down PFAS more effectively and efficiently.”

➔ For more information about PFAS@Mines, visit pfas.mines.edu.

Paul C. Johnson
President and Professor
Heritage Society Member

Brian Winkelbauer
President and CEO, Mines Foundation
Heritage Society Member

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COMMUNITY-CENTRIC CARBON CAPTURE AND STORAGE

A new collaboration will advance the development of a carbon storage hub with local stakeholders

BY EMILIE RUSCH

Mines, Carbon America and Los Alamos National Laboratory were awarded \$32.6 million in funding this year from the U.S. Department of Energy's Carbon Storage Assurance Facility Enterprise (CarbonSAFE) initiative to advance the development of a potential carbon storage hub for the Pueblo, Colorado area.

CarbonSAFE Eos was one of nine projects selected by DOE as part of a \$242 million nationwide investment to accelerate the development of large-scale, commercial carbon storage projects with capacities to securely store 50 or more million metric tons of carbon dioxide deep underground.

The goal of CarbonSAFE Eos, named after the Greek goddess of the dawn and new beginnings, is to reduce industrial emissions from cement, hydrogen and power plant operations and at the same time, create a model for responsible, community-centric carbon capture and storage (CCS) from the ground up, inclusive of community feedback in support of sustainable economic and social development goals.

"Given the urgency and scale of our climate challenge, we have to accelerate the buildout of CO₂ storage hubs region-by-region across the country," said Brad Crabtree, assistant secretary for fossil energy and carbon management at the U.S.



Mines, Carbon America and Los Alamos National Laboratory officially announced their partnership and project funding on May 19, 2023, during the Carbon Management Symposium hosted by the Mines Global Energy Future Initiative.

Department of Energy. "The Colorado School of Mines project represents an important step toward that goal, and we look forward to working with them in this critical effort."

"This is a positive plan for our higher education system, for students in Golden and Pueblo, and for our air, climate and planet. I was proud to sign new laws in partnership with the legislature to save people money on energy and reduce carbon emissions and pollution," said Colorado Governor Jared Polis.

The DOE funding will cover data collection, detailed site characterization, planning, permitting and significant community and stakeholder engagement for the project, as well as training for the next generation of CCS professionals. The project will be co-led by Manika Prasad, director of the Mines Carbon

Capture, Utilization and Storage (CCUS) Innovation Center, and Carbon America Senior Geologist Chris Cassle.

"To meet our global climate goals, we need to do so much more than we're currently doing," Prasad said. "Large-scale carbon sequestration sites, like the one we hope to build with the community of Pueblo, are an important piece of the puzzle, capable of reducing greenhouse gas emissions by millions of metric tons and enabling communities to transition toward zero-emissions energy generation."

"This grant represents a significant milestone in our commitment to mitigating climate change and developing sustainable energy solutions," said Brent Lewis, CEO of Carbon America. "By collaborating with the exceptional researchers at Colorado School of Mines and Los Alamos National Lab, we aim to unlock new possibilities for carbon capture and storage, helping to build a cleaner and more resilient future."

"Los Alamos National Laboratory is excited to be a partner on this CarbonSAFE project along with Colorado School of Mines and Carbon America," said Rajesh J. Pawar, senior scientist in the Earth and Environmental Sciences Division at Los Alamos. "This project strongly aligns with the Laboratory's mission related to Energy Security through deployment of clean energy technologies while facilitating energy transition to meet net zero emissions goals. The Los Alamos technical team will be contributing to various aspects of this project, utilizing its decades-long experience and multidisciplinary capabilities related to CO₂ capture, transport and storage."

The Eos project aims to be an exemplar of community-centered carbon capture and storage, focused on how CCS in Pueblo can advance quality jobs, enable further business investment, and promote environmental justice and community partnership. The CarbonSAFE initiative falls under the DOE's Justice 40 goals of ensuring that 40 percent of the benefits of federal clean energy investments flow to disadvantaged communities and help enhance energy equity. Should the project proceed to operations, it will also help fund education in Colorado.

"Pueblo has remarkable potential to demonstrate a new energy future. We are excited to create a community decarbonization solution anchored in vibrant community engagement and input for long-term social and economic success," said Ashleigh Ross, vice president of strategic engagements and policy at Carbon America.

In addition to technical work, the project team will start early pre-planning outreach activities to support community engagement for the project. Community workshops will be held in the region to engage in two-way dialogue about the project and what community-centric CCS could look like in the area.

"We want to set a new high bar for industry-community compatibility and for this project to become the model for successful community relations for potential CCS projects on a national scale," said Jessica Smith, professor of engineering, design and society at Mines and key member of the project team. "We will be developing the engagement strategy with key stakeholders in Pueblo to make sure it's done in a way that's locally responsive."



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
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Implementing technology like robotics helps the mining industry meet today's increasing demand for minerals and other materials, often in more effective and environmentally sustainable ways.

INDUSTRY 4.0!

SHAPING THE NEXT TECHNOLOGICAL LANDSCAPE

BY JEN A. MILLER

In the midst of a Fourth Industrial Revolution, companies are increasingly shifting to cyber-physical tools and systems—and Mines graduates are well-prepared for the new challenges

In the First Industrial Revolution, water and steam mechanized production. In the second, electrical power enabled mass production. In the third, electronics and information technology made automated production possible.

The world is now in the midst of the Fourth Industrial Revolution: a cyber-physical expansion that is, according to the World Economic Forum, “blurring the lines between the physical, digital and biological spheres.” This revolution, which started in the mid-2010s, is changing the ways we live and work due to increased development and implementation of technologies like artificial intelligence, machine learning, virtual reality and blockchain.



Cyber-physical tools will increase productivity, automate processes and solve more complex problems, opening new doors that no one even knew existed before. But what does the Fourth Industrial Revolution's promise mean for established industries that have enabled previous industrial revolutions, and how is Mines and its graduates stepping up to the challenge?

