

MINES

MAGAZINE

COLORADO SCHOOL OF MINES ALUMNI MAGAZINE



ON THE FRONTLINES OF TECH

Advancements in digital technology are being made at a rapid pace, and many Mines alumni have built successful careers by embracing the challenges and opportunities of these new innovations.

12

SMART ENGINEERING

Mines researchers are developing new smart technologies to improve efficiencies, which gives young engineers a leg up when adapting to technological changes in industry.

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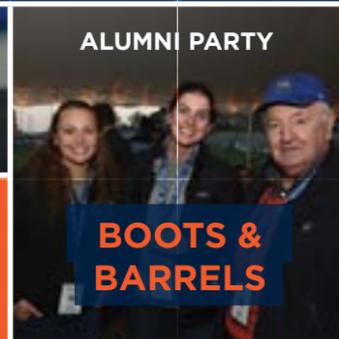
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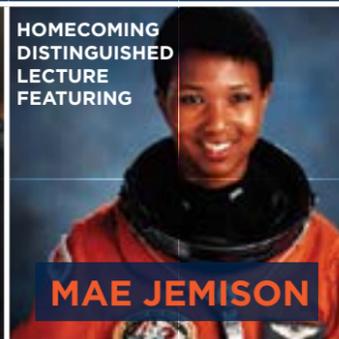


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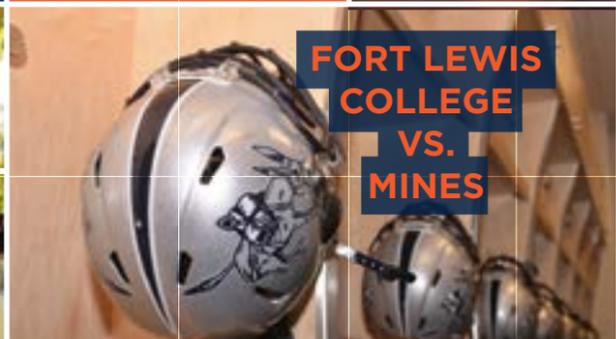
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Cover image: New technology has allowed humanity to adapt to new environments and has spurred societal advancements. Today, engineers and scientists continue to develop and use cutting-edge technology to improve processes and business practices, with Mines alumni and researchers at the forefront of innovation.

FEATURES



ON THE FRONTLINES OF TECH

Mines alumni are embracing new digital technology to meet society's ever-changing demands and new methods of social and business interaction.

SMARTER ENGINEERING

Mines researchers are working on new smart tech to improve efficiencies in many industries, and students are learning how to adapt to technological changes to be successful beyond the classroom.

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Comments and suggestions are welcome. Contact us via our contact form at minesmagazine.com/contact-us or via mail at *Mines Magazine*, 1500 Illinois St., Golden, CO 80401. To update your address, go to minesalumni.com/update or email minesalumni@mines.edu.

OPENING REMARKS

THE JOURNEY AND CLIMB AHEAD

Commencement is a celebration of accomplishment and an opportunity to reflect on one's journey through Mines. The Class of 2019 will always be special to me because I began my own Mines journey with them.

In August 2015, we climbed Mount Zion and placed our 10-pound rocks on the M. Together we discovered E-Days and other unique Mines traditions and learned what people mean when they talk about the predictably unpredictable weather in Colorado (which was especially true in the week leading up to May's commencement). We became part of and learned much about the Mines community—the hard work, dedication and multi-faceted talent of our students, the passion and enthusiasm of our professors and staff, the everlasting pride of our alumni and the common values and (sometimes quirky) traits that bind us all together.

Through the Class of 2019's journey, I saw the transformative power of Mines and began to understand the pride of our alumni and their propensity for professional and personal accomplishment. At many universities, students are often passive participants in their education and effect little change on their university as they pass through it. At Mines, the opposite is true.

Even with the time their challenging courses demand, our students are engaged and making their mark on Mines. For example, the Class of 2019 was key to establishing a new tradition, Oredigger Camp, where upper-class students welcome new students to the Mines community and introduce them to traditions, resources and what it's like to be an Oredigger. They also fueled the growth of innovation and entrepreneurship at Mines through the Blaster Design Factory and the Mines Maker Society. A group of them even brought back the *Prospector* yearbook after about a 10-year hiatus.

Through the Class of 2019, I was also able to see a much greater potential for Mines going forward. Those aspirations are documented in our MINES@150 strategic plan—we intend to thrive, to separate ourselves from the competition, to tackle grand challenges and be the preferred partner for industry, government and others who rely on our graduates and innovations. Mines will be known as the premier hands-on science and engineering university in this country.

We have reasons to be optimistic. We are strategically sized to be special. Our location in Golden and Colorado is advantageous. We have a well-established reputation. And we have our alumni, who are largely an untapped resource but are starting to lead key initiatives for Mines. At a time when some are questioning the value of a four-year college experience, our graduates stand as proof of what a motivated university and its ambitious students and alumni can do together.

You can see that in the stories in this issue of *Mines Magazine*. You will also find stories on two alumni who have been pillars of the Mines community: Marv Kay '63, who has been such an integral part of Mines that we just named the main path through campus after him, and Ramona Graves PhD '82, whose multi-decade impact on Mines and the petroleum industry is being recognized at her retirement through a new endowed chair established in her name by former students and friends.

I will remember the Class of 2019's journey and the mark they made at Mines. We owe it to them and every class that preceded and will follow them to answer their ambition with our own.

Here's to the journey and climb ahead. Go Orediggers!



Paul C. Johnson, PhD
President and Professor



UNDERSTANDING ANTARCTICA

INVESTIGATING WHAT IS MELTING THE ICE SHELF

Mines Geophysics Assistant Professor Matthew Siegfried was part of a team of scientists investigating an Antarctic ice shelf the size of Colorado and Utah combined that discovered an ancient geologic structure that controls the flow of ocean water deep under the shelf.

Researchers working on the project ROSETTA-Ice (Ross Ocean and Ice Shelf Environment, and Tectonic setting Through Aerogeophysical surveys and modeling) also mapped the thickness and internal structure of the ice shelf and identified a new mechanism for weakening large ice shelves that are presently stable. ROSETTA-Ice is a three-year interdisciplinary survey of the floating Ross Ice Shelf, which slows the flow of about 20 percent of Antarctica's grounded ice, equivalent to 38 feet of global sea level rise.

"Our conceptual understanding of Antarctica is still so new that we are quite literally redefining basic geologic boundaries beneath the ice," Siegfried said. "Now armed with this new insight into geology, we can begin to consider how the underlying geology interacts with modern ice and ocean processes to drive the changes we see occurring today."

Beth Burton '99, MS '04, a geophysicist with the U.S. Geological Survey's Geology, Geophysics, and Geochemistry Science Center in Denver, and Chloe Gustafson '15, a PhD candidate at Columbia University's Lamont-Doherty Earth Observatory, also contributed to the findings.

Ross Ice Shelf is typically more than 1,000 feet thick, which prevents traditional ship-based surveys of the seabed below it. The team's approach was to use the IcePod, a complex instrument package developed at Lamont-Doherty Earth Observatory and mounted on the outside of a ski-equipped LC-130 military cargo plane that flew a total of about 55,000 kilometers in a grid across the ice shelf. The instruments in IcePod measured the ice shelf height, its thickness and internal structure, and the magnetic properties and gravity signal of the underlying crust.

Each time the airborne team flew across the ice shelf, measurements from the IcePod magnetometer (used in geophysical surveys to detect magnetic anomalies) were almost unchanging until, halfway across the ice shelf, the instrument came alive, displaying large variations like the heartbeat on a cardiogram. When the team mapped

its results, it became clear that this "heartbeat" always appeared in the middle of the ice shelf, identifying a previously unmapped segment of the geologic boundary between East and West Antarctica.

When using IcePod's measurements of Earth's gravity field to model the shape of the seafloor beneath the ice shelf, "we could see that the geological boundary was making the seafloor on the East Antarctic side much deeper than the West, and that affects the way the ocean water circulates under the ice shelf," said Kirsty Tinto, the Lamont research scientist who led all three field expeditions.

Using the new map of the seabed under the ice shelf, the team ran a model of ocean circulation and its effect on ice shelf melting. Compared with the Amundsen Sea to the east, where warm water crosses the continental shelf to cause rapid melting of the ice shelves, little warm water reaches Ross Ice Shelf. In the Ross Sea, heat from the deep ocean is removed by the cold winter atmosphere in a region of open water, called the Ross Shelf Polynya, before flowing under the ice shelf. The model showed that this cold water melts deeper portions of East Antarctic glaciers, but it is steered away from the West Antarctic side by the depth change at the ancient tectonic boundary.

Overall, the ROSETTA-Ice researchers found that the local processes that contribute to polynya formation are key for understanding the fate of the world's largest ice shelf. Their study suggests that global climate models used to assess Antarctic ice sheet changes for future climates must be able to predict these local processes near the ice front, not just the large-scale changes in the circulation of warm deep water.

By **Emilie Rusch**



A team of scientists identified a previously unmapped segment of the geological boundary between East and West Antarctica, enabling them to run a model of ocean circulation and its effect on ice shelf melting.

Photo courtesy of Matthew Siegfried

BUILDING LEADERS

MINES ROTC CONTINUES ITS LEGACY OF TRAINING THE BEST AND BRIGHTEST CADETS

Capt. Brian Hotchkiss is the current department head of Mines ROTC, training cadets for future military service and leadership.

Photo by Ashley Spurgeon

Mines Magazine is kicking off a new series about Mines' military connections. We sat down with Capt. Brian Hotchkiss, ROTC department head, to talk about the value of ROTC at Mines and what the future holds for cadets.

What do you like about being at Mines?

I like the size of the campus, and Dan Fox [vice president and dean of students] and President Johnson really make us feel like part of the team. In general, pretty much everybody in the United States supports the military, but this place feels special. It's still shocking when people say, "Thank you for your service." There are not too many jobs where that happens.

How is ROTC structured today, and how has it changed over the years?

When it was mandatory, ROTC could be as difficult as they wanted to make it. Cadets probably had to endure a lot more. Now it's a volunteer force—a volunteer army. We are looking for people who are really good at what they do and are a value added to the force. We have some criteria that need to be met, but in general, we try to develop their skills.

We take the first semester and assess the cadets. They have to do a physical fitness test, and they're responsible for accurately diagramming their degree plan all the way out to graduation. After their freshman year, cadets become an MSII—military science, level two. Between their third and fourth year, they'll go to advance camp in Fort Knox, Kentucky, where they're evaluated on leadership and small unit tactics and some physical events. Then they're in MSIV, their fourth year. They then spend their last semester as an engineer and have an independent study with me. After that, they commission.

What does the future of Mines ROTC look like?

