

MINES MAGAZINE

For Colorado School of Mines Alumni and Friends • Winter 2021

What comes next

Preparing for the dangers that follow
natural disasters

Plus:

Creating responsible technology for a more
inclusive future

A new center for entrepreneurship and
innovation provides a leg up for innovation

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This snow-dusted shot of a frozen Clear Creek was taken during Thanksgiving Break. Can you spot the faint outline of the M in the distance?

- ▶ Follow Mines on social media for more beautiful shots of Golden and the Mines campus, and keep up with everything happening with your fellow Orediggers.



Photo by Tim Flynn



FEATURE

WHAT COMES NEXT 18

Engineers and scientists play an important role in helping communities avoid or prepare for the aftereffects of natural disasters, such as volcanic eruptions, wildfires, earthquakes and more.

INSIDE MINES



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A state court judge uses her position to help boost others in her field. **24**



Getting alumni involved at Mines lays the foundation for the next 150 years. **28**

SKILL SET



The Rubik's Cube is about solving problems—big and small. **30**

ON THE COVER: After the initial events of a natural disaster, engineers and scientists are critical to helping avoid and prepare for the dangers that follow. Pictured here is lava flow from the disastrous Kīlauea eruption in 2018.

Photo by USGS Hawaiian Volcano Observatory



COLLABORATIVE PLAYLIST

Mines Musics Together

Blaster and Marvin are always looking for some new tunes. Got suggestions?

Marvin the Miner - 130 likes - 588 songs, over 24 hr



#	TITLE	ALBUM	ADDED BY	DATE ADDED	
1	Kodokushi (VIP) Mihka!, Kyoto Black	Kodokushi (VIP)	buggiboy	Oct 9, 2020	♥ 3:20
2	Interstellar Love Story D-Real [愛], Tsundere Twintails, Lavera	Interstellar Love Story	buggiboy	Oct 9, 2020	♥ 3:29
3	Strawberry Road dark cat	Strawberry Road	buggiboy	Oct 9, 2020	♥ 3:07
4	Not Holding Back Ivory Rasmus	Not Holding Back	buggiboy	Oct 9, 2020	♥ 2:47
5	still feel. half-alive	Now, Not Yet	buggiboy	Oct 9, 2020	♥ 4:07
6	Absolute Territory Ken Ashcorp	Absolute Territory	buggiboy	Oct 9, 2020	♥ 4:28
7	Suffer Baby LissA	Suffer Baby	buggiboy	Oct 9, 2020	♥ 3:17
8	Smile - Marshall Jefferson Remix Katy Perry, Marshall Jefferson	Smile (Marshall Jefferson Remix)	buggiboy	Oct 9, 2020	♥ 2:38
9	ice cold. (with Kimbra) half-alive, Kimbra	Now, Not Yet	buggiboy	Oct 9, 2020	♥ 2:57
10	It's Been A Long Time Rakim	The 18th Letter / The Book Of L...	1288296450	Oct 12, 2020	♥ 3:57
11	Paper Planes M.I.A.	Kala	1288296450	Oct 12, 2020	♥ 3:25

MINES MUSICS TOGETHER

Building community through a shared playlist

As a way to connect and build community while social distancing in 2020, Mines put together a collaborative Spotify playlist where Orediggers could add their favorite tunes and check out what others in the Mines community were listening to. The list became an interesting mashup of popular favorites that span generations, such as the best of AC/DC and Elton John, contemporary hits from artists such as Taylor Swift and Dua Lipa, nerdy soundtracks such as the Pokémon theme and more.

► Check out and add to the ever-growing playlist by searching for “Mines Musics Together” on Spotify. You can also open the Spotify app, navigate to the search bar, click the camera icon to the right and scan the image to the right to access the playlist.



EDITOR'S LETTER

Orediggers climb together

It goes without saying that 2020 was a tough year. But through it all, we have seen Orediggers come together to support each other and help the world through the most challenging of crises.

Through the nuances of living through a pandemic to fighting and recovering from devastating natural disasters, such as the incredible wildfires that tore through Colorado and the West Coast last summer, Orediggers have been central to overcoming these overwhelming challenges. Alumni and campus researchers have taken on projects to help fight COVID-19, the Mines community has come together to be a stronger ally for equality and Orediggers have stepped up to help each other overcome and recover from the economic strains many have experienced over the last year.

And though Orediggers have been essential to responding to these immediate crises, they're also essential to what comes next—doing their part to mitigate the aftereffects of these challenges, whether immediate or far into the future. That's largely what drove the decision to feature the work alumni, students and campus researchers

are doing to prepare for and lessen the impact of the aftereffects of natural disasters so prominently in this issue. All around the world, Orediggers play a central role in helping communities prepare for the dangers that follow such events, including deadly landslides, flooding and more. Orediggers are actively working to make the world a safer and better place, and that is a story we are eager to tell.

In this issue, you'll find many examples of Oredigger ingenuity, and as Mines approaches its 150th anniversary, we will share many more examples of how Orediggers are using their creativity and unparalleled technical skills to make a positive impact on Mines and the world. If you or a fellow Oredigger has been involved in a project that exemplifies the Mines spirit, share them with us so we can celebrate those achievements and the good work Orediggers have become known for. I look forward to hearing about all the exciting things you're doing and sharing them in future issues.



Ashley Spurgeon



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'YOU ARE BUILT FOR THIS'

Despite 2020's challenges, the Mines community came out stronger than ever

I spent three days congratulating our December graduates as they took celebratory walks across a small commencement stage set-up in Steinhauer fieldhouse. Much as I love our crowded commencement ceremonies in Lockridge Arena, this was a more personal experience. Rather than a rushed 4-second stage crossing during a 90-minute ceremony, graduates and their families had the opportunity to savor the moment, pose for pictures and be congratulated (with elbow bumps and socially distanced cheers) on their great accomplishment.

While this year's event was constrained by pandemic-related public health guidelines, our graduates' pride and excitement were not. Trustee Jesus Salazar '01, MS '02 assured graduates in his recorded remarks, "You are built for this." He reminded them that they have the tools and experiences necessary to persevere and push ahead, even in a pandemic. Board Chair Tom Jordan '80, MS '87 shared a memorable discussion he once had with another CEO who confidently said you could send Orediggers anywhere, and under any conditions, they would get the job done. The strong work ethic, creativity, perseverance and great teamwork that have always been signature traits of Mines' graduates are strong in this graduating class.

And they're strong in the Mines community, too. Despite all of 2020's challenges, we've seen faculty, staff and students, alumni, parents and friends band together and

press ahead. In the face of ever-changing conditions, our community rallied around an Oredigger Promise and took good, daily care of ourselves and one another.

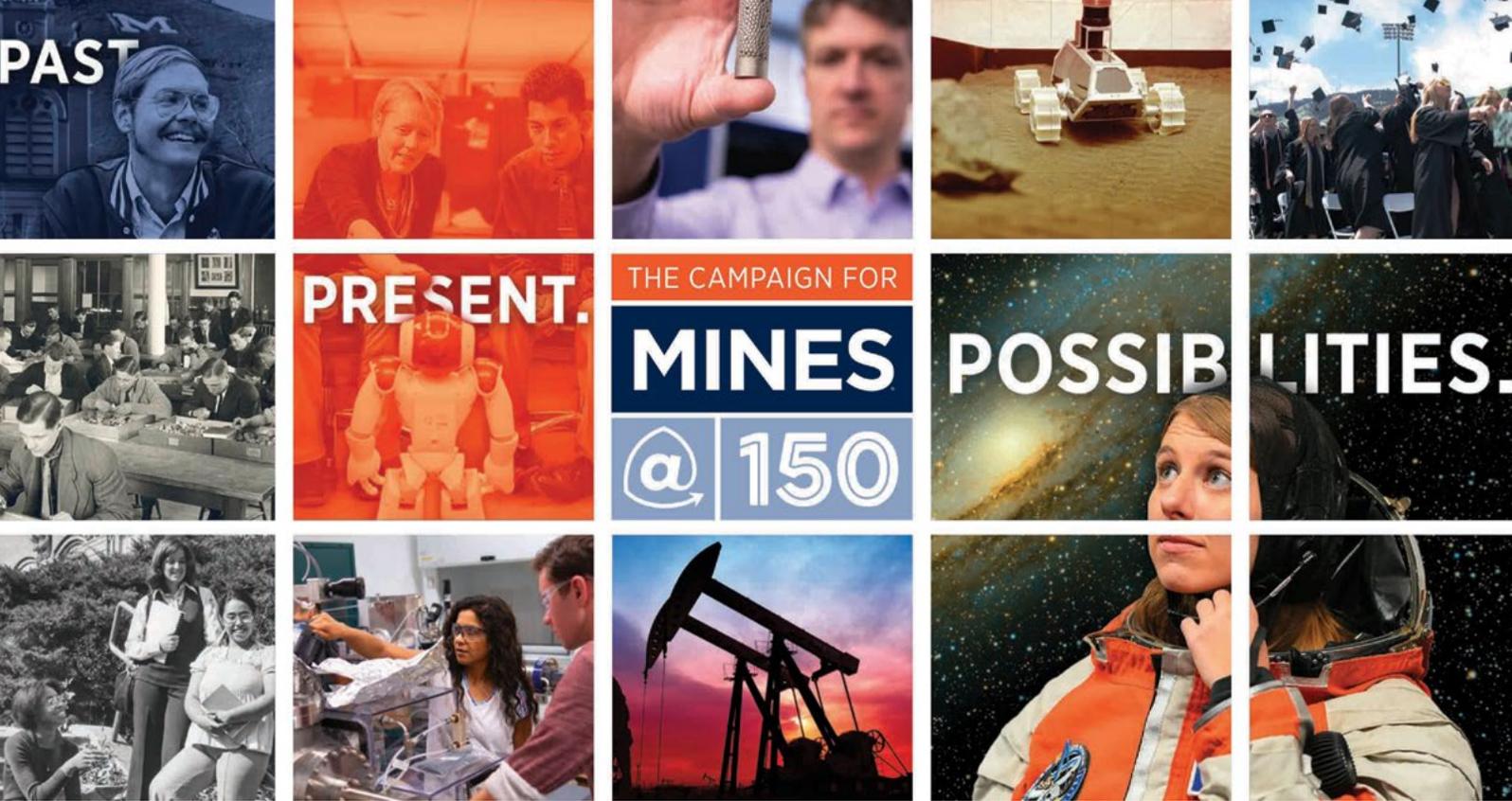
With our campus open, and while wearing masks sewn by many of you, we unveiled two new residence halls, began preparation for our new Innovation Complex and opened the McNeil Center and its state-of-the-art classrooms for design and project-based courses. We earned accreditation to offer online degree programs. Mines' student athletes hoisted our fifth straight RMAC All-Sports Competition Cup. We even saw record rates of giving to support students and fund Mines' future and a record level of external funding for our faculty's research.

While 2020 brought challenges and losses that we never want to experience again, it has reinforced how special Mines is. I hope we remember all those climbs this community completed together.

Wishing you a bright, healthy, beautiful and even better 2021. Go Orediggers!

A handwritten signature in black ink, appearing to read "Paul C. Johnson".

Paul C. Johnson
President and Professor



Visit the campaign website at campaign.mines.edu to be inspired by people who are making a difference for Mines.