"We are going through a change in life," said Sebnem Düzgün, Fred Banfield Distinguished Chair of Mining Engineering at Mines. "Since we are in the middle of a lot of fast changes, it's really difficult to have an overview of those changes, but we are predicting—and prepared for—what's going to happen."

THE MINE OF THE FUTURE

For an industry like mining, the Fourth Industrial Revolution means envisioning and designing the "mine of the future," said Walter Copan, Vice President for Research and Technology Transfer at Mines. That means using resources like sensors connected through the Internet of Things (IoT), artificial intelligence, machine learning and autonomous systems to take a "holistic approach to understanding what a resource looks like and what opportunities there are to carry out an operation for mining and minerals processing in the most effective and environmentally sustainable way," he said.

It also means taking cues from other industries, like in medicine where laparoscopic surgery done robotically has become commonplace, and apply those enabled technologies. "You can have people in one part of the world carrying out delicate manipulations that are being done on the other end by robots and sensors," Copan said.

Cyber-physical technologies are now allowing those kinds of advancements and advantages to translate into mining, which is, due to the nature of the work, very different than the controlled and sterile environment of an operating suite. Technologies like robotics, automation, materials handling and advanced geospatial sensing are changing the way mining happens, Copan said, as are underground sensor networks and working in GPS-denied environments with IoT powered by 5G and quantum-based sensors.

"Since we are in the middle of a lot of fast changes, it's really difficult to have an overview of those changes, but we are predicting—and prepared for—what's going to happen."

—Sebnem Düzgün, Fred Banfield Distinguished Chair of Mining Engineering

This work "makes sure we're getting the material efficiently and safely from the subsurface," he said.

These tools may also enable "total mining" where "you may be going after a particular metal like lithium or platinum or one of the rare earth elements we need for electric vehicles or advanced batteries," Copan said. Through cyber-physical technologies, instead of just mining for one thing, companies can "target other materials that are available in the same mining operation and seek to extract the total value" from a location, instead of doing so over and over again at multiple sites.

The goal is to use a combination of advanced technologies to extract resources "in the safest way possible and most efficiently with regards to water and other materials, controlling those processes to get the maximum value with minimal environmental damage," he said.

EMBRACING EMERGING TECHNOLOGIES HELPS MINES MEET INDUSTRY DEMANDS

Throughout its history, Mines has been part of other technology revolutions, playing key roles in the rise of electronics, advanced computing and space exploration. Students are taught to be problem solvers and critical thinkers, whether they learn about that exact technology in the classroom or apply those skills to a new technology bursting on the scene. "Mines is preparing students at all levels to be confident problem solvers and ready with the foundational skills that help them see the big picture," Copan said.

Scott Fischaber '03 has had a front-row seat to see the Fourth Industrial Revolution in action, specifically how data collection and analysis has enabled changes to leap forward. In 2009, he co-founded Analytics Engines to build data analytics solutions to help other companies from across the public and private sectors to solve their business challenges using data.

In addition to this work, the company, which is headquartered in Belfast, Northern Ireland, runs a data analytics event there every year. It's one of the many ways in which Fischaber has seen access to technologies, like data analytics change, and become more widely available.

"It was basically a bunch of technologists in the room 10 years ago," he said of the conference's early days. Then business-oriented professionals started to realize the power of data, which prompted investment from players like Google, Amazon and Apple. That in turn pushed the technology ahead and made it more affordable to everyone else.

"We see the same thing happening in the analytics and AI space, that these technologies that were in the field of multinational organizations are now in the hands of everybody else," Fischaber said.

It's a pattern that keeps repeating itself. Large language model AI-enabled chatbots went from exclusive products for global companies to something anyone can use through mainstream platforms like ChatGPT.

Fischaber said Mines enabled him to take his skills and apply them to these quickly adapting fields. "At Mines, I had the opportunity to do things I was interested in to prepare for my professional life, but I also got that wider grounding in engineering in general," he said, which is vastly different than the higher education system in the United Kingdom, where he earned his PhD and also where college students specialize much earlier.

"We see the same thing happening in the analytics and AI space, that these technologies that were in the field of multinational organizations are now in the hands of everybody else."

—Scott Fischaber '03



Many industries are turning to cyber-physical technologies, like the mining industry using robotics, automation and other advanced systems, to change the ways in which we source and extract minerals.

Gianna Ricotta '11 has also been able to apply a Mines degree to a field that was just getting off the ground when she graduated. She expected to have a career in the oil and gas industry, and that's where she started after earning her degree. But she quickly realized that she was more interested in project management than strictly being an engineer. So she went back to school to earn her MBA and jumped into the tech space.

"I like the start-up life. It's trial by fire. You don't really have a set job description or role. I go around and plug holes where I see them," she said.

That's what she does as the director of product delivery at BurstIQ, a blockchain-enabled platform that "provides the back-end plumbing to connect a lot of disparate data," she said. Blockchain is a shared database, with an unchangeable ledger for recording transactions. Because "blocks" on the blockchain can't be altered, using this kind of database allows for different ownership models of how personal data is collected, managed and controlled.

Her experience at Mines prepared her to switch gears and work with technology with a potential that was just starting to be realized when she earned her undergraduate degree. While blockchain is normally associated with cryptocurrency, it's current and potential applications reach far wider, and she is steering how it can be used in the healthcare space.

Ricotta said she could make the career shift because "Mines encourages problem solving and curiosity," she said. She still uses techniques she learned at Mines to innovate and tackle engineering problems today.

She has also recruited fellow classmates to work for BurstIQ. "We want to be in a role where we're making an impact and learning new things, and problem solving is foundational for a lot of Mines graduates."