We're working on designing a trailer that accommodates the 3,000 pounds of equipment that's required for the new fitness test the Army now requires. There are a couple of prototypes out there right now that people have been working on, but I think if anybody can engineer it, it'll be us. We're going to come up with a multiuse trailer that stores the equipment, and it'll be more effective to have a mobile unit that can be shared across many units.

Something a little further down the road is developing an air rifle competition team. Marksmanship used to be a big, competitive thing at Mines, and I'd like to bring that back.

I also want to start a professional discussion series with people who are either successful in their civilian career and can connect that to the cadets or people who can speak to how to move forward and be successful in the military and how ROTC helped them. I'm trying to get people who will influence these cadets. It really reinforces the things we teach them.

What is it like to carry on the legacy of Mines ROTC alumni?

We're very proud of the history of the previous Mines cadets and officers. It's a pretty rich and strong history. I think every army unit is really tied into their past, and that develops pride. I can see there's a lot here—a lot of history, a lot of things to be proud of. We definitely appreciate alumni support and look forward to more involvement.

Interviewed by **Ashley Spurgeon**

► If you would like to share your ROTC or military stories and experiences with Mines ROTC, contact Fran Aguilar at faguilar@mines.edu.

ATHLETICS

OVERACHIEVING OREDIGGERS

AMONG THE ELITE

In college athletics, the NCAA's Elite 90 award represents the absolute best of the best when it comes to scholar-athletes. The award is given to just one recipient in each of the NCAA's 90 sanctioned sports across all three divisions, recognizing the student-athlete with the top GPA at each championship. It's an exceptional achievement for an institution to win one in a year, and in 2019, Mines track & field came away with two.

Ben Schneiderman '17 and Megan Wenham '19 took home the outdoor track & field Elite 90 awards in late May, making Mines the first school in NCAA Division II history to win both the men's and women's awards in the same year.

Schneiderman holds a 3.96 GPA and is working on his master's degree in metallurgical and materials engineering. He finished his track career as a First-Team All-American in the 10,000-meter run.

Wenham finished an incredible Mines career with an unblemished 4.0 GPA, receiving her bachelor's degree in mechanical engineering in May. She was also a First-Team All-American in the steeplechase and was named the RMAC's Female Scholar-Athlete of the Year in early June.

Photos by Tyson Jex/West Texas A&M University



Andrew Epperson '14, now an assistant track & field coach at Colorado State University, paces the field in the 10,000-meter run at the Kit Mayer Invitational on April 13, 2019.

Photo by Tim Flynn

RUNNING ON THE WORLD STAGE

Former Mines distance running standout Andrew Epperson '14 is headed to one of the biggest events in world athletics this fall after being selected to the United States marathon team for the International Association of Athletics Federation World Championship. One of just three American men selected for the field, Epperson will run in Doha, Qatar, on Oct. 5, 2019. He had previously competed in the 2016 U.S. Olympic Trials and qualified twice for the Chicago Marathon, finishing as high as 12th in 2016.

Epperson is currently an assistant coach for Colorado State University's cross country and track & field teams, and the Houston native served in the same role at Mines before moving to Fort Collins. As a student-athlete at Mines from 2010-14, he was a two-time cross country All-American and qualified for the NCAA Division II National Championships in both the indoor and outdoor 5,000-meter run and the outdoor 10,000-meter run.

GOLF, TRACK & FIELD CONTINUE THEIR WINNING WAYS

The spring season proved to be a successful one in 2019 as two Oredigger teams defended their conference titles from the year before.

Under the leadership of RMAC Golfer of the Year George Markham and RMAC Coach of the Year Tyler Kimble, Mines golf ran off a string of four consecutive tournament wins in the spring, culminating in their victory at RMAC Championships. For the second straight year, the Orediggers won by a single stroke after 54 holes—this time over nationally ranked Dixie State—as Nic Beno, Markham, Tim Amundson and AJ Berry all finished in the top 10 individually. It was the first time in 51 years that Mines won consecutive RMAC Tournament championships and their seventh overall. The Orediggers went on to earn a berth to the NCAA Regional Championships.

The men's outdoor track & field team claimed its second consecutive RMAC Championship with a dominating effort at the conference meet in late April, outclassing the field by 40.5 points to win back-to-back outdoor crowns for the first time in program history. The women's team also finished a best-ever second as the two teams combined for nine gold medals. The Mines men later reached their highest national ranking ever at No. 2, while both the men's and women's programs achieved successful NCAA Championships appearances with a combined 10 All-America finishes.



Photo courtesy of Rocky Mountain Athletic Conference



Photo courtesy of South Dakota School of Mines & Technology

2018-19 SEASON HIGHLIGHTS

★★★★ 10 ★★★★★

RMAC TEAM CHAMPIONSHIPS
THE MOST IN CONFERENCE HISTORY

4th CONSECUTIVE
RMAC ALL-SPORTS CUP VICTORY



37

ALL-AMERICANS

7 RMAC
COACHES
OF THE YEAR

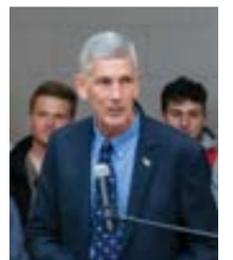
10 RMAC
PLAYERS
OF THE YEAR

3.16 ATHLETIC
DEPARTMENT
GPA

110 STUDENT-ATHLETE
DEGREE RECIPIENTS

JOHNSON NAMED CHAIR OF RMAC EXECUTIVE COMMITTEE AND PRESIDENTS' COUNCIL

President Paul C. Johnson was named the Rocky Mountain Athletic Conference Executive Committee and Presidents' Council Chair on June 3, 2019. Johnson will serve a two-year term leading a five-president council made up from the 16 members of the RMAC. He will have responsibility for making interim decisions and instituting immediate actions in emergency situations which involve the best interests of the conference, an active member institution or a student-athlete. Johnson will also recommend to the Presidents' Council any legislation, eligibility rules, regulations or policies, along with several other duties.



By Tim Flynn

► For more on Mines athletics, visit minesathletics.com.



EARTH OBSERVATION IN MINING

MONITORING THE RELATIONSHIP BETWEEN
RAW MATERIALS AND HUMAN DEVELOPMENT

Nearly 70 percent of the world's population is expected to live in urban regions by 2050, and the inevitable transformation of rural areas will increase the need for raw materials, generated through sustained mining activity. Advances in earth observation (EO) systems will help make that process more efficient and sustainable.

Earth observation (EO) systems provide excellent opportunities for such exploration. An EO system consists of a sensor system—a camera—that collects data from the Earth surface, a platform—a satellite—on which the sensor system is mounted, a data transfer system that delivers the collected data to the ground station and a set of algorithms to interpret the data.

However, the cameras we use in our everyday lives are designed for human vision and inadequate for mineral mapping. Human eyes can only see red, green and blue wavelengths on the electromagnetic spectrum, but rocks and their mineral content can be better identified with hyperspectral cameras that can detect a broader wavelength range.

The minerals in rocks and soils have unique signatures. These mineral signatures are used to interpret the images collected from the hyperspectral cameras to create mineral

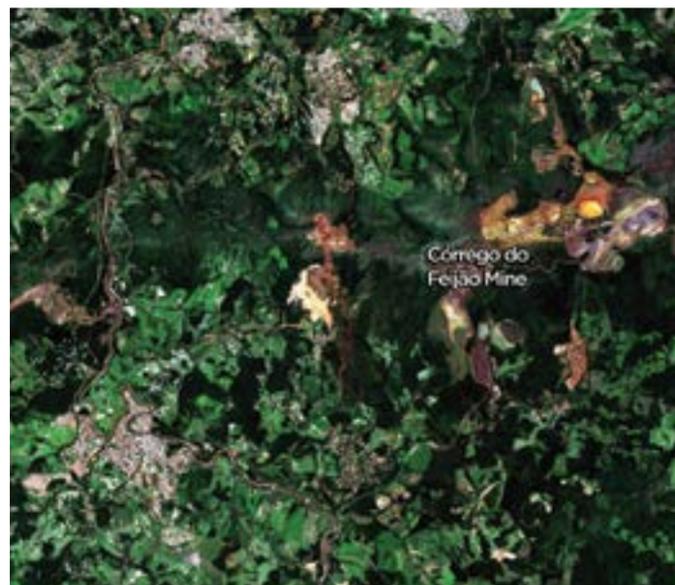
maps of a given region, providing exploration geologists with a better understanding of geological processes and helping them narrow down an exploration area. Hyperspectral images are also useful for low-cost mine environmental monitoring and can help mining companies monitor their operations' downstream impacts and develop effective mitigation measures.

EO systems can also help find new opportunities at abandoned mine sites and map minerals that can be exploited in an economical way. In surface mine operations, drones equipped with hyperspectral cameras can collect images from exposed orebody, helping mine planners update mineable reserves.

The applications for EO systems in the mining life cycle (from mineral exploration to mine closure) are seemingly endless, and this technology is becoming essential in the mining industry, with many benefits for future geological exploration and human development.



By **H. Sebnem Duzgun**
Fred Banfield Distinguished Endowed
Chair in Mining Engineering



These Earth observation system images show the effects of the Córrego do Feijão Mine collapse in Brazil earlier this year. The collapse released a torrent of tailings that flattened buildings and polluted the Paraopeba River, a source of drinking and irrigation water for many people in the area.

Images courtesy of H. Sebnem Duzgun

A GOLDEN PROGRAM

50 YEARS OF MINERAL AND
ENERGY ECONOMICS AT MINES

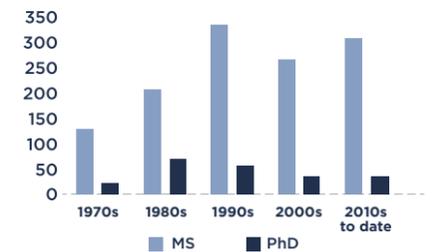
This year, Mines marked the 50th anniversary of the mineral and energy economics (MEE) graduate program with a special celebration on April 16, 2019. The event featured a campus tour, networking reception, a presentation by President Paul C. Johnson and Rod Eggert, interim director of the Division of Economics and Business, as well as an alumni panel moderated by Ian Lange, MEE program director.

"MEE students have distinguished themselves while at Mines but even more so after graduation as executives in mining and energy companies, banks and financial institutions, as consultants, ministers of mines and energy and as academics," Eggert said.

Before it was a program, mineral economics was a class at Mines—covering risk assessment, capital formation and use, resource availability, forecasting market prices and trends and the impact of technology changes on resources companies. However, the desire for a more extensive economics curriculum led to the launch of the mineral economics graduate program—later becoming the mineral and energy economics graduate program.



Graduates By Decade



Throughout the years, the program has continued to grow, offering more degree options and educating students on specific areas of management and evaluation of economic alternatives. To date, the MEE program has awarded a total of 1,145 master's degrees and 197 PhDs.