“ The students have so much drive to help me get through life independently. This is just huge for me. ”

Velette Britt, Air Force veteran and recipient of student-designed adaptive athletic equipment



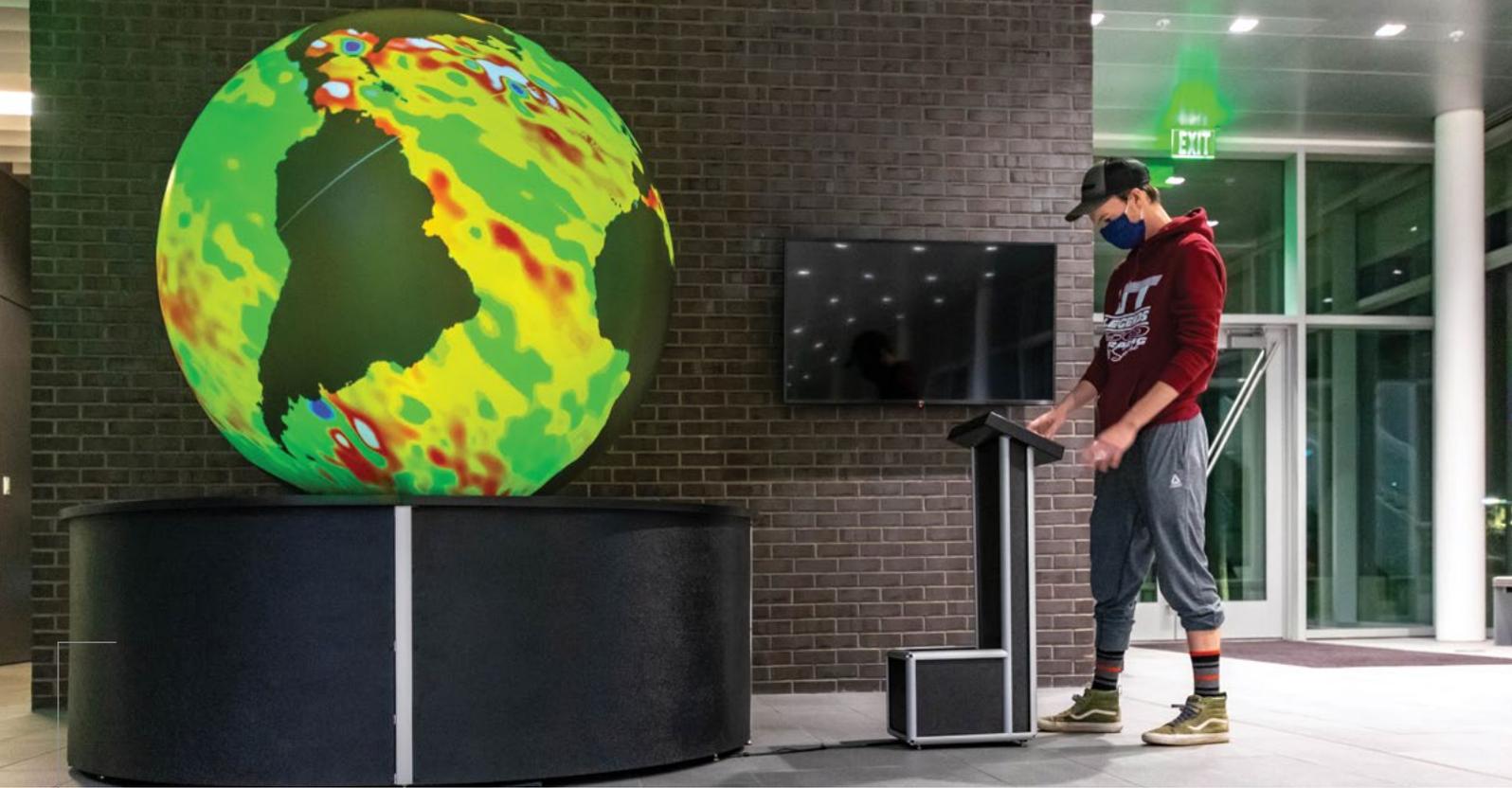
“ Part of my impulse to give back is related to becoming a police officer. I view being a police officer as giving back to the community and helping people. ”

Bryann Lynch, Mines police officer



“ Through this program, students with exceptional leadership potential will gain the skills and knowledge they need to take initiative, inspire others and successfully advance our ever-changing world. ”

Bruce Grewcock '76, creator of the Grewcock Presidential Scholars Program



○ MINES ON A SPHERE

■ The CoorsTek Center for Applied Science and Engineering's atrium has a new addition—a 5-foot-wide GeoDome Globe with an interactive display that features research, educational and informational maps and even a campus tour. The globe's interface features sections highlighting cross-cutting Mines specialties—earth, energy, environment, space, biological engineering and the humans at Mines.

“Featuring the work of our campus partners on such an eye-catching installation is what makes this project unique,” said Physics Professor Fred Sarazin, who led the effort to acquire the globe. “The current Mines content available on the globe is just the beginning. There is a huge potential on campus to add more. The globe will be used as a novel education tool for faculty and students alike.”

○ MAKING MEASUREMENTS ON A SEISMIC SCALE

■ Mines geophysics students installed a broadband seismometer behind the GRL Annex building on campus as a temporary seismic station this fall. With help from a seismologist and a geologist from the Colorado Geological Survey, the students enrolled in Assistant Professor Ebru Bozdog's Earthquake Seismology class monitored and listened to ambient noise, including local construction work, with the hope of recording local and distant earthquakes from around the globe. The class analyzed the data and characterized recorded signals and report observations.

The group is planning to collaborate with the Colorado Geological Survey to deploy a permanent station close to the Mines campus,



but in a quieter area to increase the quality of earthquake and other environmental signals, such as landslides, recording continuous seismic data that would be open-access through IRIS and available for students and researchers.

CONNECTIONS

- ▶ Have you run into a fellow Oredigger in an unusual place? Gone on a trip with classmates? Visited campus to share your expertise? We want to know all about it! Send us your connections at minesmagazine.com/connection. •



○ A NEW HUB FOR INNOVATION AND ENTREPRENEURSHIP

■ Thanks to a generous lead gift from Frank '52 and Mary Labriola, Mines is developing the Labriola Innovation Complex, a new state-of-the-art multi-facility complex that will be the central hub for innovation on campus.

The Labriola Innovation Complex will include maker spaces, project team spaces, creativity and collaboration spaces and design project classrooms—everything needed to imagine, design, prototype and test new inventions, products and code.

President Paul C. Johnson said, “The Labriola Innovation Complex is going to further cement Mines’ position among the world’s top STEM-focused universities by expanding the hands-on and learning-by-doing opportunities that are key to our students’ growth as engineers and scientists, and eventually, industry leaders.”

COMING OUT ON TOP

No. 4 engineering school in the nation, according to *Money Magazine*.

Mines alumni landed their alma mater the **No. 12** spot in a new ranking of the Top 25 U.S. Universities put out by *Forbes Magazine* in Oct. 2020.



○ ENGINEERING A SIMPLE INSULIN CALCULATOR

■ Callie McCaffery, a mechanical engineering student, was one of just 10 Girl Scouts this year to be named a 2020 National Gold Award Girl Scout, the top honor from the Girl Scouts of the USA. McCaffery was recognized for developing a simple insulin calculator for her Gold Award project, inspired by her brother, who was diagnosed with Type I diabetes a couple years ago. Most diabetes patients have to manually calculate the necessary units of insulin needed in the “honeymoon period” when a patient’s body still creates some insulin and a pump isn’t a viable option. McCaffery’s solution was to build a simple, sharable calculator that cuts the math out of the equation entirely for both diabetics and their caretakers.

“I’ve always been a problem-solver,” McCaffery said. “I couldn’t fix Type I diabetes, so I found a problem that I could fix.”

- ▶ Kennda Lynch PhD '15 was featured in the second episode of Netflix’s *Alien Worlds*, discussing the Danakil Depression in Ethiopia and what it can tell us about what alien life might be like on other planets. •



Photo by Finn Lassen

TAKING THE FIELD

A star Oredigger athlete goes pro abroad

BY TIM FLYNN

One of the best athletes to ever patrol the pitch at Stermole Stadium, Emily Garnier '18 is an unforgettable player for many Mines soccer fans. A leader during a period of incredible team success for the Orediggers, Garnier stood out as a shutdown center back and now continues her winning ways as a professional player in Europe.

A three-time all-American, Garnier earned three Rocky Mountain Athletic Conference (RMAC) Defensive Player of the Year awards while leading Mines to three consecutive RMAC regular-season and RMAC Tournament championships. She was Colorado's Sportswoman of the Year in soccer and was twice named Mines' top female student-athlete. Garnier graduated second all-time at Mines in assists with 30 and fifth in points with 54. Now, Garnier continues to

make her mark abroad, albeit after some starts and stops.

"It wasn't a straight shot, but it was what I really wanted to do [after graduating]," Garnier said. "I did the whole 'after-grad Eurotrip,' but in my backpack, I had a soccer ball and my cleats and was training throughout the whole time."

At first, lack of exposure prevented Garnier from getting her professional career off the ground. "In Europe, they don't really know much about our college system, so if you're not from the top D-I schools, they don't know what your level is," she explained. "No one was willing to give me a look."

But Garnier had received an earlier offer from the Soccer Management Institute in Italy, which luckily still had an open defender slot on the club Empoli.

Over the next two seasons, Garnier became a fixture in Empoli's lineup, helping the club earn promotion to the Italian Serie A after her first season. But it still took some time for her to adjust to a culture that was obsessed with the game in a way she didn't understand.

"It was really tough for a while. At training, no one spoke English. My coach didn't speak English at all. He would explain a drill, and one of the girls would come over and translate it for us," she said. "It was sink or swim, but I started to pick up 'Soccer Italian,' and then by the end of my two years, I would say I'm conversational."

This year, a new opportunity emerged with Fortuna Hjørring, one of Europe's top clubs, in Denmark. After signing, Garnier was slotted into the starting lineup—but she quickly realized she was going to have to adjust all over again.



Photos by Sam Boender

RUNNING AWAY WITH THE COMPETITION

Cross country may have been the only Rocky Mountain Athletic Conference championship held in fall 2020, but the Orediggers made sure to represent. The Mines men's and women's programs dominated the day in Colorado Springs on Oct. 24. The men's team captured the team title for the second year in a row,

led by repeat

individual

winner Dylan

Ko, while

Zoe Baker

made

history as

the first

individual

women's

conference

champion for

Mines, leading the

Orediggers to second

place overall.



"You cannot pick two more different places than Italy and Denmark," she said. "Here it's more balanced, more physical, more running. In Italy, it's the opposite, it's all about tactics, possession. It's like a sin to play a long ball—at Mines, that was my thing—but I'm actually grateful for that, because it has developed my game in a completely different direction."

CONNECTIONS

- ▶ The mining engineering department hosted a virtual chat with new Department Head Steve Enders '76 and other mining faculty in mid-November to share what students are learning and what the department's future looks like. •

Photo by Alex Vogel



AMPING UP THE VOLTAGE

BY ASHLEY SPURGEON

A 1979 Volkswagen bus goes electric

When 2020 graduate Gracie Cole's parents bought a brand-new Volkswagen bus for their growing family in 1979, they had no idea one day it would be converted from a combustion vehicle to an electric one. But that's exactly what happened when Cole bought the vehicle from her parents a few years ago and turned it into her senior design project, called Re-Volt. The bus was in great shape, and Cole saw a way to bring a classic into the future.

"I'm not fixing this because it's broken," Cole said. "This project is a way to improve the performance and reliability but also to keep it relevant in the decades to come."

The team

Cole said the learning curve isn't so much on the combustion side—it's the electrical components that pose the biggest challenge—so setting up a senior design team with students from different disciplines was key. Three electrical engineering and 12 mechanical engineering students currently work on the project.