BurstIQ also submits a project for Mines students to work on with the company every year, because she knows that students are learning how to think about engineering problems in new, Fourth Industrial Revolution ways and are going to be leading the charge into whatever that world will be.

"We are problem solvers," she said. "We see a problem here. Let's try to figure out why it's happening and how we can fix it to improve our process."

"We want to be in a role where we're making an impact and learning new things, and problem solving is foundational for a lot of Mines graduates."

-Gianna Ricotta '11

THE FOURTH INDUSTRIAL REVOLUTION PUSHES INDUSTRY CHANGES

Mines is bridging the gap when it comes to helping industry realize the potential of these technologies and making that mine of the future happen, even if it means pushing industries that traditionally have been slower to adopt new technologies into the future.

Mines' faculty is deeply involved in this work, as are students who are being prepared for careers impacted by the Fourth Industrial Revolution by working on real-world problems right now. Through the Innov8X studio at the McNeil Center for Entrepreneurship and Innovation, students can work on open-ended questions and incubate promising solutions to problems through either summer residency programs or as a class as part of their regular academic coursework.

"We bring the challenges of industry into the classroom," said Düzgün. "They say what they need, and based on those needs, our students find solutions."

It's far from unusual for those solutions to "lead to an innovation or establishment of a new startup company," she said, and that students are taking the solutions they develop to market.

This fall, Mines will also open the Beck Venture Center, which will offer guidance on business model development, introductions to mentors with technical or industry expertise and guidance for raising capital.

"Those centers are not only helping our students but also matching our students with alumni and faculty and their innovation needs," Düzgün said. "In terms of what Mines is doing, it's everything."

A GOOD STEWARD TO THE WORLD

Leslie Collins '98 empowers workers and protects the environment in Meta's supply chain

BY SARAH KUTA

Long before technology company Meta's virtual reality headsets land in the hands of consumers, the futuristic devices must make their way through a complex supply chain. As Meta's head of responsible supply chain sustainability, Leslie Collins '98 leads a team that strives to ensure safe, healthy and fair working conditions in the company's global hardware supply chain.

It's a role that she—and the company more broadly—takes incredibly seriously. More and more, consumers want to know how and where their favorite products get made. Companies need their supply chains to be resilient, since disruptions of any kind can be bad for business.

But, beyond that, protecting people and the planet is simply the right thing to do.

"It's about being a good steward to the world," Collins said.

As a child growing up in Pueblo, Colorado, Collins never imagined she'd end up traveling all over the world on behalf of major international companies like Meta and HP. But when a high school guidance counselor encouraged her to dream big and make the most of her strong math and science scores, she set her sights on Mines.

Her Mines education helped her rise through the ranks at HP, from a fresh-out-of-college technical role to being global manager of supply chain responsibility. Early in her career at HP, she visited an international factory for the first time and uncovered her deep passion for human rights and supporting worker well-being, a broad, industry umbrella term that includes everything from working hours to ergonomics to wages and benefits.



"I had no idea when I left Mines that this was going to be my long-term career path, but just that whole experience of being on the supply chain floor and seeing how brands work and how other countries produce goods really lit a fire inside me to see how I can further support and protect workers," she said.

Now, at Meta, she's continuing to keep worker wellbeing and environmental sustainability at the forefront during every step of the product development cycle—from mining the raw materials to manufacturing the consumer hardware to, finally, reusing and recycling products that have reached the end of their useable lives. Throughout its supply chains, the company wants to ensure that materials are being sourced responsibly, that workers are safe and healthy and that operations make as little environmental impact as possible.

To promote supply chain responsibility, Collins' team leverages a set of social, environmental and ethical standards developed by the Responsible Business Alliance, an international group originally made up of only leading electronics companies but has since expanded to other sectors, like retail, automotive and toy. Meta also annually publishes its own anti-slavery and human trafficking statement, as well as a conflict minerals disclosure and policy.

With these and other standards as their guiding lights, Collins and her team promote collaboration with a supplier development approach that is based on a continuous improvement model, working closely with suppliers to help them understand, prevent and mitigate risks in and to their business.

For example, last year, Meta partnered with a third-party company to create a new "Building a Respectful Workplace" program that builds suppliers' and workers'

"THAT WHOLE EXPERIENCE OF BEING ON THE SUPPLY CHAIN FLOOR AND SEEING HOW BRANDS WORK AND HOW OTHER COUNTRIES PRODUCE GOODS REALLY LIT A FIRE INSIDE ME TO SEE HOW I CAN FURTHER SUPPORT AND PROTECT WORKERS."

understanding of harassment and discrimination in the workplace and supports their capacity to identify and address these issues. The company also completed an environmental health and safety (EHS) analysis that led to the creation of a practical toolkit to help suppliers manage some of the most common EHS challenges in the workplace.

Collins' team also leads Meta's water restoration program tied to initiatives for the company's data centers, which power platforms like Facebook and Instagram. By 2030, the company aims to make the data centers "water positive" by returning more water to the environment than they consume.

Through it all, she's remained committed to making the world a better place.

"It's in my DNA, and I'm so grateful to have a passion-based job to wake up to every day," she said. "Knowing I may be making even a small positive impact on someone's life motivates me."

SHERIDAN ROSS PC

ATTORNEYS AT DIFFERENT PERSPECTIVES



Patent



Trademark



Commercial Litigation



IP Litigation



REMEMBERING ONE HELLUVA OREDIGGER

Marv Kay's legacy will live on at Mines

BY MINES STAFF

Marv Kay '63, the iconic Mines and City of Golden leader, died on April 19, 2023, at age 84. His generosity, leadership and influence spanned generations of athletics, university and civic community members.