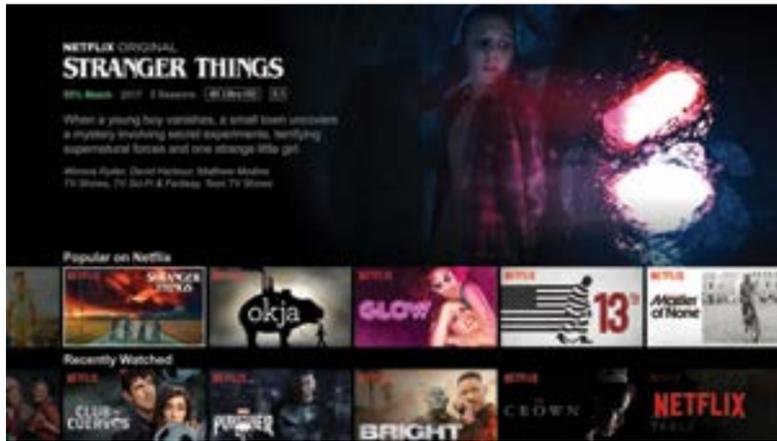
The program continues to evolve, preparing students for the ever-changing mineral and energy industries. According to Lange, "Given the increased integration of mineral and energy markets from the current energy transition, our program is more integral than ever before."

By **Kelly Bruce**



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Netflix's interface is based around a customized user experience that relies on machine learning and AI to recommend personalized content to subscribers.

Image courtesy of Netflix



KAMYAR MOHAGER '04

“In every instance, I worked hard to be empathetic toward users and thoughtful about the products I helped to create. The school teaches you to use your science and engineering skills to be good stewards of the Earth and society in general.”

BALANCING LARGE-SCALE BENEFITS AND PERSONAL PRIVACY

For engineering manager Kamyar Mohager '04, the rewards of a career in digital technology reside in balancing job requirements with subscriber joy. As the head of Netflix's messaging personalization and platform teams, Mohager is tasked with providing value to subscribers while also acting as a responsible steward of their privacy. He leads a group that facilitates communications with more than 140 million subscribers across 200 countries and 29 different languages.

It's a challenge Mohager savors. "I love tackling these huge issues of scale and personalization," he said. "It's rewarding to work on products that impact millions of people—I find it gratifying to build businesses that provide highly personalized value on such a broad scale."

Mohager arrived at Mines at the height of the dot-com boom and quickly became immersed in his computer science courses, particularly those that dealt with consumer-facing software. After completing a degree in mathematics and computer science, he went to work for the social networking platform MySpace, then moved to the career-building site LinkedIn, followed by the transportation mobility company Lyft, before being recruited by Netflix in 2017. "In every instance, I worked hard to be empathetic toward users and thoughtful about the products I helped to create," he observed. It's a philosophy he said was instilled by his Mines education. "The school teaches you to use your science and engineering skills to be good stewards of the Earth and society in general."

At Netflix, AI and machine learning come into play when personalizing content for each user. "There are machine-learned models we use broadly to help recommend content to our subscribers," Mohager explained. "In messaging, we interface with these models to get title recommendations on a per-profile basis. This allows us to provide users with relevant, discoverable content that enhances their enjoyment of our service."

Mohager and his team constantly monitor engagement as well. "We write programs that tell us whether the messages we deliver are having the right impact and working correctly. Our goal is to provide highly relevant messages to our subscribers without bombarding them, and to do this, we must be able to measure our efforts at scale," he continued. "Consequently, our systems must be robust—they must not only emit data, but also collect and analyze it. We're sending out billions of messages per month—for instance, a new-season alert for *Stranger Things*—and they must all be localized for individual subscribers' interests and language preferences."

The platform's sheer number of users is growing steadily every quarter, driving the need to continually evolve Netflix's operations and keep it sound while also building for the future.

To master such challenges, one must be flexible and nimble in problem-solving. "You learn how to do this at Mines," Mohager explained. "The school instills good engineering and problem-solving skills and teaches you to attack a problem with rigor."

WORKING HARD AND SMART

Solid problem-solving skills and a strong work ethic are essential for those interested in technology careers, agreed mechanical engineer Elizabeth "Lizzie" Miskovetz '14, a mechanical design engineer with Silicon Valley automobile maker Tesla. "The tech field is fast-paced, and you're expected to produce," she observed. "No one tracks hours—you just work as much as necessary to get the job done—but the mission is rewarding. You're helping to develop new technologies and create products that improve people's lives."

A San Francisco Bay Area native, Miskovetz said she began following Tesla in 2012. "It's a cool product and a disruptor in the auto industry, and it became a dream of mine to work there," she said. "Not only are the cars visually unique, but they are also innovative in the way they operate—everything from the big center touch screen to the autopilot features forces you as the driver to rethink what your car can be and what it can do for you."

Miskovetz now works in the company's low-voltage wire harness group, designing wiring systems. "We're in charge of the nervous system for the car—we provide power and signal to everything from the switch that moves your seat to the sensors that direct the autopilot system," she explained. "It's awesome to work on a product that people think is both cool and useful. Chatting with Tesla owners about what they like (or even don't like) about their cars is really inspiring for me. I feel like my job has made a tangible difference in peoples' lives, as well as the health of the planet."

It's that personal component that Miskovetz says is the most important consideration when coming up with new tech. "As an engineer, when you build an innovative product, it

forces you to think differently about how someone will use what you're designing," she said. "You have to consider what is truly intuitive for the user. And this changes over time—today's consumers are much more adapted to things like tapping and swiping on a touch screen than consumers were 20 years ago before everyone had a smartphone in their pocket. I think the team that designs Tesla's user interface, as well as the team that designs the shape and fundamental feature requirements of the vehicle, do a good job of keeping the user in mind."

It's all a bit futuristic, Miskovetz admitted. AI and automation in manufacturing are advancing at exponential speeds, and some are uneasy with the ramifications of new digital technology. Nevertheless, she remains intrigued by the possibilities. "The generation that's entering the workforce in the next 10 years has grown up with smartphones, so their theoretical limits and ideas of what's possible are very different from ours," she said.

Miskovetz concedes that for many, innovations like the cloud can be tough to comprehend. "I've always been a fan of futuristic scenes—a phone as a piece of glass, holograms, that sort of thing—but for earlier generations, new technology can be intimidating. As engineers, we must find ways to make it intuitive as well as enticing," she observed. "That's one of the things that drew me to Tesla—I think the company does this extremely well."

Miskovetz admitted that she does hear concerns from the public that as a result of advances in AI and machine learning, people will be replaced by machines. But business without humanity simply isn't effective, she argued. "AI will undoubtedly allow some systems to operate independently of people, but we also have to find ways for humans to continue to contribute."



Tesla is changing the game for automobile operations by incorporating AI and automation into their designs.

(Inset) The sensors on Tesla's vehicles allow them to operate on autopilot by providing 360 degrees of visibility around the car.

Photos courtesy of Tesla



DANIEL PIERCE '10

“I realized that I could use my computer science skills to help companies who do good in the world, and that was inspiring.”

DOING WELL WHILE DOING GOOD

Facilitating ways for humans to contribute is the *raison d'être* for the work of Daniel Pierce '10, vice president of engineering at CiviCore, a technology company that provides cloud-based solutions to nonprofits seeking to run online giving events and manage volunteer and grant tracking information in a cost-effective way.

A computer science major at Mines, Pierce was drawn to CiviCore's mission as an undergraduate intern. "I realized that I could use my computer science skills to help companies who do good in the world, and that was inspiring," he said.

CiviCore provides the platforms, software and management systems that allow its users to serve their constituencies in a cost-effective way. Pierce manages CiviCore's day-to-day tech solutions, ensuring that the company's tracking and event management programs are kept up-to-date and that servers are robust enough to maintain functionality, particularly when clients are running giving days simultaneously.

"We work with several hundred direct clients, giving them the space to reach thousands of constituents

and raise over \$100 million a year," Pierce said. "Our technology allows us to customize solutions to match the needs of individual organizations. Most nonprofits can't afford to create completely customized software systems—the first 80 percent of the system build is doable, but the last 20 percent is very costly to create and maintain on an ongoing basis."

With CiviCore's assistance, however, organizations can get on with the business of helping others, confident that their data is secure and their customers' privacy is protected. "Privacy on the internet is a much bigger issue than ever before, and regulations are becoming increasingly tight," Pierce observed.

To meet privacy and security standards, CiviCore contracts with Amazon Web Services to store client data in encrypted files and maintains offsite backup files in case of emergencies. But clients must also do their part. "Security and privacy tend to be a shared responsibility," Pierce said. "While we can do many things and can simplify the landscape for our clients, they also have to understand what is required of them to keep everything safe and secure."

APPLYING KNOWLEDGE IS KEY

Machine learning, AI and security are increasingly important ideas for those seeking to use data effectively and conscientiously, Pierce said, and students wishing to pursue careers in digital technology must be conversant in these fields. Mastering an array of programming languages, however, is no longer critical. "Learning how to pick up and implement new technologies quickly is more important than actually learning the new technology itself," he explained.

Miskovetz, at Tesla, agrees. The biggest challenge for students, she says, is simply to keep up. "The working world is changing very quickly, and AI has in no way reached its limits, so students need to be looking ahead and thinking about what transferable skills they can acquire," she said. An understanding of manufacturing and project planning is particularly important, she noted, and it's knowledge that can be gleaned through extracurricular activities such as the Mines Formula Club, which Miskovetz participated in as a student. "It was a refreshing way to step away from the textbooks and use my knowledge to plan, manufacture and build a project, a skill set that's incredibly important in the real world," she said.

Miskovetz is also keen on internships. She completed three as an undergraduate and has mentored several interns at Tesla since joining the company. "It's become clear to me that the students who get hands-on experience through internships are more engaged and able to hit the ground running when they enter the workforce," she said.

Netflix's Mohager, too, believes strongly in the value of hands-on experience, especially through real-world opportunities. And he speaks from experience. Leaving Colorado for a job in California at 23 years old was scary, he said, but the risk paid off. "Students shouldn't be afraid to take chances—you never know where your career will end up."

A computer science degree allows one to focus on many different industries, so the onus is on students to know themselves, noted Pierce. "The most important thing is to find an industry you're interested in and a place where you can make a difference," he counseled. "There's going to be a significant need for computer science and technology skills for the foreseeable future—I don't see that changing."