"We rely heavily on our electrical engineers, but mechanical is a necessary integration, too," Cole said. "We've been able to work really well together."

The conversion

One of the biggest factors in the conversion was making sure the bus can not only keep up with traffic, but travel long distances with minimal charging, like the cross-



Photo by Gracie Cole

country trips Cole's family took when it was fresh off the assembly line.

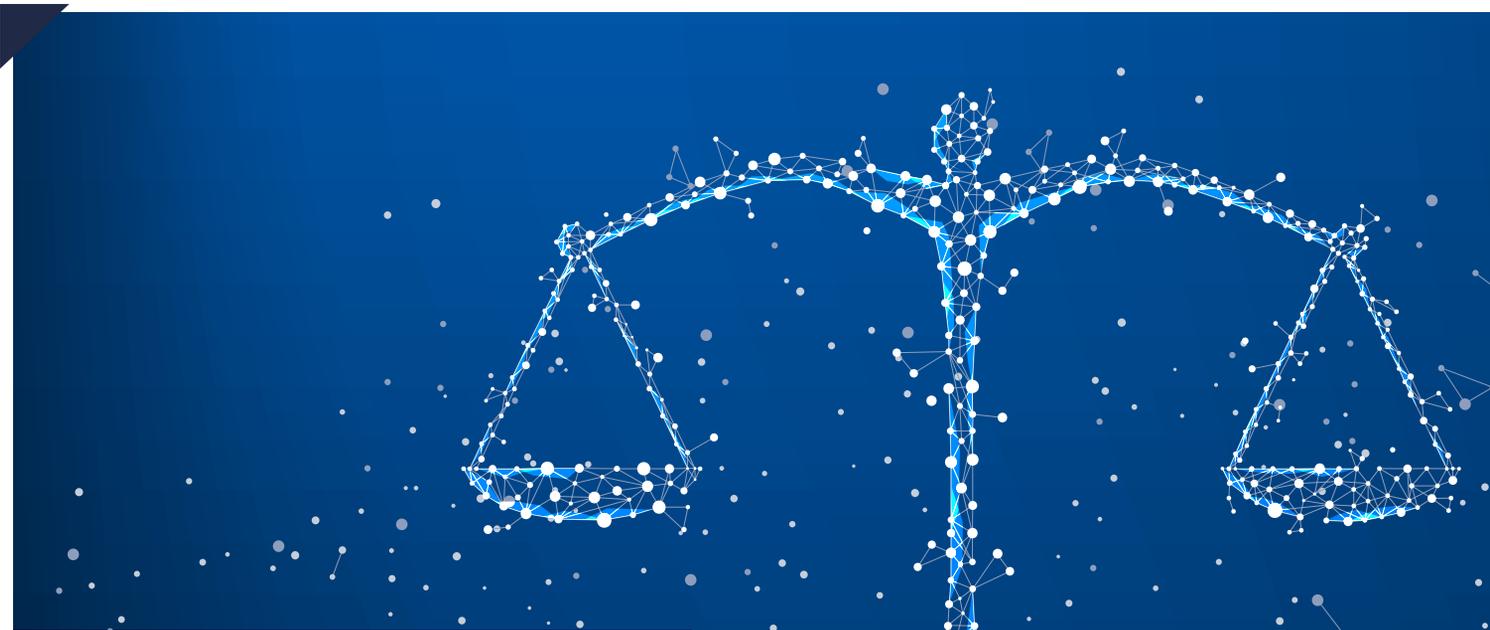
The Re-Volt team was able to keep the Volkswagen's existing transaxle and transmission, which will integrate seamlessly with the new design and connect to the electric motor. Eighteen Tesla Model S batteries are going to be arranged in three parallel packs of six. A motor controller, which connects to the electric motor, relays performance commands based on user input. The embedded systems subsystem will make all the various components talk to each other and monitor everything, including relaying the cabin temperature and telling the user interface how hot the batteries are.

What's next

Cole's first road trip to test out the new system when the project is complete? "Maybe take a drive down the California coast," she said. "I don't know if it gets more iconic than that."

► Follow along with the Re-Volt team's progress at revoltswagen.com.

► The Women of Mines Interest Group hosted several virtual events this fall, including networking panels, workshops and a virtual happy hour. •



BY JENN FIELDS

BUILDING BOTS TO BENEFIT ALL

Exploring how engineers can create technology for a more inclusive future

During a recent lesson on pedestrian detection, Tom Williams' computer vision students spent the first 15 minutes of class hashing out a major design issue. The problem wasn't a mechanical or a coding dilemma but a moral one: How will the robots be used?

"If you're a robot, you need to be able to tell where people are so you don't run into them," said Williams, an assistant professor of computer science whose research is focused on human-robot interaction. The problem sounds simple. "But there are a lot of morally fraught ways you can look at pedestrian traffic." Based on the design, could humans use the robots to discriminate against some pedestrians? What implicit biases might designers bring to how the robot detects pedestrians? Would the robots gather data and create a privacy concern? Could they be used to cause harm, physical or otherwise, intended or not?

Ethical concerns aren't new to robot and artificial intelligence developers. But as technology evolves,

so do the moral questions about how it's used, who uses it and who it's used on. Though they're trained in the technical aspects of this work, the designers of these technologies are also actively engaged in social and psychological conversations about race, class and gender equity, and how responsible designers are for the technology they create. The ethical considerations are wide-ranging, from questions of jobs and economic security to privacy, bias and discrimination.

"In engineering design, we often feel hesitant to talk much about the personal experience the designer has brought to the product," said Qin Zhu, an assistant professor of ethics and engineering education who co-teaches a robot

CONNECTIONS

- ▶ With a shared interest in Montana's Beartooth Mountains, Doug Jones '81 and Matt Lemke '12 connected last summer to identify which peaks can be seen from the heart of Billings. •



ethics course at Mines with Williams. “I think that’s a missing point. In engineering, design often assumes a linear model, where if you design a good technology, society will choose it. But ‘good technology’ is often subjective. Often, it doesn’t address the concerns of society early in the design.”

Zhu, who is trained as an ethicist, noted that one way designers can address moral questions is through the team itself. “A diverse team is a very important condition for building inclusive technologies,” he said. “I think there are many different reasons why many people from different cultural backgrounds can generate a lot of great ideas. If you want to tackle a complicated issue, it often calls for morally creative solutions.”

The workforce itself is where inclusive technology starts, said Dagny Stahl, a senior computer science major who is the head of Mines’ Association for Computing Machinery-Women chapter. “With inclusivity, I think the main thing that needs to happen is that the environment needs to change. Tech needs to be less of this exclusive bubble where if you’re not already inside it, you can’t contribute,” she said. “I think to break that bubble, we need people from more backgrounds coming in.”

‘A more friendly future’

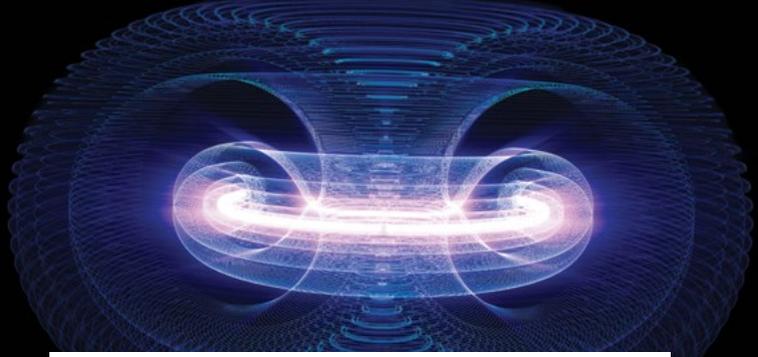
When anti-racism protests broke out around the globe this summer, Williams co-authored an “open letter from robotics researchers” with other Colorado-based robotics professors that addresses the role designers have in creating certain technologies, such as non-consensual facial recognition and predictive policing models, that can be used by law enforcement against marginalized communities.

The open letter also calls for “requiring state and local governments to acquire informed public consent before acquiring robotic technologies.” This is a slice of a big-picture conversation happening with consent right now. Big tech companies have pervasive public power, Zhu said, but they didn’t consult with the public before implementing these technologies—some of which are changing people themselves.

“Artificial intelligence and robotics are so pervasive in your everyday life,” Zhu said. “If you live with a Google Home for 10 years, this kind of influence is very nuanced but sometimes significant. If you look much longer-term, you may become a different person without even thinking, in your moral reasoning.”

The next generation of engineers is already thinking about these and other moral questions, though, Zhu said. “I have a lot of hope in Generation Z. When I talk to them, they are worried about privacy, not just robotics and AI, but how technology in general can build a more friendly future.”

- ▶ When 2020 graduate Justin Lewis’ job with alumni-led Downing was canceled last summer, he offered to work as an unpaid intern to gain industry experience, ultimately enabling Downing to later hire him full-time. •



FUSION FUTURE

A new possibility in the search for a carbon-free power supply

Fusion has the potential to be an unlimited carbon-free power supply, according to Colin Wolden, professor of chemical and biological engineering at Mines.

“Fusion is not unlike the processes that occur in the Sun—tritium and deuterium, isotopes of hydrogen, fuse together to create helium, which is accompanied by a very small loss of mass but an enormous release of energy in accordance with Einstein’s famous relation $E = mc^2$,” he said. “This heat can be harnessed and used to run steam turbines in power plants instead of burning coal.”

But a critical challenge to implementing fusion power lies in the effective and safe management of tritium, a radioactive isotope with a short half-life. Wolden and Doug Way, professor emeritus of chemical and biological engineering, hope a composite metal membrane they developed for high-temperature hydrogen separations in conventional petrochemical refining operations could hold the key. These dense metal membranes purify hydrogen isotopes from impurities with perfect selectivity, critical for tritium-related applications.

The researchers are adapting the membrane technology to the unique constraints of the fusion environment with a goal of enabling lower cost and safer fusion energy systems by eliminating major fuel cycle components and reducing tritium inventory, release and required breeding ratios. The Fusion Safety Program at Idaho National Laboratory, including Mines alumnus Thomas Fuerst PhD '18, will validate the membranes using the state-of-the-art facilities within its Safety and Tritium Applied Research (STAR) facility.

“At INL, we are investigating membrane technology to extract tritium from the breeder blanket as well as separate tritium directly from the reactor exhaust, which will provide improved efficiency and safety streamlining the current tritium fuel cycle,” Fuerst said. “We look forward to the collaboration with Mines as these advanced composite membranes may provide the answer.”

AN UNWELCOME DINNER GUEST

Dangerous chemicals could be lurking in your vegetables

You might know what’s in your drinking water, but how about the vegetables on your dinner plate? It’s possible they could contain concerning levels of poly- and perfluoroalkyl substances (PFASs) if they’re grown with PFAS-impacted water.



Mines researchers are actively studying this issue—here’s what we know so far:

Studying the impact

Researchers compiled available data on how much individual PFAS are taken into vegetable crops irrigated with contaminated water to estimate the daily dietary exposure intake of PFAS through vegetables in children and adults. Using statistical modeling techniques akin to election model prediction forecasts, they’re considering a range of variability and uncertainty to identify the “most likely” intake and hazards associated with consumption. The team also predicted risk-based threshold concentrations in produce and irrigation water to provide screening levels for assessment. These represent the range of concentrations for individual PFASs in irrigation water predicted to be below a level of concern for human health.

Analyzing the findings

The team used real-world data from PFAS-contaminated groundwater to conduct a hazard analysis of a theoretical farm comparing different risk estimates based on established state, federal and international toxicity reference doses. This analysis showed estimated exposures to most PFASs exceeding available or derived human health toxicity reference values—indicating water-to-crop transfer is an important exposure pathway for agricultural communities with PFAS-impacted irrigation water.