A longtime Mines coach and administrator, Kay was inducted into the Colorado Sports Hall of Fame in 2019. In honor of his legacy, April 11, 2019, was proclaimed Marv Kay Day in the State of Colorado, in Golden and at Mines. Maple Plaza, the central pedestrian thoroughfare on the Mines campus, was also renamed Marv Kay Way.

Perhaps the most enduring symbol of Kay's influence is the Mines football stadium that was named in his honor when it opened in 2015. He was also famous for being the inspiration for the Mines mascot, Marvin the Miner.

Kay—a member of the Mines and Rocky Mountain Athletic Conference Athletic Halls of Fame—was one of the most influential individuals in Mines Athletics during his more than 40-year career. He spent a lifetime as a student-athlete, coach, administrator, professor and fundraiser at Mines. He shared his lifetime of sage wisdom as the keynote speaker at Mines' spring commencement in 2016.

"Rarely do we see people like Coach Kay who have committed their entire life to one school and the surrounding community," said Mines Athletics Director David Hansburg. "Marv Kay is clearly the greatest Oredigger of all

time, and his legacy will live on forever in the hearts and minds of his countless friends."

As a student-athlete at Mines, Kay lettered in football and wrestling and was an All-American lineman in football. He was also president of his junior class, the fraternity Sigma Phi Epsilon and was named Mr. Engineer during E-Days.

After graduating with a degree in engineering in 1963, Kay served in the U.S. Army Corps of Engineers for two years before returning to Mines to coach swimming and football. He became the head football coach in 1969. Over the next 26 years, he won a then-school-record 84 games (he still ranks second), was the RMAC Coach of the Year in 1975 and 1979 and coached 13 All-Americans and 50 All-Conference players. After his coaching days, he served as Mines athletic director for nine years. In 2016, he was inducted into the ROTC Hall of Fame.

Kay's influence and leadership reached beyond campus to the greater community. He served as the mayor of Golden from 1988 to 1996, as a member of the Golden City Council from 1986 to 1998 and as president of the Golden Chamber of Commerce in 1983. The Chamber recognized him as Outstanding Citizen in 1988 and 1993. Kay was a founder of Leadership Golden in 1984. He joined the Golden Civic Foundation Board in 1986 and served until his death. He was the board's president in 1987 and 2003.

Kay's last professional chapter was as a development consultant for the Mines Foundation, which he joined in 2010. Because of the close relationships he built over a lifetime, Kay was a master at matching alumni passions with important causes for the university in athletics and beyond.

Mines held a public celebration of life for Kay on May 15, 2023, at the football stadium that bears his name on the Mines campus.

➔ If you'd like to honor Marv Kay's legacy, donations can be made to the Marv Kay Champions Fund or Golden Civic Foundation, and you can also share your favorite memories or messages for the Kay family by visiting weare.mines.edu/marv.

MINES FOOTBALL RETIRES NO. 74

Mines football bestowed its highest honor with a surprise retiring of Marv Kay's uniform number 74 during a celebration of life ceremony held in his memory on May 15, 2023.

Held at the stadium bearing his name, Kay's daughters were presented with a jersey and a large banner was unveiled at the west end of the stadium bearing the number 74, which he wore as a student-athlete at Mines. His number becomes just the second one retired by the football program, joining Harry Campbell's No. 48. A permanent display honoring both numbers will be incorporated into the stadium this summer.

Current Oredigger football player Zack Morris—who, like Kay, plays offensive line—wears No. 74 and will continue to do so until his graduation to honor Kay, at which time the jersey will be permanently retired.



IT REALLY IS ROCKET SCIENCE

Paul Anderson '85 is up for any challenge when it comes to the space industry

BY SARAH KUTA

Since childhood, Paul Anderson '85 has never been afraid of a challenge. It's a character trait that propelled him to success on the basketball court and the golf course as a two-sport athlete at Mines, while also earning top grades in his classes. It's also helped him excel in his decades-long career in aerospace engineering, a complex and ever-evolving field that's become an important piece of Colorado's economy in recent decades.

Over the last 37 years at Lockheed Martin, he's worked on countless high-profile, high-impact projects—ranging from the Orion Artemis II mission, which aims to return astronauts to the Moon, to the Mars Reconnaissance Orbiter, which is searching for evidence of water on the Red Planet.

"I didn't know anything about space or that it would be a passion of mine until I got into it," said Anderson, who currently serves as the deputy program manager for the Orion program at the company. "I just loved the challenge—that was the underlying thing that made space so attractive to me. I'm very, very competitive, and there's no greater challenge than what we do in the space industry. For people who love challenges, it doesn't get a whole lot harder than this."

As the aerospace industry continues to grow in Colorado and beyond, Anderson is also helping to promote Mines' influence and interest in space exploration through his involvement in the Aerospace Interest Group at Mines. With his leadership and input, Mines continues to make meaningful contributions to the aerospace community. Chief among them? Its graduates, who go on to work for the more than 500 aerospace-related companies in the Centennial State.



"Colorado is the Silicon Valley of aerospace, and Mines has just done an incredible job of adapting as this industry has just exploded," he said.

But aerospace wasn't always so big in Colorado. When Anderson graduated from Mines in the mid-1980s, most students pursued careers in the energy industry—either oil and gas or mining. But, on a whim, he decided to accompany a friend to a weekend job fair, where he had a fateful meeting with a representative from Martin Marietta (now Lockheed Martin). He wasn't especially interested in aerospace engineering at the time, but he was curious and decided to see what the industry was all about.

He's been with the company ever since, working his way up through various roles until he began managing large projects and teams at the company, which is a major prime contractor for NASA, the U.S. Department of Defense and other publicly funded agencies. Though he's been at Lockheed Martin his entire career, Anderson said he's never had a boring day at work.

"Every project is so different, it feels like I've had 25 different jobs," he said. "What I always say is, 'It really is rocket science.' What we do every day, in most cases, has never been done before."