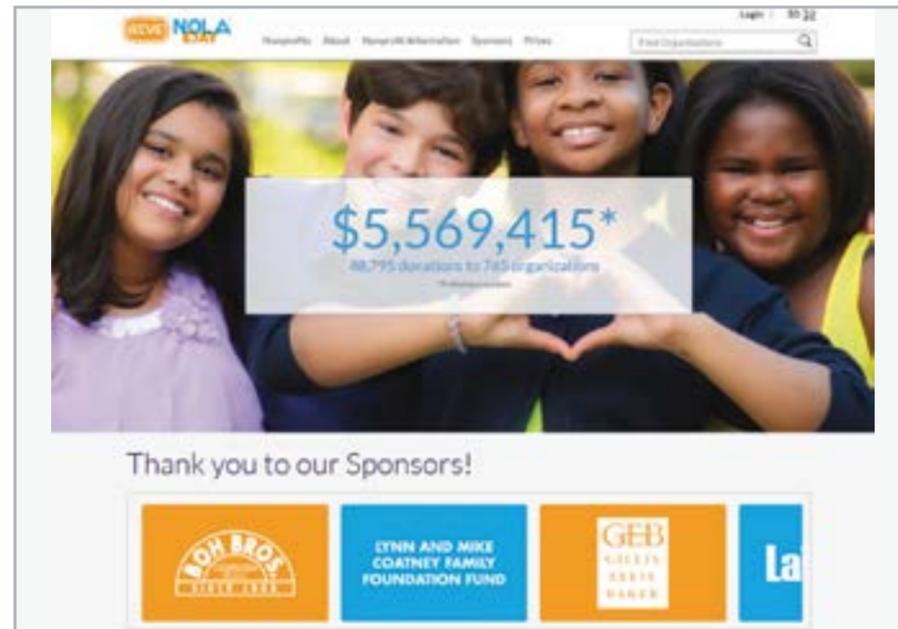


ELIZABETH MISKOVETZ '14

“It's become clear to me that the students who get hands-on experience through internships are more engaged and able to hit the ground running when they enter the workforce.”

This image shows the homepage of GiveNOLA, a 24-hour event hosted by the Greater New Orleans Foundation to inspire people to give to nonprofits within that community. CiviCore provided the technology for GiveNOLA's giving day, allowing the organization to have a customized, secure interface that maximized the event's success.

Image courtesy of Daniel Pierce



“The most important thing is to find an industry you're interested in and a place where you can make a difference. There's going to be a significant need for computer science and technology skills for the foreseeable future—I don't see that changing.”

DANIEL PIERCE '10

SMART ENGINEERING

Technological innovations improve efficiencies and teach young engineers valuable skills

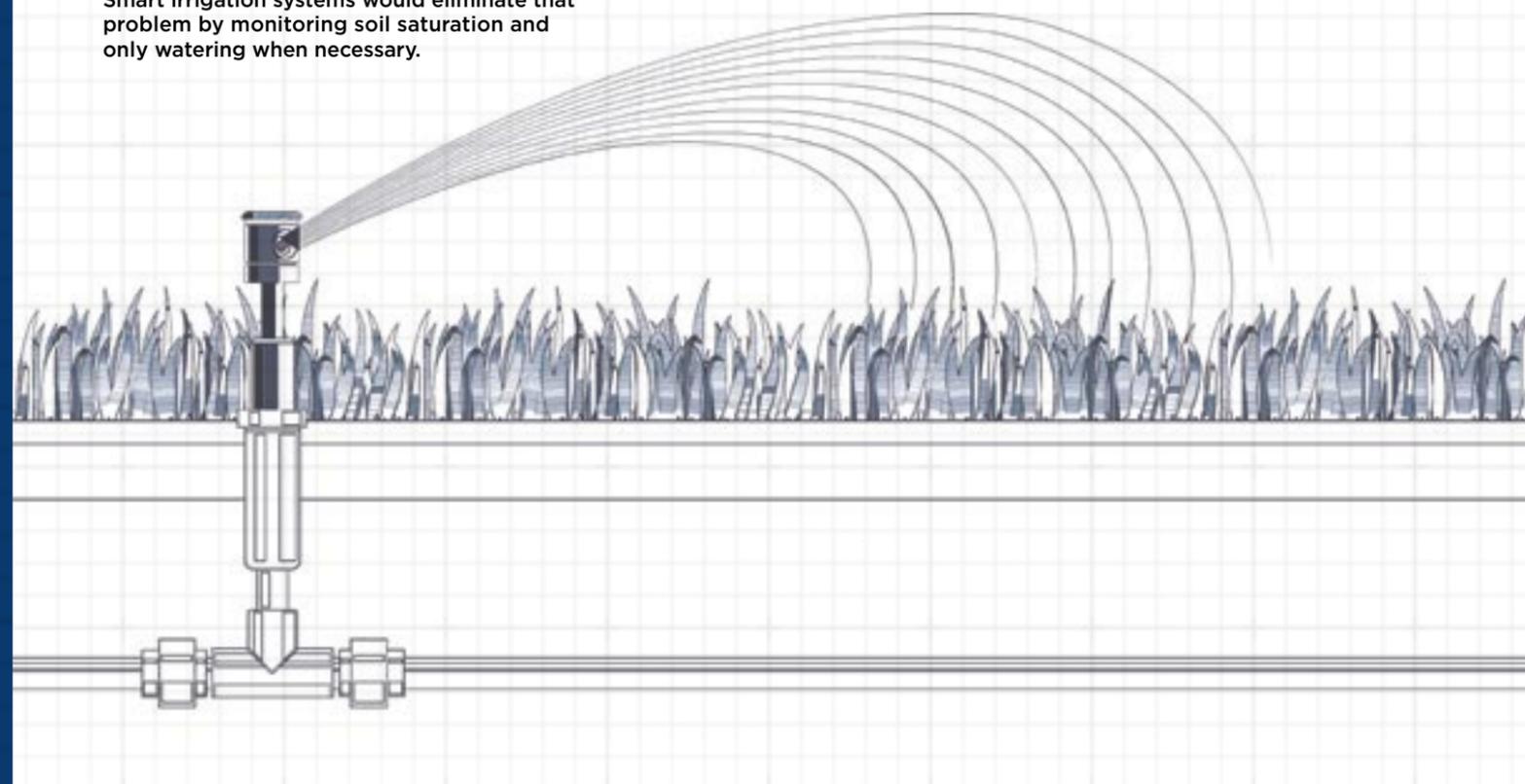
By **Teresa Meek**

Wearables, thermostats and virtual assistants—the kind of smart devices we're familiar with today—are just ripples on the surface compared to the tidal wave to come.

By 2020, the research company Gartner predicts there will be 20 billion internet-connected “things,” including jet engines and cars. Smart technology—which incorporates sensors into machinery and parts to collect data then analyze, share and use that data in real time—is fast becoming an essential tool in many industries, including manufacturing, transportation, energy, construction, health care, agriculture and more.

This means up-and-coming engineers need to understand how to incorporate sensors and data analytics into their designs. At Mines, faculty and students are working on a wide array of projects that not only give them hands-on experience with smart technology but help industries advance their knowledge and solve real-world problems.

Ever notice sprinklers running while it's raining? Smart irrigation systems would eliminate that problem by monitoring soil saturation and only watering when necessary.



CONSERVING RESOURCES WITH SENSORS AND NETWORKS

Smart technology can help end users manage resources more efficiently and save money. A smart irrigation system—which Civil and Environmental Engineering Professor Junko Munakata Marr and Computer Science Professor Qi Han are working on under a National Science Foundation grant—shows how technology can make a difference.

Most landscape irrigation systems—the kind used for parks, golf courses and lawns—are operated manually or use a timer, which isn't the most efficient. Studies show sensors that monitor existing soil moisture can reduce the amount of water used in sprinkler systems by 61 percent. But existing sensor systems are often cumbersome to install, only manage soil saturation by preventing irrigation from occurring or collect information that requires landscape managers to read and compile the data then decide on an action to take. By the time they reach a decision, conditions may have changed.

Munakata Marr and Han are working to automate the decision-making process and direct irrigation controls in real time. They'll also use “reclaimed water”—treated wastewater—in a way that won't damage plants.

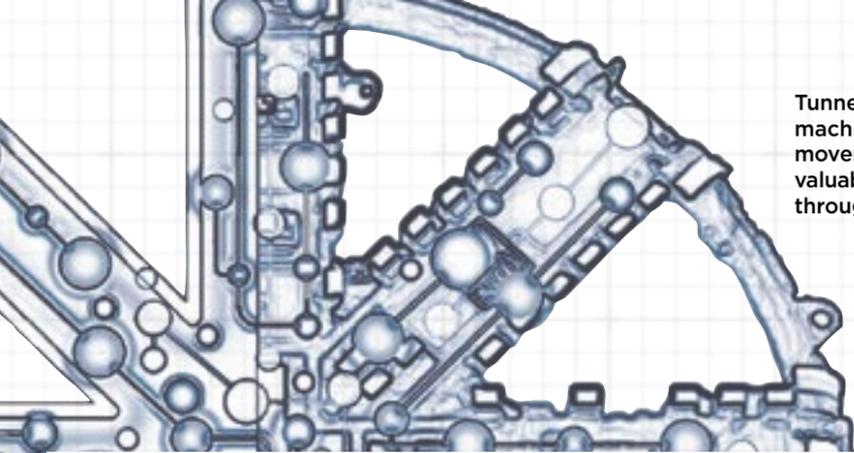
The project requires multiple sensors connected into a wireless adhoc network, which Han is developing. The system is designed to irrigate only when necessary and will determine the correct proportion of reclaimed water to use.

It's a delicate balance, because reclaimed water is saltier than tap water, and too much salt kills plants. “There are a lot of moving parts that need to communicate smoothly with one another. It's more complicated than it sounds,” Munakata Marr said.

One complicated step is translating landscape data into actionable information. Civil and environmental engineering graduate student Max Weiss and computer science undergraduate student Jordan Newport are working with Munakata Marr and Han on that part of the project.

To make a proper irrigation decision that balances the need for water conservation while also managing soil salinity, sensors must be able to report moisture and salinity simultaneously. Wireless communications will transmit data to a central location. There, a decision is made about when and how much water is applied to the landscape, sending a command to an irrigation valve to turn water on or off. The goal is to make sure the soil is not too wet, salty or dry, while conserving water and protecting plant health. When salinity gets too high, more water is needed to flush salt out of the soil. However, that requires using additional water, so the “rules of the game” must be determined to solve the optimization problem.

“It's a big learning curve, but it's really exciting,” Weiss said. “Knowing how to code and translate data into something useful can only benefit engineers.”



Tunneling is becoming faster and smarter with tunnel boring machines that use sensors to measure pressures, forces, movements and vibrations as the machines work, providing valuable information about the material the machine is drilling through and suggesting optimal settings in real time.

SHIFTING INTO OVERDRIVE

Below the surface, tunnel boring machines used for roads, subways and water systems are big, heavy and slow, usually advancing just a few inches a minute. Mike Mooney, the Grewcock University Endowed Chair and director of Mines' Center for Underground Construction and Tunneling, is working with colleagues to speed up the machines and make them smarter.

"We're using AI techniques to learn from data how to operate the machine better. The idea is to make it move faster, be more productive, avoid stoppages and prevent damage to nearby buildings," Mooney said.

Data from sensors measuring pressures, forces, movements and vibrations as the machines work provide valuable information and suggest optimal settings in real time. In Seattle, Mooney and his crew installed a monitoring system that warned operators of impending boulders, allowing them to make adjustments and avoid damaging expensive equipment.