Christopher Higgins, professor of civil and environmental engineering, said, “Even when drinking water has been treated and is considered safe, there is a potential for exposure from vegetables irrigated with contaminated water or grown in contaminated soil.”

► Learn more about this research on minesnewsroom.com.

CONNECTIONS

- Musab Al-Saud, director of political and congressional affairs at the Royal Embassy of Saudi Arabia and son of a Mines alumnus, presented a webinar with the Payne Institute for Public Policy in October 2020. •

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CAREERS.MINES.EDU

YOU ASKED, OUR EXPERTS ANSWERED



Photo by Philipp Arndt, Scripps Institution of Oceanography

What trends are we currently seeing on the Antarctic ice shelf, and what new technologies and research methods are expanding our knowledge about the changes we're currently seeing?

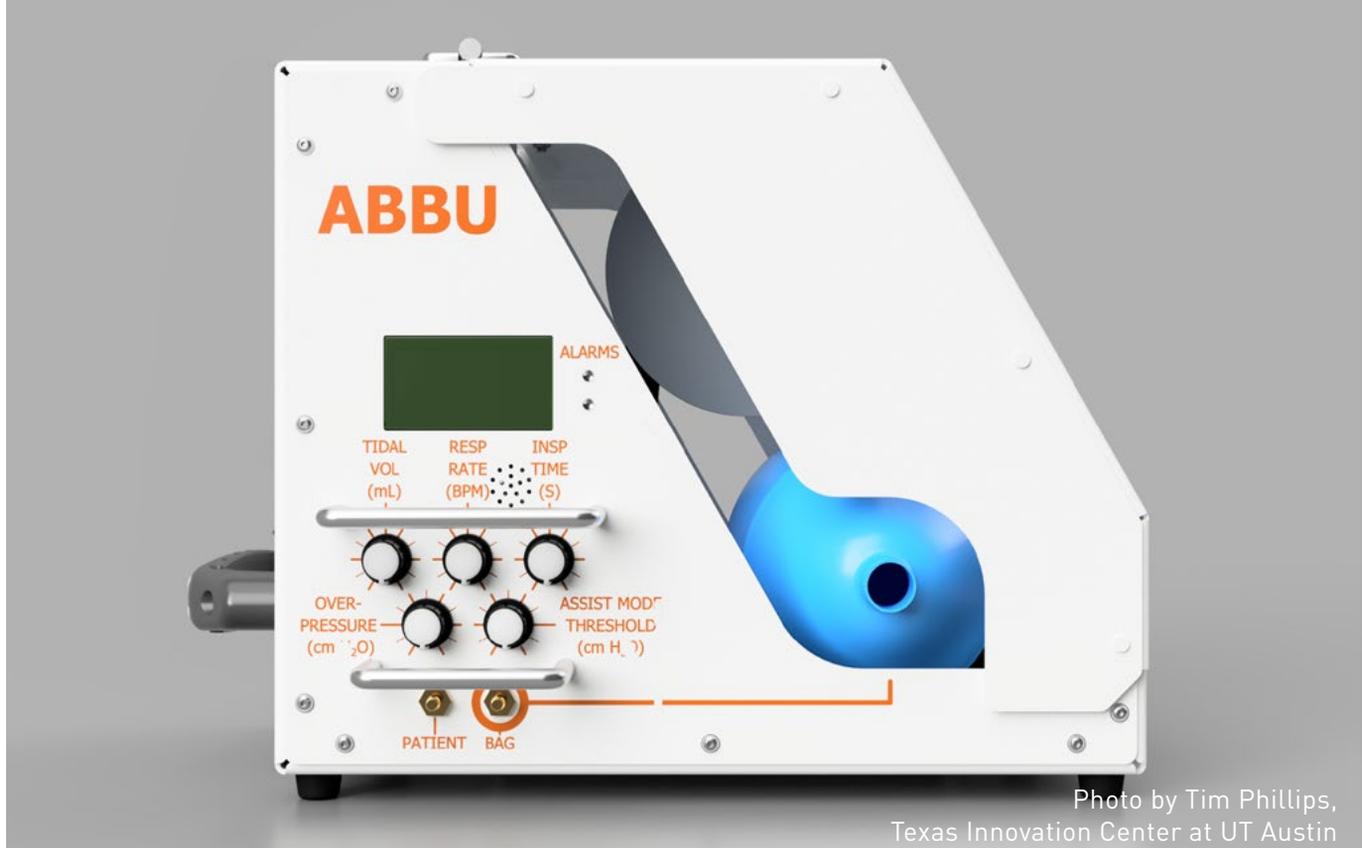
Matthew Siegfried, a physical glaciologist and assistant professor of geophysics, answered:

The Antarctic ice sheet remains one of the biggest question marks for projecting the Earth's climate over the coming decades. Covering an area about 1.5 times that of the continental United States, we are trying to measure small signals over large areas in a place where we have only had widespread, continuous satellite coverage since 2010. This short observational record is particularly problematic when we know the ice sheet changes on time scales ranging from minutes to millennia.

Thanks to recent (and upcoming) innovative satellite missions launched by NASA and the European Space Agency, we can quantify the exact amount of ice mass Antarctica contributes to sea level rise every year better than ever before. But projecting how Antarctica—and the rest of Earth's glaciers and ice sheets—will change in the future, along with the subsequent impact that these changes will have around the globe, requires a combination of detailed studies of ice, ocean, atmospheric and geologic processes that drive changes, using older, less precise datasets to test hypotheses and continued innovation in satellite instrumentation to monitor ongoing change in even finer detail.

Have a question about science, engineering or anything else?

► Submit it at minesmagazine.com/contact-us for a chance to be featured in this column.



TAKING A BREATH

BY ASHLEY SPURGEON

Solving the ventilator shortage with windshield wiper parts

Early on in the COVID-19 pandemic, medical professionals in ICUs across the country faced a critical shortage of lifesaving ventilators. And it looked like there was no easy way to increase production.

Thomas Milner '81, MS '86, a former professor at the University of Texas at Austin, and his research team there came up with an idea for a “bridge ventilator” to help fill the demand for these lifesaving devices, but with an unusual twist—the machine includes a windshield wiper part.

We sat down with Milner to learn more about this ventilator and the laser-based research he’s currently working on at the University of California, Irvine’s Beckman Laser Institute.

What was a main consideration your team made when designing a new ventilator?

Thomas Milner: Many ventilators have a very minimal functionality. Ventilators fall into two classes—you have one class that doesn’t really listen to the patient or try to breathe with the patient, and then you have another class

that tries to breathe with the patient, so it gives a breath when the patient says, “I need a breath.”

We made the decision pretty early on that we would not try to build one of the ventilators that doesn’t listen to the patient. We felt like if it’s going to really have much use, it’s going to have to be operable in what’s called a patient-assist mode. That required some fairly careful software development to learn how to sense or detect when the patient is trying to breathe.

Your team used a windshield wiper motor from a Toyota Camry to power a small caster wheel that automatically compresses the artificial medical breathing unit bag to control oxygen flow, eliminating the need for a person to manually compress the bag. What was the inspiration for using this mechanism?

Milner: We knew it had to be something that was readily available and can run and run without failing and was inexpensive. When you’re looking to manufacture something, you have to make sure there’s enough parts and inventory to meet however many you’re

CONNECTIONS

- ▶ Jennifer Miskimins MS '00, PhD '02, Jim Crompton '74, MS '76 and Will Fleckenstein '86, MS '88, PhD '00 led the November Lunch Bunch event to talk about how Mines is educating the next generation of petroleum engineers. •

manufacturing. There's a lot of motors that could be used, but they were generally a lot more expensive, and the inventories for them were much lower. There's a variety of windshield wiper motors with large inventories and they're very reliable—they last a long time—and the cost is low.

What other COVID-19 research are you working on?

Milner: The National Institutes of Health put out a call for a technique to be able to screen millions of people a day. Most of the existing approaches are chemical-based, but I started talking to some of my colleagues here at the Beckman Laser Institute and we started thinking about how we can detect the virus optically.

So a person would wear what we call a “smart mask” that essentially has a little harvesting patch embedded in it. The person would walk up to a kiosk, which would have to recognize the person, recognize some markings on the mask and then direct a laser beam to the site of the harvesting patch in the mask. And then by looking at the light that comes back from that harvesting patch, the discrimination of whether the virus is there—or not—can be made.

HOW THE BRIDGE VENTILATOR WORKS

Existing Assisted Bag Breathing Units use a manual resuscitator, called an artificial medical breathing unit bag. The bag is a handheld device that fills up with oxygen and a mask that patients wear to receive ventilation. But the unit requires a person to compress the bag frequently to help patients breathe, presenting a problem when medical personnel are stretched thin.

The windshield wiper motor in the bridge ventilator allows the bag to compress automatically with four potentiometers to control the respiration rate, oxygen volume, time to inhale and maximum pressure.



GIVING CAMPUS AN UPPER HAND

Mines researchers are helping the university respond to pandemic challenges

Mines researchers came up with several ideas this fall to help Mines respond to the challenges of the COVID-19 pandemic on campus. Some of the projects underway include:

Environmental engineers are analyzing wastewater, hoping to find cases before symptoms or a positive test result emerge. So far, their results have matched with the number of confirmed COVID-19 cases on campus, with researchers hoping they may someday be able to predict—and prevent—an outbreak.

Mathematicians are looking for transmission patterns and hoping to identify an optimal testing approach. Researchers are taking two mathematical approaches: a compartmental model that simulates infectious disease scenarios by grouping people based on their disease status and an agent-based model, which tracks individuals within the Mines community and provides a detailed look at how transmission might occur.

Mechanical engineers are collecting real-world data from the heating, ventilation and air conditioning (HVAC) systems in campus buildings to help inform future system updates. Researchers are using the data to calculate the overall probability risk of airborne transmission in specific rooms, considering factors such as air flow rates and the number of people expected to be in each space at a time.

► Learn more about these projects and the others helping keep the Mines community safe at minesnewsroom.com.

► Scott Hodgson '03 gave a talk at the American Society of Heating, Refrigerating and Air-Conditioning Engineers' November meeting, discussing the design and controls in the CoorsTek building on campus. •



What comes next

By Sarah Kuta

After a natural disaster, engineers and scientists play an important role in preparing for the dangers that follow

As a child growing up in Albuquerque, New Mexico, Rebecca Kramer '09 always flipped to the back of her family's encyclopedia to stare in awe at the pictures of erupting volcanoes. She begged her parents to buy her more books about this powerful natural phenomenon.

Today, Kramer is living out her childhood dream of working with volcanoes, but she's taken a slightly different, more nuanced path. Kramer helps protect communities in the Pacific Northwest from the aftereffects of volcanic eruptions, which can be just as bad as—if not worse than—the initial event.



This image shows the burn scar from Colorado's Calwood Fire in fall 2020. The wildfire burned for more than a month, consuming a total of 10,106 acres.

Photo courtesy of the Colorado Geological Survey



Kramer is a geophysicist at Cascades Volcano Observatory, a U.S. Geological Survey office in Vancouver, Washington, where she helps repair and maintain the specialized equipment used to monitor volcanoes in the Cascades. She's currently helping install a modern detection system around Mount Rainier to protect nearby communities from lahars, a dangerous and destructive mudflow that can occur after eruptions and other seismic and weather events. "They are one of the deadliest volcanic hazards," she said.

Kramer is one of the many scientists and engineers around the world who examine and mitigate the aftereffects of natural disasters, such as the rock slides that follow wildfires and tsunamis after earthquakes, for example.