"WHAT I ALWAYS SAY IS, 'IT REALLY IS ROCKET SCIENCE.' WHAT WE DO EVERY DAY, IN MOST CASES, HAS NEVER BEEN DONE BEFORE."

Looking ahead, the next generation of aerospace professionals will continue to solve all sorts of challenges and make new discoveries in space. One big one? Answering the question of whether life exists—or has existed in the past—beyond Earth.

"We will most likely have a definitive answer to that question in the next 20 years," Anderson predicted.

Another key area of growth will be in national defense, since having a military advantage in space is a key enabler for our nation's security. The aerospace industry will also continue to provide up-to-the-minute weather and climate data, which will help inform disaster response and emergency preparedness.

And as it evolves even more, the industry will continue to lean on experts in a wide array of fields, from computer science and electrical engineering to accounting, political science and communications.

"Space truly provides inspiration for everybody," said Anderson. "From the nerdiest engineers to college athletes, business and history majors and artists, it really is for everyone."



Kenny Hora,
Class of 2025
Student Philanthropy Award

Jake Coker '19
Young Philanthropist Award

David Hansburg,
Athletic Director
Faculty & Staff Philanthropy Award

Jim Thorson '85
Volunteer of the Year Award

Beavers Charitable Trust
Foundation Philanthropy Award

Charlie '71 & Judy McNeil
Tourmaline Award



Teresa Johnson wears tourmaline yoga leggings at the Terra Persona booth at the Geological Society of America Connects 2022 event in Denver, Colorado.

MICROSCOPIC MASTERPIECES

Terra Persona's personal and home decor products celebrate geology's hidden artistry

BY ASHLEY SPURGEON

If you've ever looked at a rock sample under a microscope, you might think you're looking at an intricate piece of abstract art.

That kaleidoscope of colors and complex crystal structures is exactly what inspired Teresa Johnson '10, MS '15 and Mandi Hutchinson MS '16 to create Terra Persona, a personal and home decor brand that prints microscopic geologic photographs on products such as tote bags, clothing, tea towels and more. Using their geology backgrounds, the pair focused on combining science, art and sustainability to create a brand that both inspires and educates while being environmentally and ethically conscious.

"I love looking at rocks under the microscope," Johnson said. "Then turning it into something artistic filled another need in my life to be creative."

Although Hutchinson left the company in 2019 to focus on her gem and mineral business, Alta Gema, Johnson is still looking down the microscope to find the most interesting images to share with others. We recently sat down with Johnson to learn more about how Terra Persona has evolved since its inception and what Johnson has learned from starting her own business.

MINES MAGAZINE: WHERE DID YOU START WHEN FIGURING OUT HOW TO SELL YOUR PRODUCTS?

Teresa Johnson: Originally, we wanted to market this to everybody and were just looking for interesting rocks. Mandi had a background in the gem industry and mineral shows, so we decided to purchase some samples that were more familiar to the gem industry. It was a lot of pieces that people like to make jewelry from. We started going to gem and mineral shows, and people were really interested.

Later, I was able to procure a microscope to take to shows with me, and people were actually able to look at what was underneath the microscope. We could talk about the science aspect of it and why a specimen looks a certain way and the physics of light and how it bends and goes through crystals depending on their shape.

Then we started going to geology conferences, and that is definitely our niche. These are the people who look at the designs and know what they are. I've had people come up to me and say, "Oh, my gosh, is that meteorite NWA 10153? I did research on that rock." And that's just so special. There's more interacting and sharing with other researchers about what they're doing.

MM: WHAT IS A CHALLENGE YOU'VE HAD TO OVERCOME IN THIS PROCESS?

Johnson: I wanted the images that are printed to look exactly like it looks under the microscope, which is a bit of a challenge with variations in the microscope's lighting, the software, the camera, the printers. Everybody handles colors differently. It took about a year to get the color down correctly. We wanted to make sure geologists could identify the rock type, the minerals and the textures of everything that was going on.

A cross-polarized photomicrograph of the Martian nakhlite meteorite NWA 10153 that is used in some of Terra Persona's product designs.

Photos courtesy of Teresa Johnson



MM: WHAT WAS THE INSPIRATION FOR HAVING SUSTAINABILITY BE A CENTRAL PART OF THIS COMPANY, AND HOW DID YOU GO ABOUT INTEGRATING IT INTO YOUR BUSINESS PRACTICES?

Johnson: We knew we wanted to have quality products. We wanted the people who were making them to be paid fairly. We wanted the materials that were being used to be sourced locally as much as possible.

For the jewelry, I found a great company at the Tucson Gem Show that works with a community in India teaching trades, benefitting the community. One of my favorite companies I'm working with is Knotty Tie. I was able to put our designs on their custom ties. The tie fabric is made from recycled plastic water bottles and feels just like satin. They also have a social responsibility piece where they're working with refugees in Denver to achieve economic self-sufficiency through skills-based employment. It's something that's super important to me, and anytime I can collaborate with a local company or anybody who is trying to do the right thing, I'm going to take advantage of that.

MM: OTHER THAN YOUR EDUCATION AS A GEOLOGIST, HOW HAS YOUR MINES BACKGROUND HELPED YOU START TERRA PERSONA?

Johnson: I learned how to tackle really hard problems. So much of Mines is dealing with big projects, and this company is like a big project. When it was time for our first release and our website launch, things went completely haywire at about one o'clock in the morning when I thought it was ready to go. One of the software programs we were using made a major change overnight and completely wrecked everything, so I had to stay up all night fixing it to meet our deadline. My Mines education really instilled in me how to really dig in and get things finished on a tight deadline.

MM: WHAT ADVICE DO YOU HAVE FOR ANYONE LOOKING TO START A SIMILAR VENTURE?