Petroleum Engineering Associate Professors Bill Eustes and Jorge Sampaio, Chemical Engineering Assistant Professor Joe Samaniuk, Geophysics Research Professor Rich Krahenbuhl and Mooney are collaborating on a DARPA initiative that aims to dramatically improve the speed for building small-diameter tunnels. Normally, it takes about 24 hours to construct a small-diameter tunnel 500 meters long, but working with key industry collaborators, the Mines Rapid Tunneling Technology Team thinks they can get that down to 83 minutes or less.

Some of the improvement will come from using smart sensor data to make adjustments on the fly. "Our research has shown we can improve drilling and tunneling speed by 30 percent to 100 percent by using AI," Mooney said.

Mooney believes intelligent drilling will inevitably become an industry standard. "To be cost effective, industry will push the envelope as far as technology will let them. If one contractor does it, the rest will have to adapt to be competitive," he said.

TAKING SMART TECH TO THE MOON

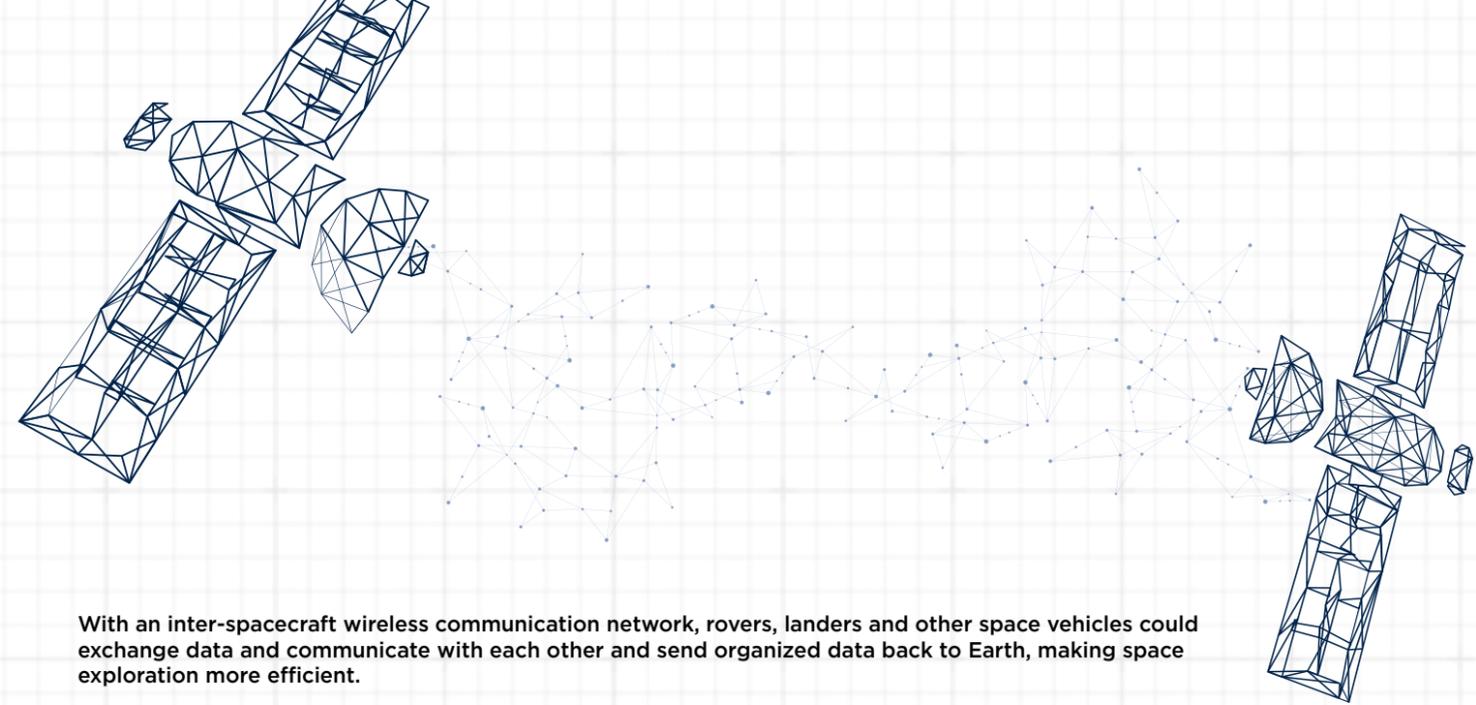
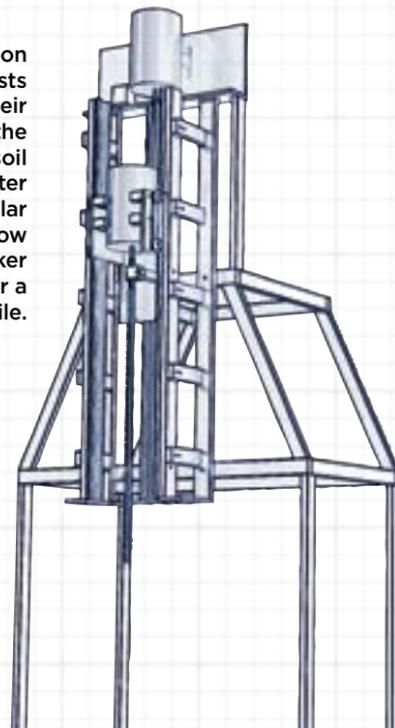
Smart drilling techniques could also be used in outer space, and Mines researchers are already working on extraterrestrial applications.

Scientists now know the Moon contains water, which could be used both for drinking and to create fuel for further space exploration. But first, you have to find the water and figure out how to get to it, said Jamal Rostami, Haddon/Alacer Gold Endowed Chair in Mining Engineering and director of the Earth Mechanics Institute.

NASA's current plans involve taking samples of the lunar surface and sending them to Earth to determine whether a site contains enough water to make drilling worthwhile. Rostami and his team at Mines have a better idea: analyzing lunar soil, or regolith, to determine drilling parameters that will allow the system to reveal a site's water content in real time.

"While you're drilling through a sample, AI and machine learning algorithms will analyze the operational parameters

A smart drill on the Moon would take scientists to new frontiers in their search for water. With the ability to analyze lunar soil and determine the water content of a particular area, the drill would allow scientists to make quicker decisions about whether a drill site is worthwhile.



With an inter-spacecraft wireless communication network, rovers, landers and other space vehicles could exchange data and communicate with each other and send organized data back to Earth, making space exploration more efficient.

of the drill, and from this data, they will conclude what type of material you're cutting," Rostami said. "All we need is data from the drill. If we can do on-site measurement and verification, it would speed up the work by months, if not years."

In addition to looking for water, NASA plans to collect data and images from multiple space vehicles as they land on the Moon or circle around it. But transmitting the data from each vehicle would be a slow process riddled with omissions and duplications.

Computer Science's Qi Han is working with Mechanical Engineering Research Assistant Professor Christopher Dreyer and robotic researchers at NASA's Jet Propulsion Laboratory to develop an inter-spacecraft wireless communication network. The network would let rovers, landers and other vehicles exchange and organize their information, then feed it to a single carrier with high storage capacity and computing power. The carrier would transmit data to Earth.

"It's about communication and control and making sure spacecraft are covering all the locations they're supposed to cover," Han said. "The robots could communicate with each other and adjust their decisions in real time."

USING SENSORS AND DATA WISELY

From urban underground to outer space, Mines faculty and students are finding innovative ways to incorporate smart technology into engineering decisions. Working their way through these technical problems is proving advantageous for young engineers, providing students with skills in data management and coding that are integral to tomorrow's technologies and valuable to employers.

Mines' emphasis on problem-solving ability, working under pressure and creativity enables students to pick up smart technology skills quickly. Even more important, the foundation Mines provides helps shape their decisions about when and how to use such technology.

"Smart technology can be quite dumb if it isn't used right," Mooney said. "We need students with strong fundamentals who know how to use technology and judge whether it's doing what it's supposed to do."

Technical knowledge, sound judgment, quick problem-solving ability and creativity all came together last fall for Summer Evans MS '19, who was part of a Mines team that beat 20 competitors from across the globe to win a Facebook hackathon.

The team developed an Android app that creates an interactive indoor map from a photo of a floorplan using augmented reality technology. They created the app in just 24 hours on a software platform only one of them had any experience with.

With just an hour left in the competition, the team tested their app only to find it didn't work. They managed to fix the software bug just as the event organizer was counting down the last seconds.

Their Mines education gave the team the foundation it needed to win, Evans said. "What Mines provides isn't so much experience with a particular smart technology," he explained. "Technology comes and goes. What Mines does is prepare students to move into any new technology and contribute."

EXTRACTION EVOLUTION

HOW MINING TECHNOLOGY HAS CHANGED SINCE MINES' FOUNDING

Since Mines was founded in 1874, technology has drastically changed, with new inventions propelling game-changing societal advances. These technological developments have altered the way humanity has interacted with the world and continue to influence modern research and learning experiences.

The mining industry is just one area that has seen a dramatic shift in technology in the past 150 years, with new enhancements allowing miners to work more quickly and safely. But long before computers, motorized vehicles or even electricity, the mining industry used comparably simple tools to extract valuable resources from the earth.

The tools shown here—a hand pick, assayer's mold, candlesticks, blasting caps, drill bits, single-jack hammer and rock hammer—represent some of the more traditional technologies in use when Mines began educating students in the field. With these tools, many of the processes miners used to extract minerals and other resources from the earth were completed by hand, requiring extensive amounts of time and physical labor.

COAL MINER'S HAND PICK

This hand pick from 19th-century France was used in tight spaces or low-backed coal seams in mines to pry down blocks of coal.



SINGLE-JACK HAMMER

In tight quarters within a mine, a single miner would use a 3- to 4-pound hammer to hand-drill holes for explosive charges during extraction, striking a chisel-pointed steel drill with the hammer. In more open areas, two-person teams could drill using a double-jack hammer to strike the steel, with one person holding the drill steel and the other swinging the hammer. Single- and double-jack refers to the number of miners involved in the drilling.



ROCK HAMMER

This hammer was used for splitting and breaking rocks to obtain a fresh surface and determine the rock's composition, bedding orientation, minerology, history and more. Today, a rubber-handled steel rock pick is more commonly used.



MINERS' CANDLESTICK

Before electric and carbide lamps, candles were used to provide light in some mines in the 19th century. The spike was driven into a framing timber or suitable crack, or the hook would allow the candle to be hung nearby. The smaller candle stick was a mass-manufactured item made from a single piece of wire, while the larger candle stick was made by a blacksmith.

ASSAYER'S MOLD

To determine the content or quality of ore, assayers melted samples in the conical cavities of an assayer's mold. The sample cooled into a cone-shaped solid with two layers—metallic ore on the bottom and silicate minerals on top. The metallic layer was broken off to undergo cupellation, which separated base metals from precious metals. Silver was typically dissolved in nitric acid, and the final sample was reweighed to calculate the gold and silver content.