Many of these aftereffects present short- and long-term problems that can disrupt entire communities and the systems they rely on every day. Wildfires can burn so hot that they melt a city's underground water pipes, causing widespread damage to vital infrastructure and water contamination. Hurricanes and high-wind events can knock power lines to the ground, leading to monthslong power outages and, potentially, wildfires.

Because of continued population growth, increasing urbanization, climate change and other factors, these and other aftereffects are top priorities in fields such as civil and electrical engineering, geology and geophysics, where industry professionals and researchers alike are studying and taking steps to mitigate their impact on health, safety and local economies. Their focus is on community-wide resilience, which encompasses everything from individual homes and businesses to above- and below-ground utilities, highways and natural landscapes.

"With these natural disasters, often what you see is the impact at the ground level, but because of the nature of our infrastructure, the effects go down into the ground or even above in the air," said David Ray '91, a former commander with the U.S. Army Corps of Engineers who now works as a senior program manager at HDR Engineering. "You have to go in and assess all the different aspects and not just repair and replace them but rebuild them in a manner that they will be more resilient."

Early warning system

Mount Rainier looms over much of western Washington—on a clear day, you can see the towering fourteener from Seattle. The active stratovolcano has erupted many times over the last half-million years. But even when it's not erupting, it's still dangerous.

To help protect against lahars, which can contain giant boulders, debris and water from rapidly melted glaciers on the surface, Kramer's team is installing broadband seismometers and infrasound sensors along high-risk drainages on the mountainside. Together, these devices serve as an early warning system by detecting ground-shaking activity and low-frequency sound waves in the atmosphere.

This system is an important tool in its own right, but it's made even more effective by the people living in Mount Rainier's shadow—communities such as Orting and Ashford—who are well aware of the volcano's potential for destruction and deeply engaged in emergency preparedness and mitigation efforts.

"One thing that really impresses me is how much a lot of these communities really own their hazards," Kramer said. "People really get excited about volcanoes in their backyards, and with that knowledge, they're able to make judgment calls about preparedness."

Post-fire debris flows

As prolonged drought continues to plague much of the Western U.S., scientists are also studying one of the most destructive potential aftereffects of wildfires: rock, mud and landslides, which are collectively referred to as post-fire debris flows.

Mines researchers such as Paul Santi and Danica Roth are leading efforts to better understand these debris flows by researching topics such as rock behavior, drainage systems, erosion and soil mobility, among others.

Roth, assistant professor of geology and geological engineering, helped develop an important new model for characterizing and predicting how sediment moves downhill after wildfires. Students in Roth's surface processes and geomorphology group are also investigating questions around water infiltration and factors affecting surface roughness following wildfires.

In addition to deepening the scientific understanding of geomorphology, their research is helping inform the work of the USGS' Geologic Hazards Science Center, headquartered on the Mines campus. Often working in collaboration with Mines faculty and students, geologists within the center's Landslides Hazards





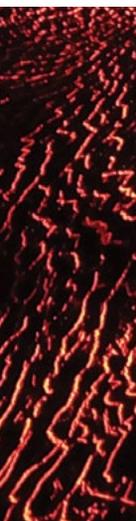
Photo courtesy of
Cascades Volcano Observatory

“One thing that really impresses me is how much a lot of these communities really own their hazards. People really get excited about volcanoes in their backyards, and with that knowledge, they’re able to make judgment calls about preparedness.”

–Rebecca Kramer '09



Rebecca Kramer '09 and a colleague construct an enclosure and solar panel frame for a remote monitoring station to detect lahars on Mt. Rainier.





USGS scientists examine a fissure caused by the 6.4 and 7.1 magnitude earthquakes that hit Ridgecrest, Calif. in July 2019.

“We try to make the system as reliable as possible and have as many backups in place as we can.”

–Lindsey [Ozark] Sayers '02





Program create maps and other resources to help warn the public about debris-flow hazards after wildfires.

“Wildfire often consumes a lot of the material that’s on the ground surface, which makes the ground smooth and easier for water to run across the surface,” said Francis Rengers, a USGS research geologist. “Fire can also make the soil really water-repellent. Those two things create a direct link between fire and debris flows. After the fire is out, unfortunately, it’s a hazard that still needs to be on people’s minds and should definitely be a concern for people in a burned area.”

Mines graduates are putting this knowledge into practice in Colorado, where record-breaking wildfires wreaked havoc across the state this summer. As an engineering geologist for the Colorado Department of Transportation, Matt Tello MS ’20 is using slope evaluation and rockfall modeling techniques to help protect drivers from dangerous rockslides on Colorado’s busy highways and mountain passes.

Wildfires—and the ensuing soil and surface conditions—are a leading cause of rockslides on the road, along with high-intensity rainstorms and the state’s repetitive freeze-thaw cycles. CDOT mitigates rockslides with tactics such as scaling (rock removal), blasting and netting.

“[Fire] creates, basically, a double whammy, so we’re looking at preventative measures for the debris-flow potential in areas affected by wildfire,” Tello said.

Keeping the lights on

In addition to wildfires, earthquakes are also a constant threat in California, a state with many heavily populated metropolitan areas. Initial destruction aside, these powerful natural disasters can also disrupt the infrastructure that delivers electricity to homes and businesses, which can make response and recovery efforts all the more challenging.

Electrical engineers at Southern California Edison are working to make the power company’s equipment and systems more resilient in the face of natural disasters and other potential disruptions across their 50,000-square-mile service area. As the senior manager for Southern California Edison’s substation projects group, Lindsey (Ozark) Sayers ’02 helps design, engineer and install new technologies to help reduce the impact of earthquakes, wildfires and high winds on the company’s five million customers.

“We try to make the system as reliable as possible and have as many backups in place as we can,” she said. “Loss of power is definitely a concern because so many of our emergency resources need power—the police stations, the fire stations, the hospitals.”

To help keep the lights on during earthquakes, her team built steel support structures to help stabilize substations’ voltage transformers, which often sway back and forth during seismic activity.

They’re also installing several technologies to help reduce the energy and duration of faults. The benefits of these measures are twofold: they help keep the power on during and after natural disasters, and they also help prevent wildfires, which can spark from wires toppled by high winds and other events.

“It doesn’t matter what causes the faultage incident, it’s all about reducing current and reducing time so you can reduce the amount of fault energy,” Sayers said. “By reducing the fault energy, you reduce the potential of a fire.”

The community’s role

At the city and county level, communities should carefully evaluate proposed new developments or retrofits in existing disaster-prone areas. They should also factor in the changing severity and frequency of natural disasters and their aftereffects because of climate change, according to Karen Berry, director of the Colorado Geological Survey, the Mines department that works with local communities to turn hazard research into actionable land-use plans that protect public safety, costly infrastructure and local economies.

Similarly, individuals should spend time researching the potential hazards in their community and fully understand all the risks they may face, including the aftereffects, then take steps to avoid or prepare. Buying a mountain cabin may sound idyllic, but an uninformed buyer may find it’s located in an area that’s ripe for wildfires and the ensuing post-fire debris flows, Berry noted.

“People feel like, ‘If the government lets somebody build there, it must be safe,’” said Berry. “And there are all kinds of reasons why that’s not necessarily true. People need to be aware of what the potential hazards are and be prepared.”





Photo by Marybell Trujillo,
BelleImages

FINDING THE OPTIMAL SOLUTIONS

An engineer's path to the judiciary

BY AND SCHUSTER

As one of the 22 judges sitting on the Colorado Court of Appeals, Terry Fox '89 spends her days mentoring young lawyers and those aspiring to be judges, advocating for greater gender and racial diversity in Colorado's judicial system and, of course, hearing cases. Fox, who is 28 years into a varied and exceptional law career, said the rigor she experienced at Mines helped prepare her for the hard work and discipline it takes to succeed on the bench.

Fox started out as an environmental engineer at Vista Chemical Company in 1989, where she worked with an in-house lawyer regarding the federal, state and local laws that governed her work, sparking her interest in law. Fox, who has a natural curiosity and love for learning, would take the regulations home, read them and come back to work asking more questions. "Engineering is about a spectrum of options. It's about asking, 'What is the optimal solution for this particular set of problems?'" Fox said. "Law is a lot of the same."

Fox completed law school by night while working as an environmental engineer by day, then went on to work for the Texas Supreme Court. After practicing law at a large firm with a natural resources group and both state and federal attorney's offices, she

CONNECTIONS

- ▶ M Club San Antonio hosted a guided walking tour at Canyon Lake Gorge in December 2020 for Mines alumni in the area. •

was nominated to a judicial position on the Colorado Court of Appeals in 2010. Throughout her career, Fox has worked to help increase diversity on the bench. "Years before I ever considered becoming a judge, I was always very interested in helping women and minorities who wanted to be judges," Fox said.

As part of her service with the Colorado Women's Bar Association, she chaired the Judicial Committee, which supports women applying for judicial positions in the state. Fox also served on the Colorado Hispanic Bar Association's Nominations and Endorsements Committee "to advocate for qualified Hispanics who want to become judges," she said.

Fox also served on Colorado's First Judicial District Judicial Nominating Commission for six years, recommending trial judges for Jefferson and Gilpin

counties to the governor. A longtime resident of Jefferson County, she said, "It's important for the bench to represent the community I live in."

These days, Fox's advocacy focuses more on mentorship. "I always have time for coffee. I always have time to look at somebody's judicial application," she said. "While serving as a commissioner, I saw a lot of applications. I've seen what works and what doesn't, and that's something that I'm happy to share."

When asked about what the future holds, Fox talked about how much she loves the work she's currently doing. "I deeply care about applying the law fairly and equally," she said. "[As state judges], our decisions affect Coloradoans every day and every part of the state. What I do, I plan to continue doing as long as Coloradoans allow me to do it."

"ENGINEERING IS ABOUT A SPECTRUM OF OPTIONS. IT'S ABOUT ASKING, 'WHAT IS THE OPTIMAL SOLUTION FOR THIS PARTICULAR SET OF PROBLEMS?' LAW IS A LOT OF THE SAME."

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Doug Swartz
Patent Attorney,
Shareholder

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

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

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TEACHING THE KEYS TO SUCCESS

A leg up for entrepreneurs and the future of innovation at Mines

Mines graduates are widely known for their hard work, resilience and technical prowess, with many building successful businesses and leading game-changing innovations that help solve some of the world's biggest challenges. And thanks to the generous support of Charles "Charlie" McNeil '71 and his wife, Judy, the next generation of Mines innovators will have an even bigger leg up to finding success.

Here's what we know about Mines' latest move to support students' futures.

The new McNeil Center for Entrepreneurship and Innovation will instill entrepreneurial and business principles and foster innovative thinking.

As the first component to be completed in a planned entrepreneurship and innovation complex, the new McNeil Hall hosts classrooms where all Mines students take their initial engineering design course, with top-notch technology and collaborative spaces to support and encourage students' ideas and innovation. The facility comes as a response to industry demands, alumni feedback and student interest in ensuring all graduates are business-literate in addition to the deep technical knowledge they acquire through the rigorous Mines curriculum.



"We want our students to have entrepreneurial experiences at Mines and for them to acquire and practice the skills needed for success," said President Paul C. Johnson.

Students will learn how to advance their ideas from problem to start-up.

Going into a start-up venture or building a new business is no small feat, but through the new campus entrepreneurship and innovation ecosystem, Mines students will gain the skills, techniques and connections to get through the biggest challenges.

The McNeils' contribution will enable students to learn the basics and best practices of entrepreneurship and come up with a variety of concepts for possible ventures. Through the Mines curriculum and students' extracurriculars, they will learn how to approach business and entrepreneurship from a problem-solving angle with hands-on experiences in addition to learning business theory.