Johnson: The first thing I'd recommend is setting up a basic business plan. It doesn't need to be perfect, but it's a good place to start. And then just go for it. I've had so many people come up to me at the geology conferences and say, "Oh, I've always thought about doing this." Even if your idea might not be fresh and new, a lot of people don't take the action of getting it done and taking that step.

➔ Learn more about Terra Persona and see their latest designs at terrapersona.us.

IN THE SPOTLIGHT

Shark Box Theatre Company focuses on promoting creativity and community

BY MINES STAFF

If there's one thing to know about Mines graduates it's that they love to create, be it a new technology, a new business or a piece of art. Mark Walden '18, Makenzie Parimuha '18 and Dalton Metz '20, the founding members of Golden, Colorado-based Shark Box Theatre Company, are no exception.

Shark Box Theatre Company was first conceived when the trio—and other Mines students—were involved in Mines Little Theater productions. “Kenzie, Abby Hentges and I had this dream that one day we were going to make ‘Mines Bigger Theater,’” Walden said.

After they graduated and went on to pursue careers in engineering fields, they were all still looking for that creative outlet and opportunity to express themselves in areas outside their professional lives. In 2021, they got the theater company up and running with their first production, *Boeing, Boeing*.

We recently talked with Walden, Parimuha and Metz about the process of starting a local theater company, how their engineering backgrounds have enabled them to be resilient through challenges and the value the arts brings to them and their local community. Here is some of what we learned.

STARTING SHARK BOX THEATRE COMPANY REQUIRED ENTREPRENEURIAL SKILL, AND THE HARDEST PART WAS LEARNING TO ASK FOR HELP—AND ADAPTING TO NEW SITUATIONS.

Establishing a new theater company requires more than deciding what to perform and hiring actors to

Actors perform in the dress rehearsal for Shark Box Theatre Company's production of *Boeing, Boeing*.

Photos courtesy of Shark Box Theatre Company



fill a stage. It takes everything from creating a business plan and fundraising to building the sets and creating costumes. And that often requires help from others.

“I wanted to do everything and have my hands in every part of the process and make it all perfect,” Walden said. “But there is a zero percent chance any of it could have happened without the constant help of everyone's families, neighbors and friends. Taking my foot off the throttle and asking for that help and really appreciating that people really wanted to help was essential.”

And to add an extra challenge to getting up and running is the fact that the theater company uses different theaters for their productions and often requires creative problem solving to make the transition between rehearsal and final production seamless.

“We jump from theater to theater, but we do have a dedicated rehearsal space. However, that rehearsal space is often not the same shape or size of any of the stages we've been on,” Walden explained. “We've had to design all our sets so they can be as close to reality as possible in our rehearsal space and translate over to the stage and not be too different.”

AN ENGINEERING BACKGROUND AND A MINES EDUCATION HAS COME IN HANDY FOR ADDRESSING THESE NEW CHALLENGES AS THEY'VE COME UP.

From the puzzle of moving sets into a variety of new spaces to handling the lighting and sound, adaptability and the ability to learn new processes and technologies has been key.

“Mines didn't train me in this exact software,” Walden said when discussing the systems he's had to learn to use in each production. “They did train me how to learn. I learned similar software, so I was able to pull from my experiences and adapt to new situations as fast as I could.”

“I was also part of a lot of different clubs and organizations at Mines, and they all taught me how to be philanthropic and a lot of the conflict-resolution skills that have been important in this business,” Walden said.

With a small company, all the players often have to wear multiple hats and collaborate to bring a production together—skills Mines instilled from their first day on campus. “Pretty much everyone at every level has their main job, whether it be codirector or stage manager or actor,” Parimuha said. “But because of the nature of a small theater



Some of Shark Box Theatre Company's rehearsals for *Boeing, Boeing* were done semi-virtually due to COVID-19 pandemic restrictions.

company, you have to do more than that. You have to be thinking about what other people in the show need, like costuming and stage dressing and lighting. It really is a team effort.”

PURSuing INTERESTS BEYOND THEIR PROFESSIONAL LIVES ALLOWS FOR MORE OPPORTUNITIES TO BE CREATIVE AND BUILD COMMUNITY IN NEW WAYS.

The trio agrees that engaging in activities outside their day-to-day lives is essential for living a balanced life and keeping their creativity sharp.

“I think having a place where you can go and get out of the left side of your brain and relax and do things that are separate from engineering and everything we do on a daily basis is important,” Metz said.

“Everybody has the ability to create, to empathize, to express themselves in new ways,” Parimuha said. “And continuing to explore that side of yourself through creative means is super impactful on your overall mental wellbeing and outlook on life.”

And these benefits extend beyond the performers to include the audience as well.

“We're not just giving ourselves a creative outlet,” Walden said. “We're giving an entire community a reminder that we can co-exist as a society and that there is beauty in the world. There is something fun we can hold onto.”

➔ Learn more about Shark Box Theatre Company and their upcoming productions at sharkboxtheatre.com.



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BRINGING ACADEMIC RESEARCH INTO THE REAL WORLD

Mines student research on underground construction becoming part of industry work

BY JASMINE LEONAS

When Jacob Grasmick MS '13, PhD '19 was in graduate school at Mines, he hoped that the research he was doing would eventually advance industry practices. Now an alum of the Civil Engineering program and Center for Underground, Grasmick co-owns an engineering firm, Emprise Concepts, and is bringing what he learned at Mines into real-life application.

"I am driven by the prospect of implementing research into practice and helping to bridge that gap that we often see between academia and the industry," Grasmick said.

Grasmick's dissertation research at Mines focused on better understanding ground conditions for tunneling and other construction projects that depend on accurate data about subsurface conditions, especially in urban environments. Commonly, current practice relies on a subjective interpretation of the variables involved in underground construction, Grasmick said. He worked on developing more reliable, data-driven risk quantifications of ground conditions, analyzing data sets from around the world in North America, the United Kingdom, Singapore, Hong Kong and New Zealand.