DETACHABLE DRILL BITS

These drill bits were once fitted onto drill steels on pneumatic drilling machines that drilled through soft and hard rock materials. This process was also known as percussion drilling, with a movement similar to a jackhammer's.



BOX OF BLASTING CAPS

A blasting cap is a small, sensitive primary explosive device generally used to detonate a larger, more powerful secondary explosive, such as dynamite. The caps came in small cans or boxes made of tin, steel or heavy cardboard.



Over the years, many of these traditional mining tools have been updated or replaced, taking on modern designs and adapting to cutting-edge innovations. Now, drones can be operated for solo underground exploration or in tandem with other robots, advanced 3D subsurface models can help improve exploration success and minimize geologic risk and smart drills can provide information about a material to operators in real time to improve efficiencies.

These newer technologies have allowed the mining industry to grow exponentially and have shifted the way miners approach a worksite or determine what a particular mine has to offer. According to the Encyclopedia Britannica, "In modern mining, it is machines that provide the strength



Various mine disasters in the early 1900s prompted the U.S. Congress to create the U.S. Bureau of Mines to help improve working conditions underground. Despite the prevalence of electricity in homes at the time, mines often remained in the dark due to the high cost of installing electric lighting underground, so in 1914, the Mine Safety Appliances Company (MSA) took the initiative to create a dependable and safe electric cap lamp.

MSA enlisted Thomas Edison to help design the Edison Cap Lamp, consisting of a battery worn on the miner's belt. A flexible cord was attached to the cap lamp mounted on the front of a helmet, and the battery could power a six-candlepower lamp for 12 hours.

The hardhat shown here is likely from the 1980s or 1990s. Today's headlamps are similar, cordless versions of this model.

and trained miners who provide the brains needed to prevail in this highly competitive industry."

Beyond industry, these technological advancements have also had implications in the classroom. Today's students are no longer learning a singular field of study but required to take a more multidisciplinary approach to their education in order to be most attractive to employers and prepared to work with emerging innovations or new devices.

But these shifts in learning experiences and ever-evolving technology has proven one thing to be true: mining remains a critical field that requires new innovations to help improve processes and move the industry forward.



Carbide lamps are powered by the reaction of calcium carbide with water, which produces acetylene gas and burns a clean white flame. Commercial production of carbide mining lamps began in the early 1900s, replacing the oil-wick lamp and candles as lighting in many mines. The lamp produced no carbon monoxide, consumed less oxygen and had a better light output. Small lamps, such as the one shown here, were attached to miners' caps, while larger lamps were carried by hand or hung near a worksite.

However, the development of electric battery-powered lamps caused carbide mining lamps to soon fall out of favor, almost completely replacing carbide lamps by the 1930s.

The lamp shown here was most likely used in the 1930s.

- ▶ All of the tools featured in this piece were from the Mines Geology Museum archives. Visit the museum to see other historical mining equipment on display and learn more about earth resources. Go to mines.edu/museum for visiting hours.
- ▶ Due to changing technology and other factors that have posed different requirements for students, the Mines learning experience has changed a lot in the decades since the school was opened. Watch for our next issue to read more about the commonalities and differences between a Mines education today and that of previous generations of Mines students.

By Ashley Spurgeon



This image shows a reflected light microscope that was used to examine opaque mineral specimens. A light is aimed through the horizontal tube on the scope, and an internal prism reflects the light down through the lens onto the sample sitting on the stage. The microscope has the ability to pass light both up and down—from prism down to sample and from sample up to the eyepiece.

The microscope in this photo likely dates back to the 1930s.

TECHNOLOGICAL TIME MACHINE

A brief look back at some of the major innovations in the last 150 years



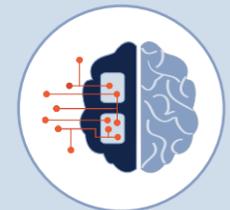
In the past 150 years, humanity experienced one of the biggest booms in modern technology, with many inventions becoming the basis for technology in use today. In 1876, Alexander Graham Bell made the first phone call and Nikolaus Otto built the first internal-combustion engine. The first electric power plant opened in 1882, a radio transmission was sent across the Atlantic in 1901 and the first airplane took flight in 1903.



In the past 100 years, society took technology further with the first test flight of a liquid-fueled rocket in 1926, the first electronic television transmission in 1927 and the first electronic digital computer in 1937. Physicists produced the first self-sustaining chain reaction in 1942, and the first transistor was created in 1947, ushering in an era of inexpensive small electronic devices. In 1957, the Soviet Union kicked off the space race with the launch of Sputnik 1.



In the past 50 years, computers became small enough for home use, and the basis of the internet was developed in 1974.



In the past 10 years, humans have made significant strides in artificial intelligence and machine learning, beginning with the program AlphaGo in 2017.

OREDIGGERS GIVE BACK

A ONE-OF-A-KIND OREDIGGER

As Mr. Engineer, head football coach, mayor of Golden and even the inspiration for a university mascot, it's clear that Marv Kay '63 shines bright at Mines.

Proclaimed by many as "the greatest Oredigger of all time," Kay's generosity, history of service and school spirit have only grown since the moment he was born and lived right across the street from the president's house. This year, his legacy was commemorated with something special—a proclamation of a day that bears his name.

The state of Colorado, the city of Golden and Mines officially proclaimed April 11, 2019, as Marv Kay Day to coincide with Kay's induction into the Colorado Sports Hall of Fame. Mines students, alumni, faculty and staff gathered to celebrate, and Maple Plaza—the stretch of Maple Street from 17th Street to just past 15th Street—was renamed Marv Kay Way.

"I'm overwhelmed at all of this," Kay said. "Mines has given so much to me. Just being here at Mines is a tremendous privilege. I don't care if you're a student, an athlete, a professor—whatever you are, it's a privilege. And we should always honor that and be very proud of that, as I am."

And Marv Kay Way is not the only part of campus that bears his name. The pathway points pedestrians in the direction of what is perhaps the most enduring symbol of Kay's influence: the Mines football stadium, named in his honor and opened in 2015.

To coincide with Marv Kay '61 being inducted into the Colorado Sports Hall of Fame, the state of Colorado, the city of Golden and Mines officially proclaimed April 11, 2019, as Marv Kay Day.

As part of the Marv Kay Day celebrations, Maple Plaza was renamed Marv Kay Way.

Photos by Thomas Cooper, lightboximages.com



Already a member of the Mines and RMAC Athletic halls of fame, Kay has certainly put his stamp on Mines athletics. As a student-athlete, he lettered in both wrestling and football and was an All-American lineman. Later, Kay coached the swimming and football teams and became the head football coach in 1969. Over the next 26 years, Kay led the football team to win a then-record 84 games and was named RMAC Coach of the Year in 1975 and 1979. During his tenure, Kay coached 13 All-Americans and 50 All-Conference players. After his coaching days, he was the Mines athletic director for nine years. Kay has remained a dedicated fan of the Orediggers, cheering on all Mines sports teams to victory.

But Kay's leadership extends far beyond Mines athletics. As a student, he was president of his junior class and a member of the Sigma Phi Epsilon fraternity and was named Mr. Engineer during E-Days in 1963. After graduating with a professional degree in engineering that same year, Kay served in the U.S. Army Corps of Engineers before returning to Golden to dedicate his career to Mines and the local community. He served as the mayor of Golden from 1988 to 1996, a member of the Golden City Council from 1986 to 1998 and president of the Golden Chamber of Commerce in 1983.

After a 40-year career as a coach, administrator, professor and fundraiser, Kay's dedication to Mines is stronger than ever, and he continues to play a large role in maintaining strong relationships with alumni to advance the school's top priorities.

"There's a special place in my heart for the city and campus, and there always will be," Kay said. "I look back at the last verse—the alumni verse—of the school song, and it goes something like this: 'Wherever in this pay dirt world Orediggers chose to roam, that M up on that mountain will always stand for home.'"

By **Anica Wong**

► The Mines Alumni Office is collecting memories and stories of Kay for a special keepsake in his honor. Visit minesalumni.com/marvkay to learn more.

MARV KAY'S MINES HIGHLIGHTS



1961
Sigma Phi Epsilon
fraternity president

1958–1963
Mines student-athlete
letterman in football
and wrestling

1962–1963
Senior class president

1963
Graduated with a
professional degree
in engineering

1966
Head swimming and
freshman football coach



1967–1968
Football defensive
coordinator



1969–1979
Professor

1969–1995
Head football coach

1980–1995
Assistant athletic director

1995–2004
Athletic director

2004
Joined Mines Foundation
as a consultant

2008
Inducted into Mines
Athletics Hall of Fame



2015
Marv Kay Stadium opened

2016
Delivered keynote
address at spring
commencement

APRIL 11, 2019
Proclaimed Marv Kay
Day in Colorado, Golden
and at Mines



"I didn't appreciate Coach Kay while I played for him as much as I do now. He gave me a scholarship and let me keep it all four years even though I wasn't a starter. I give him credit for my staying at and graduating from Mines, which is one of the best things to happen in my life. My favorite memory is that he remembered my name after 25 years of no contact.

Andy Todd '79

"From the first day I met Marv, he demonstrated those intangible qualities that make a person memorable. He had empathy for others, interest in you as an individual, leadership and enthusiasm. I looked up to him then, and I still have the utmost respect for his character. Most of all, I value his heart and how he approaches life with determination to do the right thing.

Tom King '63

"Marv befriended my dad, Tony Corbetta '48, and his dear Mines pals Al Ireson '48 and Bob Pearson '59. Marv helped build their alumni connection, which turned into meaningful lifelong friendships. Marv made a difference in the quality of people's lives. He extended his Mines welcoming ways to family members of alumni and always made my sister, Dianne, and me feel welcome and part of the Mines community. Marv's smile is the best.

Patty Corbetta

"When Marv eventually became athletic director and I president, our relationship grew even closer. This was especially true during the reorganization of varsity athletics that took place right after I became president. Since my retirement in 2006, I have remained close to Marv, particularly through our mutual involvement with the Golden Civic Foundation.

John Trefny, president emeritus

"Marv's greatest strength is his ability to create meaningful relationships with every person he meets—everyone is important in Marv's eyes. Through these relationships, Marv has helped people find the area at Mines that they are passionate about, leading to financial support that provides scholarships, lab space, athletics facilities and much more. Marv has taught so many of us about the power of character and kindness.

Brian Winkelbauer, president and CEO
of the Mines Foundation

ALUMNA PROFILE

OLYMPIAN AND ENGINEER REACHES NEW HEIGHTS IN BUSINESS

When Michelle Roark '15 was a child, she had two dreams: competing in the Olympics and becoming a chemical engineer. With dedication and hard work, she achieved both dreams and now owns an award-winning spa and wellness center, Phia Alchemy Salon Spa, in Denver.