► Visit campaign.mines.edu to learn how you can support the next generation of entrepreneurial leaders.



Charlie '71 and Judy McNeil

For Charlie McNeil, the entrepreneurial spirit is all about "PIE."

McNeil said he has always adhered to his "PIE" principles: persistence, integrity and excellence, identifying them as key components of his success and firmly believing that service and giving back are key.

"Judy and I have been fortunate as a result of our commitment to the PIE principles and through the entrepreneurial spirit," he explained. "Mines continues to have the kind of students who have the wherewithal to become the next generation of successful entrepreneurs and business leaders. We are so pleased to make this commitment."

CONNECTIONS

► President Paul C. Johnson updated alumni on the latest campus news and answered questions at the December lunch bunch event. •



Congratulations to these outstanding alumni

Each fall, the Mines Alumni Board recognizes and honors exemplary members of the Mines alumni community who are advocates for the university. The 2020 Mines Alumni Awards winners are making a difference in their own communities while also supporting Mines.

- | | |
|--|--|
| <p>1. Alumnus of the Future
Elijah Evers '20</p> | <p>5. Academic Alumni Support
William Fleckenstein '86,
MS '88, PhD '00</p> |
| <p>2. Young Alumnus of the Year
Jordan Hopper '14</p> | <p>6. M Club Leader of the Year
Alyse (White) Keller '15</p> |
| <p>3. Outstanding Alumnus of the Year
Barry Thomas '91</p> | <p>7. M Club Leader of the Year
Jared Clark '16</p> |
| <p>4. Melville F. Coolbaugh Award
Roshan Bhappu '50, MS '51, PhD '53
(conferred posthumously)</p> | |

Learn more about this year's awardees, and nominate fellow OreGivers for recognition in 2021 at weare.mines.edu/alumniawards.



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CLOSING THE GAP

Bringing Mines alumni and students together—sooner

BY MARK RAMIREZ

Motivated by his excellent student experience, the value of his education and how much he has enjoyed returning to campus, Mines' new director of alumni engagement seeks to close the gap between the time students graduate and when they once again become involved with the Oredigger community.

"I love being around the students, and I really want to see the school succeed—that's the underlying impetus of it all," said Andy Flynn '86, ME '98, who started his new position on December 2 after years of volunteering for Mines, including serving on the Mines Alumni Board.

While earning his bachelor's degree in geophysical engineering, Flynn played on the football team and was a member of the Sigma Alpha Epsilon fraternity. "There were a lot of social opportunities," he said. "I enjoyed E-Days, there was always something to do, we had a lot of fun people to go ski and climb with."

However, other than meeting former football players, he rarely interacted with alumni as a student. "I always heard stories about them, and they came through in the school



CONNECTIONS

- ▶ Mines alumni were invited to listen in and engage with students tackling emergency management and disaster mitigation challenges during the Innovate EMx Demo Day in December 2020. •

traditions and what they had accomplished,” Flynn said. “But I felt that I could have used that kind of interaction as a student—it would’ve been very helpful to learn from them.”

Flynn said it can often take alumni two decades or more before reengaging with Mines, a loss of an invaluable resource for the institution and its students. “I’ve been on calls with young graduates, and our students really connect with them because they belong in the same generation and they have a lot of questions about their career,” he said. “Closing that gap is really critical.”

Improving engagement with alumni starts with asking them back to campus, Flynn said. “I want to remind alumni that they’re part of the fabric of the school, that they

bring value to the students and the institution. I want to give them opportunities to engage with the departments and the programs.”

“I WANT TO REMIND ALUMNI THAT THEY’RE PART OF THE FABRIC OF THE SCHOOL, THAT THEY BRING VALUE TO THE STUDENTS AND THE INSTITUTION.”

This connection with alumni is a big part of the MINES@150 strategic plan. “It’s about recognizing where we’ve been, as well as where we’re going,” Flynn said. “It will require

increasing alumni visibility and bringing them into interest groups, to Oredigger Camp. Getting them involved now is laying the foundation for the next 150 years.”

While the university has changed, it shouldn’t keep alumni from finding common cause with today’s students. “Speaking with alumni who are grandparents now, they say it was hard. It’s still hard. Because of [the new] amenities on campus, new classrooms, student housing, athletics facilities ... there’s a tendency to believe that it’s easier,” he said.

“It’s really important to listen and understand where they’re coming from. They all want the same thing—they want the school to remain the best. And if you look at the rankings, that’s not changing.”



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PROBLEMS, SOLVED

BY ASHLEY SPURGEON

A 3x3x3 cube is a familiar model for overcoming challenges and cultivating curiosity

Most people have encountered a Rubik's Cube at some point in their lifetime. In fact, one in every seven people has handled one, making it one of the best-selling toys of all time and a global symbol of intelligence and ingenuity.

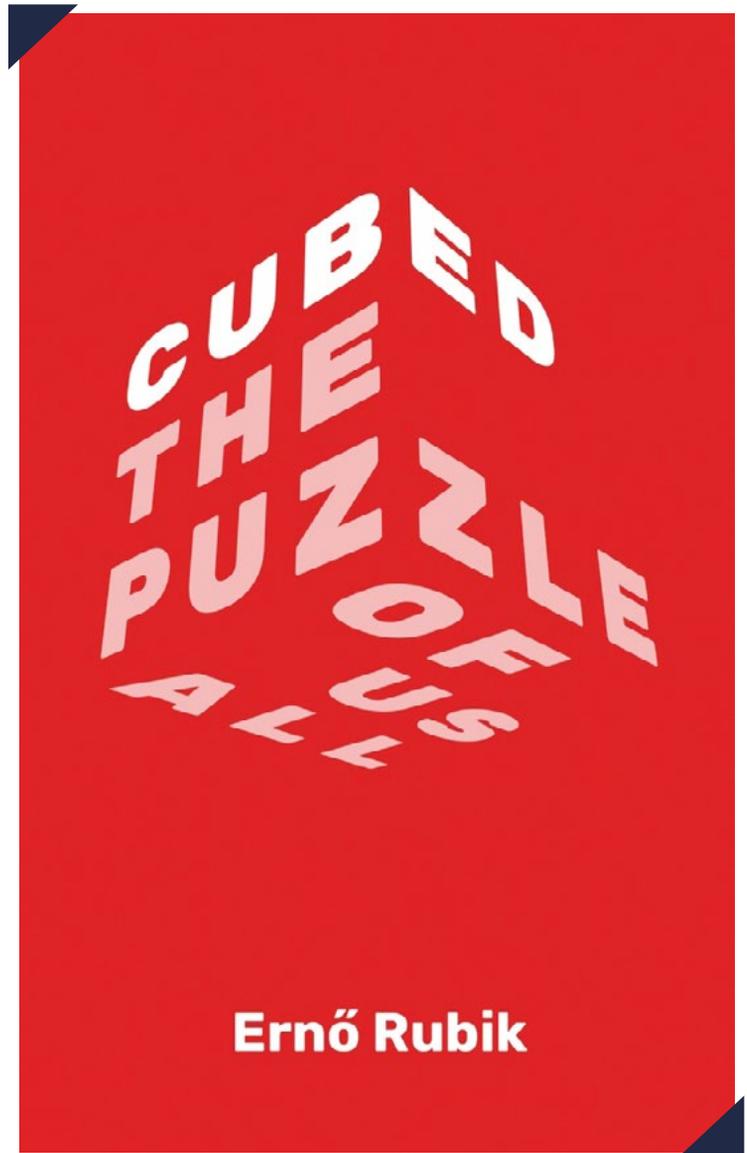
Since its invention in 1974, the Rubik's Cube has captured the public's imagination, with numerous appearances in all corners of popular culture and international competitions to determine who can solve the puzzle the fastest. But those in science, technology, engineering and math have held a particular affinity for the cube, which offers a way to practice the logic and problem-solving skills essential to those subjects.

Ernö Rubik muses on the cube in his book, *Cubed: The Puzzle of Us All*, exploring how his invention—which came into being largely for his own amusement—perhaps can reveal more about the imperfect science of creation and how to fulfill our innate curiosity.

Here are a few key takeaways from Rubik's experiences with the Cube—from when he first invented it to what it has taught him over the decades since becoming a worldwide phenomenon.

The cube is about problem-solving—but not just solving the puzzle.

With every twist and turn, a person makes unique and often calculated decisions as to how to move the jumbled colored squares into a uniform pattern. Logic and problem-solving skills are in play, but Rubik argues that there is more to the mechanical puzzle than spatial reasoning—these small, focused movements can



help teach someone how to problem-solve in other scenarios, often ones much larger than a 3x3x3 cube.

“It has often been observed that finding the solution to a puzzle is a kind of microcosm, a model for problem-solving in other parts of our lives,” Rubik writes.

Most problems—material or otherwise—can be solved through first understanding the problem, making a plan to find a solution, carrying out that plan and looking back on the work you did to solve the problem. Or in Rubik's case, if you deconstruct something, you have to be able to figure out how to put it back together again.

CONNECTIONS

- ▶ Jesus Salazar '01, MS '02 was the distinguished speaker at Mines' mid-year commencement ceremony in December 2020. •

Rubik makes the case for being an amateur.

When Rubik was first designing the cube, he didn't have any of the experiences one would think essential to making the puzzle a success. He didn't have expertise in toy design and manufacturing. He wasn't a professional engineer who could easily solve the cube's technical challenges. And he wasn't a designer who could make the cube into something as aesthetically pleasing as it is functional.

Inventing the cube became a puzzle itself. Through trial and error, Rubik had to figure out the cube's mechanical construction and how to get the different sections to move together seamlessly. But he also had to work out other problems, such as figuring out that the cube's sharp corners needed to be filed down into slight curves to make the puzzle comfortable to handle.

This amateur approach is what Rubik finds the most rewarding. "Maybe the best we can hope for is to be both at once: a forever amateur professional, or someone who makes being an amateur his profession" he writes. "The key seems to be to enjoy our professional activities, so as not to lose the way we felt when we enjoyed our first achievement, and to anticipate every new task with the enthusiasm and zest of the amateur."

Failure is essential to success.

Along with striving for perfection, many are afraid of failure, but Rubik says failure was key to fine-tuning the cube

and is essential for working out problems, as he discovered through the lengthy process of developing the cube. The failure allows someone to look at the problem again and figure out what went wrong, turning the failure into something useful.

"Failure is never pleasant, of course, but for me it is an essential component involved in any effort of learning by doing, and as such, it is actually a positive thing intellectually, even if painful emotionally," he explains.

Curiosity is at the heart of innovation.

For Rubik, the quest to discover how things work and why is central to solving puzzles—whether it's a small hand-held cube or a larger complex issue—and they cannot be solved without that innate sense of curiosity. This intrinsic motivation for understanding drives innovation, creates new ideas and helps people look at a problem from new perspectives when the first attempt was a failure.

"Curiosity means that we accept nothing, that again and again we question the fundamentals," he explains. "We find the good questions because we are interested in the 'how' of things. That is the only way forward. And here 'forward' doesn't mean a predetermined direction or something that can be fixed beforehand, but the openness, not just of the eye, but of the broader vision."



SOLVING PUZZLES AT RECORD SPEED

"Speedcubers" can solve the Rubik's Cube with lightning speed, and the World Cube Association Rubik's Cube World Championships are held every two years with competitors from around the world racing to solve the popular puzzle in record time.

Chinese competitor Yusheng Du holds the current record for the fastest solve of the 3x3x3 Rubik's Cube at 3.47 seconds—0.75 seconds faster than the previous record set by Australian competitor Feliks Zemdegs.