With the goal of getting his data-driven risk quantifications into industry, Grasmick applied for a National Science Foundation (NSF)



Photos courtesy of Jacob Grasmick

America's Seed Fund grant, which provides financial support for scientific and engineering discoveries with the potential to transform into products and services with commercial and societal impact. Emprise Concepts was awarded this grant in May 2023, with Mines as a sub-awardee, receiving \$275,000 split between his business and Mines. He's working on a six-to-12-month feasibility study and then will submit for Phase Two of the grant, which awards up to \$1 million for one to two years.

"The NSF looks for projects that will have a broader impact on the health and well-being of society," Grasmick said. "Our work fits nicely in line with the challenge we have as a nation with needing to upgrade and build new infrastructure, with the aim to help reduce the cost of civil infrastructure construction and helping make new infrastructure more sustainable."

With the help of the grant, the team is developing a computational tool to create and update subsurface models in real time using data-driven advanced analytics. The project strives to improve the understanding of ground conditions by providing a solution to update the models during underground construction in a routine and autonomous manner, making full use of the wealth of data collected during construction.

Michael Mooney, Grewcock Chair Professor of Underground Construction and Tunneling, served as Grasmick's PhD adviser.

He said the techniques Grasmick worked on within the Center for Underground at Mines help better quantify the risks involved during tunnel construction.

"Seeing these techniques that Jacob spearheaded be implemented in tunnel projects around the world, tells us that the work we're doing and the work our students are doing in the Center for Underground is really benefiting industry," Mooney said. "To me, that's the best measure of the quality of university engineering research. Is anybody using it? Is it changing practice in a positive way? And here's a case where it certainly is."

Grasmick is co-owner of Emprise Concepts, a Colorado-based engineering firm that works on civil infrastructure projects. Grasmick said about a quarter of the firm's employees are Mines alumni.

"When Jacob graduated, he could have just moved into an established company in industry. He certainly had a handful of offers from all the top underground construction engineering firms. But he has the heart of an entrepreneur and is passionate about making a positive impact," Mooney said. "He really took a leap to make that happen. Not many engineers are willing to do that and I think that's pretty special."



WHY SHOULD YOU ANSWER THE CALL THIS FALL?

'DiggerDial is a group of students who connect with alumni, parents and friends to swap Mines stories, share information about upcoming events and discuss how the OreGiver community can get involved with philanthropy.



Help today's students enjoy a well-rounded educational experience and sustain Mines' reputation of engineering excellence as a premier STEM university.



Connect and share stories with current Mines students and learn about campus events, communities and initiatives.



"My favorite 'DiggerDial story is a conversation I had with a gentleman who graduated 30 years prior. We bonded because we had both been involved in Greek Life at Mines and about how his success as a chemical engineer has helped him be a role model for current students like me."

Dominic Sands, Class of 2026
'DiggerDial Caller



Several Mines alumni volunteered at the start this year's M Climb, weighing students' rocks to ensure they met the 10-pound requirement. Pictured left to right is Heidi Miller '08, MS '11, Lisa Haley '22, Frank Merrill '77 and Gary Hoffmann '70.

1960s

Roy Glenn Vawter '60 published his book, *A Sensible Plan to Create a Dynamic Energy Future* in April 2023.

1990s

Retired **Maj. Gen. Todd B. McCaffrey MS '97** was confirmed to lead the South Carolina Department of Veterans' Affairs in March 2023.

Kiran Patankar '99 was appointed as interim president and CEO of Maple Gold Mines in August 2023.

Jack Unrau '99, a software engineer at Fidelity National Information Services, was granted patents on November 22, 2022, for "Prepaid Card Funding For Single Transaction;" on January 3, 2023, for "Systems And Methods For Prepaid Card Funding For Sponsored Purchases;" and on April 18, 2023,

for "System And Method For Payment Processing Telemetry."

2010s

Joseph Lucius Albright was born to **Jonathan Albright '10** and Ashley Albright on March 12, 2022. Joseph joined big brother Gabriel (2).

Austin Pivarnik '12 and Rachel Pivarnik welcomed a baby girl to their family. Emma arrived June 21, 2022, joining big sister Poppy (2).

Brooke (Sorenson) Guiley '15 and **Jeremy Guiley '15** are happy to announce the arrival of their baby girl, Aspen Jo. Cheyenne (4) is excited about her big sister promotion.



Chelsea Panos '15, MS '19, PhD '20 and Colt Wilkins '15



Emma, Rachel, Poppy and Austin Pivarnik '12



Keira Trujillo '18 and William Behre '18

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.



Bradley Jesteadt '20, MS '21
and Autumn Schwinn

Blake Shiparski '17 and **Jacquelyn Miller '19** were married on July 29, 2023 in Morrison, Colorado, by their friend and fellow Mines alum Amy Goldstein '18, MS '18. Nine other Mines alumni celebrated with the couple, and they were also able to share a special Coors beer with Blaster during their cocktail hour.

Chelsea Panos '15, MS '19, PhD '20 and **Colt Wilkins '15** were married in Golden, Colorado on September 21, 2022, nine years to the day after they started dating. The couple met at Mines and got to know each other in Physics II class. They celebrated with their families with an outdoor movie night, complete with s'mores instead of cake.

Daniel Lamas '16 and Kimi Bourland were married on April 28, 2023, in Dripping Springs, Texas. Several alumni attended, including groomsmen Troy Woolbert '16, Max Sanktjohanser '16, MS '17 and Austin Williams '16.

Joni Sanborn '16 and Daniel Parisian welcomed their first child,

Robert (Rowdy) Sanborn, on June 16, 2022.