While wellness retail and spa ownership might seem like an unusual career path for a chemical engineer and professional skier, Roark said it's where all her experiences come together. After competing for 16 years on the World Cup as a member of the U.S. freestyle ski team, competing in the 2006 Winter Olympics in Turin and 2010 Olympics in Vancouver, Roark retired from her athletic career. From there, she said her Mines degree and years as an athlete put her in a unique position of studying energy and its impact on performance—whether at the start gate or in life.

“When you're skiing, you stand out there and compete on your own,” Roark said. “You have to constantly figure out how to conquer your fears, live in the present moment and put your best self out there.”

For her, developing and owning a business is much the same. “There are a lot of bumps in the road when you start your own business, and it's easy to want to give up,” she explained. “But given my background, that was expected, and I knew how to handle it.”

It was also in skiing that Roark first discovered her passion for scent and the performance-enhancing power of natural energy. While competing on the World Cup, a sports psychologist encouraged Roark to use all five senses to imagine herself skiing. This practice was intended to “invoke the zone”—or conjure the feeling of skiing perfectly—so she



Michelle Roark '15 combined her experiences as an Olympic skier and chemical engineer to create a product line and open her own spa and wellness center built around the bioenergetics of essential oils, physics and natural energy.

Photos by Mike Hormell

could mentally prepare to succeed. When Roark visualized herself completing a perfect run, she said she could capture each sense easily—except for smell.

Wondering what it smelled like to ski well, Roark began experimenting with different essential oils, even becoming a certified perfumer, while she continued to compete on the World Cup. She ultimately found that smelling combinations like rose oil, Italian bergamot and grapefruit (today the basis of her scent Charisma) kept her “in the zone” while she was skiing.

Her interest piqued, Roark decided to apply her knowledge of chemical engineering to “really dive into the research of the energy contained in biological essences,” which was the basis of her undergraduate work at Mines. She even built her own device to measure the electromagnetic energy of botanical biological essences and learned to combine scent molecules into certain frequencies.

Since graduating, Roark has continued to take her research to the next level, creating a line of products with six scent categories—such as focus and balance—designed to match a person's “signature frequency” for maximum benefit to their health and wellness. She also wrote a book, *Be a Force*, which discusses the connections between bioenergetics and a person's well-being.

Roark acknowledged that her research was unusual for a Mines graduate. “I was lucky to find some really wonderful professors who weren't afraid to think outside the box and embrace my much more colorful research,” Roark said. “It's helped me with everything I've been able to do since and to find a lot of success down that road.”

By **Amanda Schuster**

A TITAN SIGNS OFF

RAMONA GRAVES PHD '82 REFLECTS ON HER 40-YEAR CAREER AT MINES

Having been at Mines for nearly four decades—first as a student then as a professor and administrator—Ramona Graves PhD '82 is a familiar face for many who have spent time on campus. She retired at the end of the 2018-19 academic year but shared a few memories and nuggets of wisdom she gained over the course of her career at Mines and in the petroleum industry.

What has been the best part of working in the petroleum industry?

I'm currently the director for academia for the Society of Petroleum Engineers. The people belonging to this society are committed to making the world a better place. They are committed to being responsible producers of oil and gas. They are committed to the excitement of drilling, finding, producing energy. Plus, it's the biggest industry in the world. The size and scale of what we do is amazing. It's addictive. Once you get into the petroleum industry, you never want to leave.

What is the most important thing you've learned at Mines?

I've learned don't sweat the small stuff but also make decisions from the heart. When I started teaching at Mines, I had a really good job in industry. At the time, [Petroleum Engineering Professor Emeritus] Craig Van Kirk told me, “Come to Mines—I'll pay you half of what you're making in industry, and you'll work twice as hard.” But I wasn't taking the job for the money—I was taking it because it was a passion. Your heart usually tells you what you want to do.

What's one takeaway you'd want other people to know about Mines?

Mines has grown into a university that makes better people—not just great engineers—out of all the great students we get. We help them develop and grow their whole selves, be it through music, through athletics, through poetry, through helping people in Nepal. We're really helping the student develop their passions. And that's one of the things that makes Mines special.

What's next for you?

I have no idea what I'm going to do next, but I will do something next. I'm not a goal setter. I look for opportunities and hope I make good choices.

Interviewed by **Ashley Spurgeon**

- Visit magazine.mines.edu to watch a video about Graves' retirement and read *Mines Magazine's* 2013 profile, “The face of petroleum engineering,” which describes her career and experiences at Mines.



Ramona Graves PhD '82 retired this year after 40 years at Mines.

Photo by Agata Bogucka

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HATS OFF TO THE CLASS OF 2019

A BREAKDOWN OF THIS YEAR'S GRADUATES



1,682

GRADUATES IN THE 2018-19 ACADEMIC YEAR

1,158

BACHELOR'S DEGREES

430

MASTER'S DEGREES

94

DOCTORAL DEGREES

8

SECOND LIEUTENANT MILITARY COMMISSIONS

5

U.S. AIR FORCE

3

U.S. ARMY

54

COUNTRIES REPRESENTED AMONG GRADUATES



REVIVING A TRADITION

At each commencement ceremony, all Mines graduates receive a gift from the alumni office after crossing the stage—a padfolio they can take with them as they start their career. But this year, graduates also received a copy of the 2019 *Prospector*, the school's yearbook.

A tradition that was put on hiatus for a little more than a decade, the *Prospector* made a comeback this year, driven by Mines students who had a passion for commemorating the sense of community they experienced as undergraduates. Zachary Orlove '19 spearheaded the project, taking on the immense task of bringing back a publication with a long history and making it unique to the graduating class.

"My buddy Sevy and I were skiing and talking about the campus culture," Orlove said about the inspiration behind bringing the yearbook back. "Some people aren't as psyched about Mines as we are, and we were floating ideas about how we could improve that. One of the things we talked about was the yearbook."

With support from Mines alumni and backed by the Mines Foundation, Orlove ran with the idea, getting a team of Blue Key members on board to help organize, write and publish the yearbook. Orlove had the idea of reducing the scope of the yearbook and turning it into a senior-focused publication, dedicating a fifth of a page to every senior



who wanted to share their story. "We wanted this book to be their chance to say whatever they wanted and have their classmates remember them in that way," Orlove said. "We wanted to give everyone a voice."

Before hanging up his hat as the yearbook's editor-in-chief, Orlove wanted alumni to know one thing about the *Prospector*: "That it's alive and well."

Photos by Colorado School of Mines



"Our time at Mines was about the challenges we chose to accept, even the small ones. And whether those challenges were good or bad, the way we deal with them is what makes us who we are. [...] For us Orediggers, it's our experiences that matter. Do not lose hope when you fail. Get help when you're lost. And use your experience to make a more developed, efficient and safer world.

Sarah Alhumaidan '19
Undergraduate Student Speaker



"As students, we chanted the importance of earth, energy and environment. As alumni of Mines, we must march forward with this motto, for it is a reminder that we are the ones who will depict the future of our society, who will write the history that the next generations remember.

Yalin Li PhD '19
Graduate Student Speaker



"Mines is a truly unique and special place. You are now joining a very special club. You're a Mines graduate. I feel so privileged to be a part of this club, and I hope you are, too.

Bruce Grewcock '76
Chairman and CEO of Peter Kiewit Sons' Inc.
Undergraduate Keynote Speaker



Welcome parties bring together incoming students and their families, current students and local alumni to celebrate the Mines spirit.

Connect to your local **M CLUB** to find your party.

ALUMNUS PROFILE

GOING NUCLEAR



Joe Krupar Jr. PhD '73 spent his career in the nuclear energy industry and is one of only a few people who have visited every federal nuclear site in the country.

Photo by Joe DelNero

There aren't many people who can say they've visited every federal nuclear site in the United States, but Joe Krupar, Jr. PhD '73 can. During his career, he carried out inspections and ensured each and every site met appropriate safety standards.

But his career in the nuclear industry had an unconventional start. As a doctoral student studying metallurgy at Mines, Krupar worked with his advisor, Metallurgical Engineering Professor Walt Bradley, on a method for hot-pressing ceramic and metallic materials into a cermet, which is typically used in resistors, capacitors and other electronic components that may experience high temperatures. However, before they could share their results with the public, the U.S. government intervened, classifying Krupar's dissertation and preventing him from publishing his findings.

"They didn't even give us a reason," Krupar said. "I remember wondering, 'Who are these people who can step in and do that?'"

It turns out, Krupar had been working on the same process the government was using to make mixed oxide fuel—or MOX fuel—a nuclear substance created from uranium

hot-pressed with plutonium oxide and used predominantly in nuclear power generation.

Krupar didn't discover the rationale for the classification of his research until he graduated from Mines and was hired by the Atomic Energy Commission, now part of the Department of Energy. He researched the design and performance of different MOX fuels and helped design, construct and operate an experimental reactor that could produce more plutonium than it burned. Krupar later became an operations manager at the Hanford Site in Washington—where plutonium used in the first nuclear bomb was manufactured in the 1940s—and chaired exchange agreements on MOX fuel between the U.S. and Japan.

Krupar also played a key role in the shutdown of Rocky Flats. Situated between Denver and Boulder, Colorado, Rocky Flats became a cautionary tale for those working with nuclear materials. The plant had operated for many years manufacturing nuclear weapons parts before production was halted in 1989 due to unsafe operating conditions.

In one instance, while inspecting part of the plant, Krupar walked unprotected into a radioactive zone that had no warning signs. When it was clear that production was being prioritized over safety, he demanded the site be shut down.

"When I got to Rocky Flats, I didn't know what I was in for," Krupar said. "I can remember my old boss from Hanford, who was on the team that came out to verify shutting the site down, said, 'I wouldn't have believed any of this unless I saw it myself.'"

After Rocky Flats was shut down, DOE investigated all of the country's nuclear sites, with Krupar leading the effort. "I saw some things you just couldn't believe," Krupar said. "It was the beginning of a whole process of safety assessments."

In October 1990, Krupar was awarded the second-highest honor given to civilians at the time: the Meritorious Service Award, in recognition of his accomplishments as a site safety representative at Rocky Flats.

Ultimately, Krupar is happy with where his career ended up, despite the wrench thrown in his plans as a doctoral student. "Mines gave me the technical background, the research experience, the emphasis on communicating what I observed and the desire to commit to public service. It's all been progress from the classification of my research," he said. "It's crazy the way things have worked out."

By **Ashley Spurgeon**

SUMMER 2019
ON OUR WALL

If you could describe Mines alumni in one word, what would it be?