Zemdegs holds the record for fastest one-handed solve of 6.88 seconds.

Polish competitor Jakub Kipa solved the Rubik's Cube with his feet in 20.57 seconds.

In 2018, a robot built at MIT solved the Rubik's Cube in 0.38 seconds.

► In partnership with Mines Admissions, alumni had the opportunity to share their Mines experiences with prospective Orediggers and help recruit the Class of 2025 at four virtual Preview Mines in Your State events in January 2021. •



MAKING THE RIGHT MOVES BY EMILIE RUSCH

In business, transitions can be risky—but rewarding

Our careers don't always follow the paths we expect. Just ask Denise Burgess, president and CEO of Burgess Services in Denver and member of the Mines Board of Trustees.

After graduating from college, Burgess put her journalism degree to work in broadcast management. Then, her father asked her to take a quick look at the marketing materials for the family-owned HVAC business—the next thing she knew she was working with her family full time. “I’ve been there ever since,” said Burgess, who in 2017 became the first-ever Black board chair of the Denver Metro Area Chamber of Commerce.

We sat down with Burgess to talk about making a family business your own and the lessons she’s learned over an unexpected—and rewarding—career.

What was it like to take on the family business when that wasn't your original career plan, and how did you make it your own while staying true to the company's roots?

Denise Burgess: The nice thing about having a family-owned firm is it is family—the roots of the company were the roots of my family. It was actually a great transition. I think my father always wanted me to take over the business, but he was wise enough to say “Go do something else until you're ready to do this.”

By the time my father passed away suddenly in 2002, I had been the heir apparent for two to three years. So I knew what I was going to do and I was able to use him as my advisor. Making it my own was mindful, and I did it deliberately.

CONNECTIONS

- ▶ Mines was featured in the Hallmark Channel holiday movie *A Christmas Tree Grows in Colorado* this year, with Guggenheim Hall and the heart of the Mines campus providing the opening shot for the film. •

In 2003, you decided to shift Burgess Services' focus away from HVAC to quality assurance/quality control and construction management. How did you assure yourself and your employees that this was the right move for the company?

Burgess: As a CEO, you assure everyone below you and then you don't sleep at night. I lost people in that transition that had been with the company for years. Understand that when you make these transitions, it is a transition—you're going to bring in new people and grow the company from that. Even though our culture has stayed the same—the baseline of being professional, being knowledgeable, making sure our clients are taken care of—it was a whole different ballgame.

In the long run, I feel good about the decision, but at the time it was a total leap of faith. It was stepping off the cliff. And then you get that one win, that one project or that one client who says, "This is a great idea." Having a good relationship with clients allowed us to do that transition. We kept a lot of the same clients.

How should leaders approach big business decisions like that to ensure they are successful?

Burgess: You can't be afraid of failure. Sometimes, in your head, it's a great idea, and then you try it and it

doesn't quite fit. Do as much planning as you can, but also know that planning makes gods laugh. Have faith in your staff and yourself and know when to cut bait, when to say this isn't working, this isn't us, this isn't a fit. Lick your wounds and then do it again. You try something else, something new.

You've been involved with many organizations in Denver and have become a prominent figure in the Denver business scene. What have you learned from your time with these organizations, and why do you think it's important for business leaders to be involved with organizations or communities outside of their company?

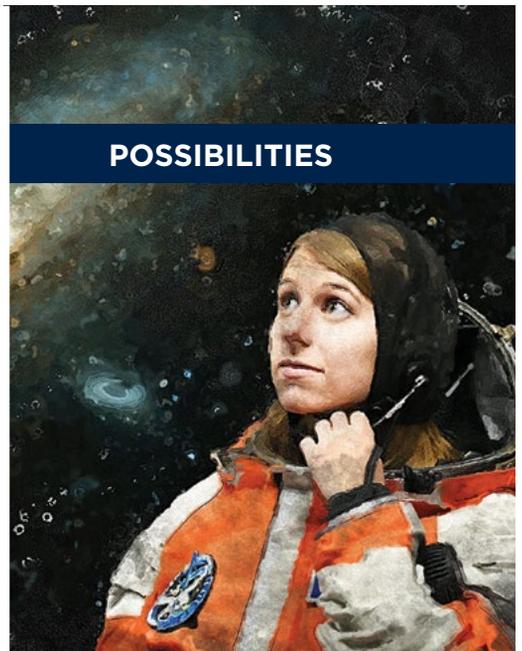
Burgess: It comes back to our corporate culture and our family culture, which has always been to give back to our community. I was raised that way, and I just can't imagine not doing it. It's also very important to look outside your own world and bubble. I'm in the construction world, and it's great to sit on a board or get involved with an organization with someone who does nothing remotely close to what I do. I learn so much, and I like getting to know people and learning different ways of doing business.



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NEXT STEPS

How to grow a professional network or career after graduation



Consider earning a certificate or checking out a graduate program.

For those who are looking to take their next step up the career ladder, a graduate-level certification or degree might be just the thing to provide that boost and help professionals stand out in their field. Graduate-level experience can help professionals gain specialized knowledge, increase their credibility and become more competitive in their field.

- ▶ Visit gradprograms.mines.edu to learn more about Mines' graduate programs.



Connect with a group dedicated to your interests and expand your network.

If you have a particular affinity for interests such as aerospace, entrepreneurship, social responsibility or supporting women in STEM, joining on of Mines' interest groups is a great way to connect with other professionals, share your expertise and learn from others. Not only do the interest groups keep alumni up-to-date with emerging trends and the latest innovations, but they can open up and help grow new opportunities for all involved.

- ▶ Go to weare.mines.edu/interestgroups to join the group that interests you.



Find a mentor or lend your expertise to others.

The Mines Mentoring Program connects businesses and professionals with Mines alumni, students and employees and provides a kick-start for aspiring entrepreneurs. Alumni can join as mentors to lend their time and expertise to other Orediggers or find a mentor for themselves and gain valuable connections and professional development opportunities to help them grow in their personal and professional lives.

- ▶ Check out mines.edu/mentoring to get involved.



Meet up with other alumni in your area who might know of new opportunities.

Some of the best connections happen in more casual environments, which is why Mines' M Clubs are perfect for catching up with other Orediggers. With M Clubs in nearly every major city across the U.S. and even several internationally, they're not only perfect for keeping alumni connected to Mines but are great for networking with other Orediggers during a volunteer event or over a beer at a local brewery.

- ▶ Find your local M Club at weare.mines.edu/mclubs.



TECH TIP

Cut down your Google search results and find what you're looking for faster.

■ A Google search can return millions of results that are hard to sift through when you're looking for something specific. But you can cut down those results with a few simple shortcuts and find exactly what you're looking for more efficiently.

Use quotation marks around your search parameters to tell Google to search for the whole phrase.

If you search for Mines football championships in Google, the search engine will search for content that contains those three words in any order. But if you search "Mines football championships," using quotation marks, it will search for that phrase exactly as you typed it.

Search Google using "site:" to search a single site instead of the whole internet.

Open Google in your browser and type "site:" and then the website you wish to search. For example, type in "site:mines.edu" but leave off the quotation marks. You'll only get results from Mines' website.

Tip in a tip: Don't want to navigate to Google? You can enter your search terms directly in your browser's address bar, without the need to go to Google first.

- ▶ Have a useful tech tip you'd like to share, or want to know more about an everyday technology? Send us your ideas at minesmagazine.com/contact-us.

CONNECTIONS

- ▶ In December 2020, Mines welcomed a new batch of graduates to the alumni community. 271 students graduated with a bachelor's degree, 195 received a master's degree and 60 earned a doctorate. •



Thank you to our 2020 alumni golf sponsors and volunteers!

Stay tuned for 2021 tournament dates

36th Annual Golden Golf Tournament

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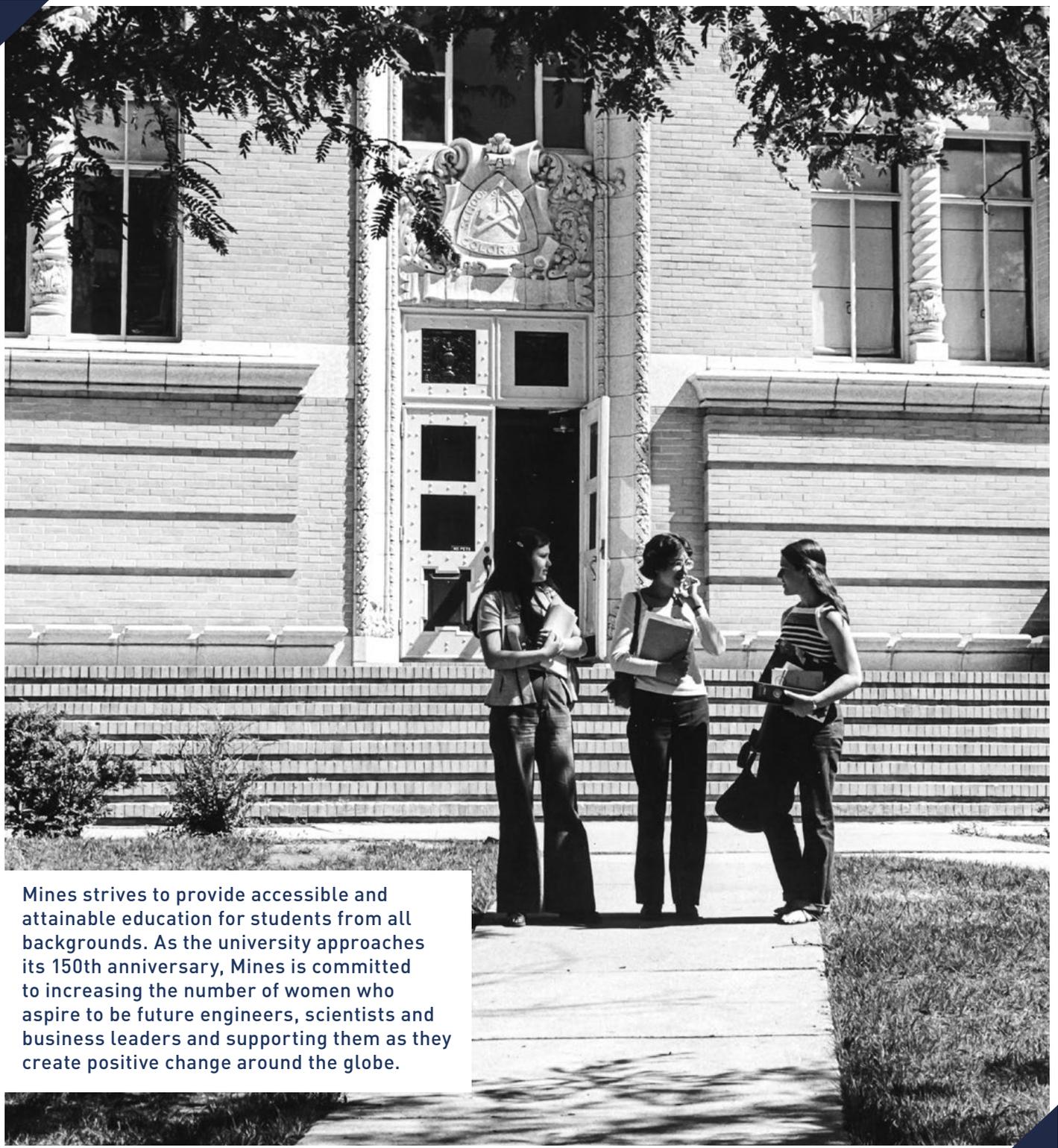
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Mike Scherrer '83





Mines strives to provide accessible and attainable education for students from all backgrounds. As the university approaches its 150th anniversary, Mines is committed to increasing the number of women who aspire to be future engineers, scientists and business leaders and supporting them as they create positive change around the globe.