Keira Trujillo '18 and **William Behre '18** tied the knot October 15, 2022, in Grand Junction, Colorado. They met during orientation in their first year at Mines and began their relationship in their sophomore year. They were later engaged on South Table Mountain overlooking campus.

2020s

On April 15, 2023, **Bradley Jesteadt '20, MS '21** married Autumn Schwinn at Chapel in the Hills in Golden, Colorado. Together, they enjoy board games, music and travel. They share a passion for coffee and explore Denver's coffee culture on a shared Instagram blog, The Caffeine Heart.

Brenna Treanor Wood '20, MS '21 and **Alex Wood '21, MS '22** were married on a beautiful late-spring day, June 11, 2023, at the Denver Botanic Gardens Chatfield Farms in Littleton, Colorado. More than 10 other Mines alumni and staff



Aspen and Cheyenne Guiley

celebrated with Brenna and Alex that day, including groomsmen Connor Smith '21 and bridesmaid Sam Ralston, assistant director of community standards at Mines. The couple met working for Residence Life at Mines and still work together today in civil engineering consulting.



Joseph Lucius Albright



Joni '16 and
Rowdy Sanborn



Jacquelyn Miller '19
and Blake Shiparski '17

Brenna Treanor Wood '20, MS '21
and Alex Wood '21, MS '22



Daniel Lamas '16 and Kimi Bourland

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IN MEMORIAM

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

Dave Blumenstein '71 died April 8, 2023. Born in 1949, Dave spent his career with the Mining Safety and Health Administration in Lakewood, Colorado. He traveled to numerous mining sites across the United States and furthered safety regulation work in Washington D.C. In retirement, he continued educating U.S. Army Corps of Engineers personnel in health and safety in affiliation with Mines.

Edward C. Burgan '54 died April 13, 2023. Ed served as a paratrooper in World War II before spending his career as a geological engineer in Canada. He retired from Hudson Bay Oil and Gas in Toronto.

J. Michael "Mike" Elder '74 died in February 2023. Mike spent his career as a mining engineer, which included building the eastbound side of the Eisenhower-Edwin C. Johnson Memorial Tunnel in Colorado. He also served on the National Ski Patrol for almost 50 years.

Eric D. Emerson '86, MS '87 died July 22, 2023. Born in 1959, Eric spent his career in the oil and gas industry, working for companies such as Unocal Corporation and Chevron. His work took him around the world before he retired in 2020.

Melville C. Erskine, Jr. '60 died September 29, 2021. Melville spent his life traveling the United States and internationally prospecting for oil and gas, geothermal steam, copper and more.

John E. Fuller '61 died January 14, 2023. Born in 1939, John spent much of his career as a metallurgical engineer at the Rocky Flats Plant in Colorado. After Rocky Flats closed, he worked at the Los Alamos National Laboratory in New Mexico. He later worked as a government classifier at the Denver Federal Center until he retired.

Joseph S. Gates '56 died December 6, 2022. Born in 1935, Joe served in the U.S. Army Corps of Engineers for ten years then spent most of his career with the U.S.

Geological Survey. He also spent two years as a technical advisor in groundwater hydrology for the U.S. Agency for International Development.

Fred A. Kumpf '59 died January 16, 2023. He served in the U.S. Army Corps of Engineers and worked for Phillips Petroleum Co. for 30 years in the international and exploration and production departments.

Denis P. McNerny '66 died January 1, 2023. Born in 1945, Denis worked as a mining engineer in coal mines constructing shafts and tunnels. He continued in heavy construction as a project manager and consulted for the World Bank but spent most of his career with Frontier-Kemper Constructors, finishing his career as president and CEO.

Timothy C. "Tim" Thompson '57 died May 9, 2023. Tim was born in 1934 and served U.S. Army Corps of Engineers. Tim worked for Tenneco Oil Co. and Wilson Industries and managed Terry's restaurant in Huntsville, Texas. He was also president and general manager of Sargent Oilwell Equipment Co., where he spent the bulk of his career. Later, he was chairman, president and CEO of Production Technologies International and a business consultant to the oil industry.

James M. "Jim" Ticconi '00 died in 2021. Born in 1977, Jim founded Constructive Engineering, designing and building interiors for commercial buildings in Denver, Colorado. He also designed tools for repairing Vespas.

Robert A. "Bob" Lame '59 died July 20, 2023. Born in 1937, Bob was commissioned as a second lieutenant in the U.S. Army Corps of Engineers. He then stayed in the U.S. Army Reserve while working for the Los Angeles County Flood Control. He eventually served full time in the Army Reserve, retiring as a major general in 1998. .

➔ 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.

ANOTHER YEAR BEGINS WITH FAMILIAR TRADITIONS

The Class of 2027 arrives at Mines

This fall, Mines welcomed about 1,623 first-year and transfer students into the Oredigger community. Incoming students kicked off their Mines journey by participating in signature student experiences such as the M Climb and Oredigger Camp, learning what it means to be an Oredigger and getting their first immersion into campus life. Here are a few of our favorite shots from the fall kickoff traditions.



CLASS OF 2027 BY THE NUMBERS

1,623 new first-year and transfer students

33% women

34% underrepresented domestic ethnic or racial groups

18% first-generation college students

3.6% international students

48 states represented

21 countries represented

Top 3 U.S. states outside Colorado: **Texas, California, Washington**

Top 3 countries outside U.S.: **Saudi Arabia, Oman, Indonesia**



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Preparations are well underway for Mines' 150th anniversary celebrations in 2024. Recently, Starzer Welcome Center received an upgraded window decal on the south side of the building facing 19th Street featuring Mines' latest logo that showcases the school's legacy. Follow along with all our anniversary activities, and join in the celebrations over the next year.

➔ Visit weare.mines.edu/150 to learn more about Mines' enduring legacy and where the university is headed next.