PROBLEM SOLVERS

Rachael Low '10, MS '12

MENTORS

Tiffany Brewster '07

SMART

Sarah McInerney '08

PERSEVERANT

Jonathan Lekawski '99

RESOURCEFUL

Cintha Lopez '18

LOYAL

Colin Fitzgerald '07

DRIVEN

Suzanne Clerkin '04

PREPARED

Liz Abbott '08, MS '09

PASSIONATE

Elise Tran '18

RESILIENT

Gregory Staff '73

PHENOMENAL

Jeffery Frayser '83

DILIGENT

Diego Castañeda '09

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Patent Attorney,
Shareholder

B.S., Engineering, with honors, 2003; M.S., Engineering Technology Management, 2005 Top Graduating Electrical Engineer

Bruce Kugler
Patent Attorney,
Shareholder

B.S., Petroleum Engineering, 1981

Doug Swartz
Patent Attorney,
Shareholder

B.S., Mining Engineering, Minor in Metallurgical Engineering, 1982

Brad Knepper
Patent Attorney,
Shareholder

B.S., Electrical Engineering, 1998

Kristen Gruber
Patent Attorney,
Associate

B.S., Chemical and Petroleum Refining Engineering, 2000

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WEDDINGS

A TEXAS KIND OF LOVE

Taylor Schneeberger '11 married Melissa Christensen in Austin, Texas, on March 9, 2019, on a beautiful spring day in the Texas Hill Country. Adam Hasskamp '11 served as a groomsman, and other Mines alumni in attendance included Drew Hoffman '11, Tyler Holtzinger '11, John Huber '11, Kurt Lindgren '11, Graham Riddile '11 and Jared Shanks '11.



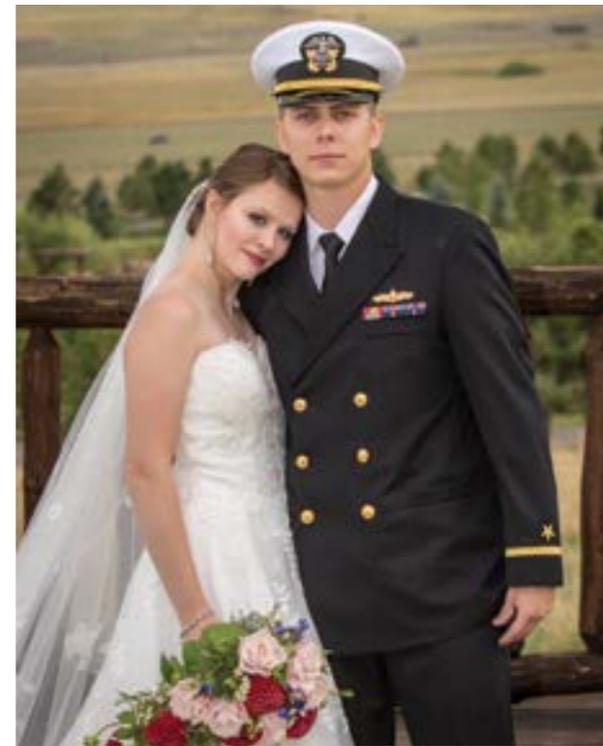
THE YEAR OF ERF

Zach Erfurd '15 married Samantha Erfurd on April 20, 2019, in Littleton, Colorado. Bill Mercer '13 was in attendance. The couple met when Zach was designing an automated ignition system for a fire pit burner for the company where Samantha worked. Zach proposed to Samantha after the couple hiked Red Rocks last summer. Both have been running Erf Tech LLC for the last three years.



CELEBRATING A NEW UNION

Jordan Cox '14 and Ellen Murray '14 were married on June 24, 2018, at the state Capitol building in Madison, Wisconsin. Mines alumni in the wedding party included Devon Tippit '14 and Bernard Beecher '13, MS '14. Jordan is a software developer at Epic Systems, and Ellen is working toward her PhD at the University of Wisconsin.



A NUCLEAR BOND

Keira Bell '16 and Brandon Bolach '16 were married on August 31, 2018, at Spruce Mountain Ranch in Larkspur, Colo. The couple met on the first day of orientation in their freshman year at Mines. Several Mines alumni attended the wedding, with Georgia Salisbury '16, Stephanie To '16 and James Jordan '17 serving as members of the wedding party. Brandon serves in the U.S. Navy as a nuclear surface warfare officer, and Keira works for Puget Sound Naval Shipyard as a nuclear shift test engineer.



PURSuing NEW DREAMS TOGETHER

Franz Martinez MS '16 and Teresa Ramos MS '17 were married in Lima, Peru, on Feb. 2, 2019. The couple came to Mines to achieve their professional goals together, and their relationship grew from there.



PETROLEUM ENGINEERS FIND LOVE

Cassie Whalen '15 and Kyle Bible '13 were married in Las Vegas, Nevada, on March 30, 2019. Both were petroleum engineering majors but did not meet until they were working in Midland, Texas. Five of the six wedding party members were Mines graduates, including Colin Marshall '16, Haley Whalen '17 and Brett Green '13.

BABIES



DIGGIN' IT WITH THE FOLKS

Korben Arlen Heyne was born on Jan. 2, 2019, to Emily (Mieritz) Heyne '09, MS '11 and James Heyne '08, MS '10. Korben holds both U.S. and Canadian citizenship.



AWESOME BROS

William Paul Loewen—pictured with his 3-year-old big brother, Henry Paul Loewen— was born on Feb. 11, 2019, to Daniel Paul Loewen '11 and Elysa Marie Loewen '11. Daniel and Elysa hope both sons will be Orediggers.



CELEBRATING A NEW ADDITION

Josh Lawrence '10 and Amanda (Harrington) Lawrence '10 are proud to announce the birth of their daughter, Allison Danece, who arrived on Dec. 10, 2018.



AN OREDIGGER'S VALENTINE

Peter Eliassen '09 and Kristin Eliassen welcomed their daughter, Sigrid Helene Eliassen, on Feb. 14, 2019. She arrived at 11:28 p.m. and weighed 8 pounds, 1.9 ounces.



THREE BOYS

Jacqui (Schmalzer) Stackhouse '07 and Dan Stackhouse '07, MS '08 welcomed a third baby boy to their family. Jackson was born on April 23, 2019, joining his big brothers, 4-year-old Shane and 2-year-old Logan.

IN OTHER NEWS



YOUNG PROFESSIONAL OF THE YEAR

Benny Lujan '07 was named the 2019 Young Professional of the Year by the American Council of Engineering Companies of Colorado and was recognized for his achievements at the ACEC Colorado Symposium and Annual Meeting Luncheon on April 26, 2019. The award promotes the accomplishments of young engineers by highlighting their engineering contributions and the resulting impact on society. Lujan was recognized for his role on several projects that relied on innovative ground improvement techniques and delivered cost savings and efficiencies to clients.

- ▶ To submit a wedding, birth or award announcement for publication in the magazine, visit minesmagazine.com/submit-an-announcement.

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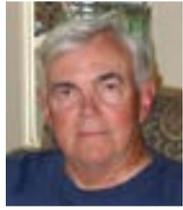
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IN MEMORIAM

“When you are sorrowful look again in your heart,
and you shall see that in truth you are weeping
for that which has been your delight.”

-Kahlil Gibran



CHARLES H. BURT '62 died March 31, 2019. He graduated from Mines in 1962 with a professional degree in geophysical engineering. During his 55 years in the geophysical industry, Charles and his family lived in Wyoming, Oklahoma, New Mexico and Texas. He was also an avid sailor.



JEREMY S. GILBERT '13 died Sept. 1, 2018. Born in 1986, Jeremy graduated early from Heritage High School in December 2003 to join the U.S. Marine Corps. He was deployed to Iraq and Southeast Asia from 2004 to 2008 and was awarded the Navy and Marine Corps Achievement Medal for heroic actions in combat and the Meritorious Mast award for successfully completing more than 200 combat patrols in Iraq. After being discharged from the military, Jeremy began classes at University of Colorado Denver before transferring to Mines. He played varsity soccer at Mines for a year and was a member of the Petroleum Engineering Honor Society. He graduated with a bachelor's degree in petroleum engineering in 2013. After graduation, he worked in the oil and gas industry in the Denver area. Jeremy was admitted to University of Denver's graduate program and was preparing to start the MBA program in September 2018.



ROLAND C. HEA '84 died Feb. 11, 2019. Roland was born in 1961 in New York and graduated with a bachelor's degree in mining engineering in 1984. Roland started his career at Lockheed Martin but eventually found his way to his true career in environmental engineering.

He worked for Environmental Resources Management for several years before working for the Colorado Department of Public Health and Environment, where he was responsible for overseeing all air quality permits and compliance for the state.



JOSEPH H. MURILLO '04, MS '05 died Nov. 19, 2018. Born in 1982, Joseph earned his bachelor's degree in economics and business in 2004 and completed his master's degree in engineering management in 2005, both from Mines.



ROBERT (BOB) L. SANDEFUR '66, MS '74 died Jan. 31, 2018. Bob attended Mines on a National Merit Scholarship and received a professional degree in physics in 1966 and a master's degree in physics in 1974. Bob worked and consulted for various mining companies during his career

and retired from CAM Mining as a senior geostatistical reserve analyst.

ARTHUR K. VEEDER '42 died June 12, 2018. Born in 1917, he graduated from Mines with a professional degree in mining engineering in 1942. After graduation, he entered the U.S. Army Corps of Engineers as a second lieutenant. He was honorably discharged in December 1943 and worked in technical and supervisory roles in the mining industry until his retirement.

► To submit an obituary for publication in the magazine, visit minesmagazine.com/submit-an-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 giving.mines.edu/givingguide.

Compiled and written by **Ashley Spurgeon**

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MINER'S PIC



HOLDING BACK THE FLOOD

In 2016, the U.S. Army Corps of Engineers created a special task force to support the repair of the Mosul Dam in Iraq. Situated on the Tigris River, the dam provides hydroelectric power generation and, at full capacity, 40 percent of Iraq's water storage needs per year.

Despite the dam's quality design and construction, it was built on a soluble geologic foundation of anhydrite, gypsum, marl and limestone. Water pressure from the reservoir continually degrades the foundation, resulting in seepage through voids beneath and downstream of the dam. The dam's failure would result in a catastrophic wave and cause a vast humanitarian crisis.

To stabilize the foundation and rehabilitate other critical dam infrastructure, the Mosul Dam Task Force (MDTF) serves as the "engineer" to administer the Iraqi government's agreement with an Italian contractor to pump grout up to 300 feet below the foundation and slow water flow under the dam.

Two Mines graduates are currently part of MDTF—Andy Olson '99, MS '09 is the deputy commander and Mike Woodward MS '10 is a geotechnical engineer with AECOM. As the project winds down, they commemorated their experience with a photo. Olson said the spillway in the background shows the dam's improved condition by highlighting a high pool elevation in the midst of significant flooding concerns in Iraq.

"This project has provided the perfect opportunity for me to apply leadership lessons I began learning in Mines' Army ROTC program as well as the technical knowledge from my geological engineering bachelor's degree," Olson said. "The U.S. Army Corps of Engineers offers a lot of challenging opportunities, but this one being so specific to geological engineering was special."

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