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

▶ Submit a class note at minesmagazine.com/classnote.

1970s

Deepak Malhotra MS '74, PhD '79 was appointed as director of Magellan Gold Corporation in September 2020.

Harry "Red" Conger '77 was appointed Teck Resources Limited's executive vice president and chief operating officer in September 2020

1980s

Sandra Stash '81 was appointed independent director of Lucid Energy Group in October 2020.

Rebecca Dodge '82 was the 2020 recipient of the American Geosciences Institute's William B. Heroy Jr. Award in recognition of her distinguished service to the institute.

The Geological Society of America named **Russell Keanini '83** as a recipient of the 2020 Kirk Bryan Award for Research Excellence in Geomorphology. The award was given in recognition of his 2017 paper "Mechanical weathering and rock erosion by climate-dependent subcritical cracking," published in *Reviews of Geophysics* and co-written by Missy Eppes.

Michael Weis '83, MS '87 became the field office manager at the Los Alamos National Laboratory for the National Nuclear Security Administration of the Department of Energy after nine years as the site office manager at the Fermi National Accelerator Laboratory in Batavia, Illinois.

Jeff Squier '84, MS '86 was elected as a fellow of the American Physical Society for his "seminal contributions to ultrafast optical technology, including the first ultrafast Ti:sapphire regenerative



Mines served as the backdrop for a special celebration this fall when David M. Redhorse and Maya Garcia were married on the steps of Guggenheim Hall on Sept. 23, 2020. **Khánh Vu '93** served as officiant, and David's son Nicholas, a current electrical engineering student at Mines, was in attendance.

Though not a Mines alumnus, David was a chemical engineering student from 1990 to 1994, participating in the McBride Honors Program and the Multicultural Engineering Program and formed a lifelong friendship with Khánh. "Mines has played an important part in my life," David said of the reason he chose to get married on campus, and with Nicholas currently pursuing an undergraduate degree, his affinity for Mines is even stronger.

Pictured left to right: Gayle Redhorse, Khánh Vu, David M. Redhorse, Maya Redhorse, Nicholas Redhorse, Tammy Walker.

amplifier; for the development and application of ultrafast lasers to micromachining, eye surgery and nonlinear microscopy; and for leadership in optical sciences at Colorado School of Mines."

Joel Schneyer MS '88 joined GMV Mineral Inc.'s board of directors as an advisor in November 2020.

Patrick Highsmith '89, MS '07 joined Timberline Resources Corporation in October 2020 as president and CEO.

John Zuklic '89 was appointed as vice president finance and chief financial officer of CITGO Petroleum Corporation, effective Nov. 4, 2020.

1990s

Quinton Hennigh MS '93, PhD '96 joined Timberline Resources Corporation's board of directors in September 2020.

John DeCooman MS '94 was appointed as the president and CEO of Sweetwater Royalties in August 2020.

**ANNIKA HABERLAND '19
AND JARED PARRISH '19**



Matthew Hoffman '94 joined the Energy and Environmental Services, Inc. board of directors in November 2020.

J. Carlos Rodriguez M. '98 was appointed as vice president of exploration of Gray Rock Resources in September 2020.

2000s

Michelle Crimi PhD '02, current director of the engineering and management program at Clarkson University, was the inaugural recipient of the university's Spatz Endowed Chair in October 2020.

Payman Farrokhyar '04 became the new president of Total-Western, effective Oct. 1, 2020.

2010s

Frelynn Cohrs '10 and Michelle Cohrs welcomed Clinton Price Cohrs on April 6, 2020.

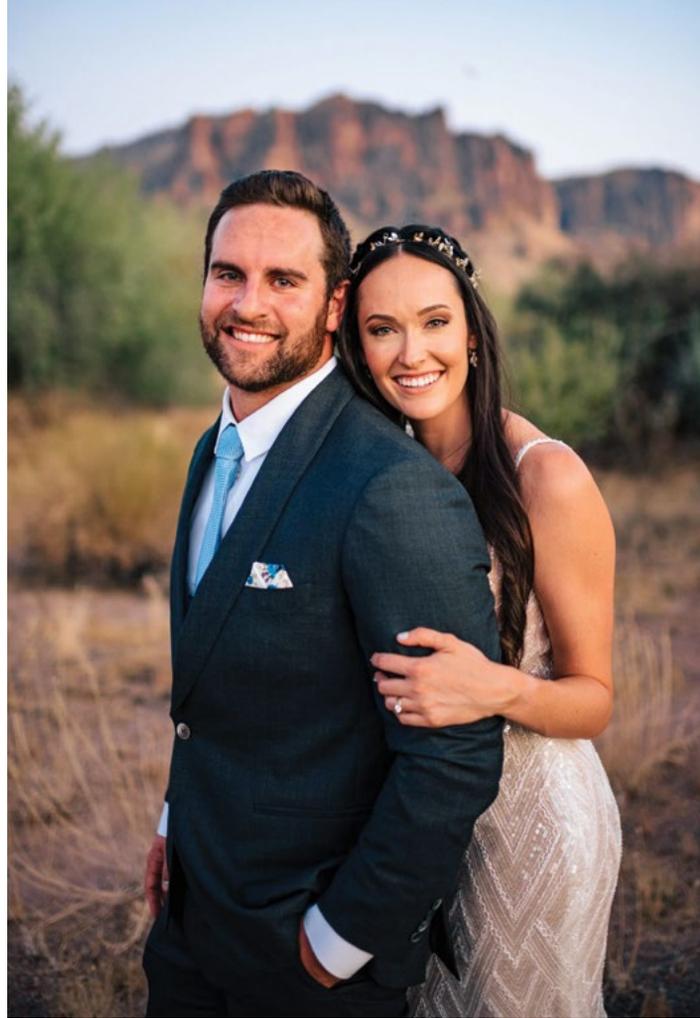
Hannah Fanucchi '14 and **Lucas Quintero '14, MS '16** were married on Aug. 15, 2020, in her parents' backyard in Arvada, Colo. The couple met at Mines while working as resident assistants and now live in New Orleans, where Hannah is doing her OBGYN residency and Lucas is completing a PhD in math.

Opting for a small wedding, **Ryan Call '15, MS '16** and **Kelsey Lewis '16** tied the knot on Sept. 26, 2020 in Arizona. Fourteen Mines alumni and friends attended the wedding.

Nadima Dwihusna '18, MS '20 married Taufik Raharjo on March 8, 2020 in Golden, Colo. Friends from Mines and Nadima's advisor, Ge Jin, attended their wedding. The couple met in California and later connected at Mines in 2013 while Nadima was completing her undergraduate degree and Taufik was completing a summer internship.

After altering their original wedding plans, **Annika Haberland '19** and **Jared Parrish '19** were married on Sept. 12, 2020 with their closest friends and family at The Club at Ravenna in Littleton, Colo. The couple met during their first year at Mines, and several Mines alumni made up the bridal party.

RYAN CALL '15, MS '16 AND
KELSEY LEWIS '16



FRELYNN '10 AND
CLINTON COHRS



NADIMA DWIHUSNA '18, MS '20



HANNAH FANUCCHI '14 AND
LUCAS QUINTERO '14 MS '16



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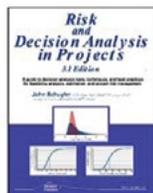
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IN MEMORIAM

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

Joseph L. Anjier '60 died July 24, 2020. Born in 1938, Joseph was a member of Sigma Alpha Epsilon, ROTC and Scabbard and Blade as a Mines student. He spent most of his career working for Kaiser Aluminum. He formed JA Engineering after retiring in 2002.

Volker W. Gobel PhD '72 died July 31, 2020. Volker attended Mines as a Fulbright Scholar from Germany. He was a geology professor at Stephen F. Austin State University in Nacogdoches, Texas for more than 40 years until he retired in December 2015.

Vladimir Y. Gretchka, former faculty member of the Mines geophysics department and the Center for Wave Phenomena, died Nov. 5, 2020. Vladimir worked at Mines from 1995 to 2001, first as a postdoctoral fellow and then as an associate research professor and co-leader of CWP. After moving to industry, he continued to closely

collaborate with CWP faculty and students.

E. Dean B. Laudeman '55 died Sept. 13, 2020. Born in 1933, Dean was an oil and gas exploration and regional vice president at Union Oil Company and served as the chairman of the American Petroleum Institute's exploration division. He was recognized by the Mines Board of Trustees as a Distinguished Achievement Medalist and a Mines Medalist.

Robert N. Prince '66 died Oct. 20, 2020. He was born in 1943 and began his career as a process engineer at Sunray DX Oil Company. He later retired from Citgo Petroleum Corporation as manager of capital budgets after 27 years.

Jack L. Tindall '54 died Nov. 10, 2020. Born in 1932, Jack played basketball, ran track and was president of Beta Theta Pi at Mines. He started his career in the oil and gas industry before serving in the

U.S. Navy as a commissioned officer. After his active service, he served in the U.S. Navy Reserve and returned to the oil and gas industry.

Robert M. "Bob" Woodbury '65 died Feb. 17, 2020. Bob was born in 1941 and was a member of Alpha Tau Omega at Mines and played lineman on the Mines football team. He was commissioned into the U.S. Marine Corps and retired as a captain, remaining in the U.S. Marine Corps Reserve for several years. He spent the rest of his career in mining.

▶ 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.

LIFE AS AN ASTRONAUT

Furthering knowledge in a simulated environment

For two weeks this fall, Bailey Burns '18 lived in a simulated lunar base on the side of Moana Loa volcano in Hawaii nearly 8,200 feet above sea level, experiencing an environment similar to what astronauts face in space—dehydrated food and all.

The experience was part of an analog mission with Hawaii Space Exploration Analog and Simulation (HI-SEAS) in partnership with NASA Goddard to explore and map lava tubes and perform biological sampling and water collection to help further knowledge and understanding of what we may find in lava tubes on the Moon and Mars.

“This was absolutely fascinating to me, because the lava tubes on the Moon and Mars can teach us a lot about how they were formed and possibly even be a safe haven for a human base in the future against the harsh space environment,” Burns explained.

But Burns said, for her, the most interesting parts of the experience were the team dynamics. “When you are living in such close proximity with five strangers—who quickly became good friends—in an isolated environment, everything is under a microscope. The good times, like game night, cooking and movie night, are really good, and the hard times, like crew tensions, sleepless nights and self-doubt, are really hard. It sparked a new interest in me to look into the crew dynamics and emotional intelligence that so many astronauts talk about while they live on the space station together,” she said. “It was really hard to do objectively in the lab, but now that I’m on the outside, I’m excited to start working on understanding what makes a team united and unstoppable in my day job.”







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The Mines campus has grown significantly over the years to accommodate and expand the Oredigger community's expertise and influence. Many buildings, such as McNeil Hall and the CoorsTek Center for Applied Science and Engineering, have been recently added to house new areas of study and provide unique and state-of-the-art learning spaces for students.

One early addition to campus was Berthoud Hall, built in 1939 as one of the many projects carried out nationwide by the Public Works Administration, to house the geology department at a time when Mines was first beginning to expand its geology program. According to the unofficial Mines history book, *Rocky Mountains to the World*, Berthoud Hall's construction "allowed Mines to carry out a more effective educational program and added much to the physical appearance of the campus, which was beginning to equal the school's excellent academic reputation."

▶ Follow along at mines.edu/mines-at-150.

