

MINES MAGAZINE

COLORADO SCHOOL OF MINES ALUMNI MAGAZINE

Winter 2020 Volume 111 Number 1



READY FOR TAKEOFF

Colorado's aerospace economy is booming, with Mines alumni providing the support that will propel the industry into the future.





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Cover image: The aerospace industry has a large presence in Colorado, with the state having the second largest aerospace economy in the nation. (Cover designed by Christina Vessa)

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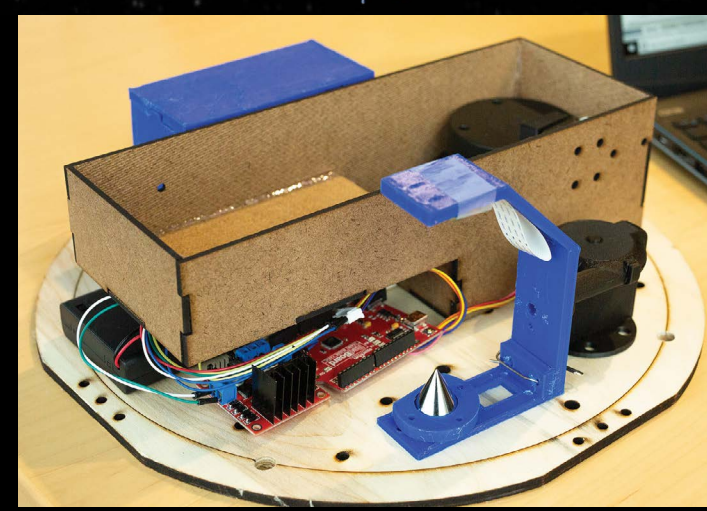
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Colorado's aerospace economy is booming, and Mines graduates are working on some of the latest projects, helping propel the industry into the future.

20 **JOINING FORCES**
Military veterans find support—and desirable career paths—at national labs.



According to NASA, more than 500,000 pieces of debris currently orbit Earth, traveling at speeds fast enough for a relatively small piece of space junk to damage a satellite or spacecraft. But the Mines RockSat-X team is working on a solution to that problem.

The 14-student team has been working on three autonomous experiments to manage space junk that will be contained in a payload scheduled to launch this summer. Each experiment aims to redirect debris without coming into contact with it, using methods such as electrostatic deflection, magnetic deflection and laser momentum transfer.



Learn more about the RockSat-X team and their projects at minesnewsroom.com, and read our cover story about aerospace in Colorado on page 14.

Artistic impression by ESA, photos by Colorado School of Mines

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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 weare.mines.edu/update or email minesalumni@mines.edu.

OPENING REMARKS

A COMMUNITY THAT CHALLENGES—AND SUPPORTS

When speaking with Mines alumni, parents, supporters and even industry leaders, I have found that the Mines story is often best told through student voices. Everyone wants to hear about today's Orediggers—their interests, aspirations and experiences at a top-ranked university well-known for its rigor, challenge and unique focus.

The same is true of Colorado's legislators. I'm invited to the state Capitol a few times each year to provide updates on Mines. Recently, I brought three students with me to a committee focused on higher education. As expected, our elected officials politely listened as I provided an overview of our progress toward Colorado's goals for higher education, but when our students spoke, they leaned forward in their seats.

The students were asked to share their stories and detail some of the challenges they've faced—and the resources, people and opportunities at Mines that have helped them overcome those challenges.

Cindy Sanchez, a senior graduating in May and Denver Scholarship Foundation recipient, shared her story of being a first-generation college student and talked about how a chance meeting with a Mines faculty member opened her eyes to the potential of STEM and inspired her dream of attending Mines. Cindy said she knew her dream was a long shot, but because of her persistence and strong interest, she was offered the opportunity to attend our summer Challenge program and pass tests in math and science. Through her hard work and mentor support, she now has nearly completed her mechanical engineering degree. Cindy ended her story by telling the committee that not only was she going to graduate with her undergraduate degree, but she's also been accepted into Mines' new advanced manufacturing graduate program to pursue a master's degree.

Evaleena Reyes, a transfer and first-generation college student from Bakersville, California, shared a similar story. When she first arrived at Mines, the rigor and workload were overwhelming, and she struggled in her courses. After her first semester, she had two options: a) leave Mines or b) enroll in Bounce Back, a course designed to help students with study, time management and other critical skills needed for success at Mines. At the end of her second semester, Evaleena's semester GPA was at a B+ level, and she's been in good academic standing ever since. Evaleena now serves as the peer mentor/instructor for Bounce Back and shares her story and lessons learned with other Mines students.

The third student speaker was Dan Topham, who also graduates this spring. Dan is a leader on the Mines Activity Council—the organization that orchestrates E-Days and other campus events—and has been a strong advocate for and leader at Oredigger Camp since its inception. Dan spoke of the importance of extracurricular activities and how they lead to academic success, a strong connection to Mines and Orediggers taking care of other Orediggers. Through Dan's story, the committee saw Mines from a new perspective—as a close-knit collaborative community where students step up to lead and take ownership for each other, their experiences and successes and the overall health of the community.

In hearing their testimonies, I was reminded just how big Mines is for them. They see their Mines journey not as a solitary slog but as a community endeavor. They all had different stories but came to Mines ready to work and have found supporters, benefactors, faculty and fellow students ready to join them in their experience. This is what makes a community and what makes Mines so special.

Go Orediggers!



Paul C. Johnson, PhD
President and Professor

COLORADO SCHOOL OF MINES



SUSTAINABLE LIVING

MINES WINS 2019 SOLAR DECATHLON AFRICA

Mines won the 2019 Solar Decathlon Africa for designing and building an affordable, solar-powered, net-zero-energy model house.

Photos by Ilyass Mousannif/InterHouse Team



WHAT: A team of students from Mines and two Moroccan universities won the 2019 Solar Decathlon Africa. The event was the first Solar Decathlon held in Africa and featured 18 teams from around the world, each of which was challenged to design and build, on site, an affordable, solar-powered net-zero-energy model house uniquely adapted to the North African climate and location.

WHO: Inter House, a team made up of students from Mines, Cadi Ayyad University and the National School of Architecture in Marrakech.

WHEN: The competition began on Sept. 13, 2019, and the winners were officially announced on Sept. 27.

WHERE: Ben Guerir, Morocco

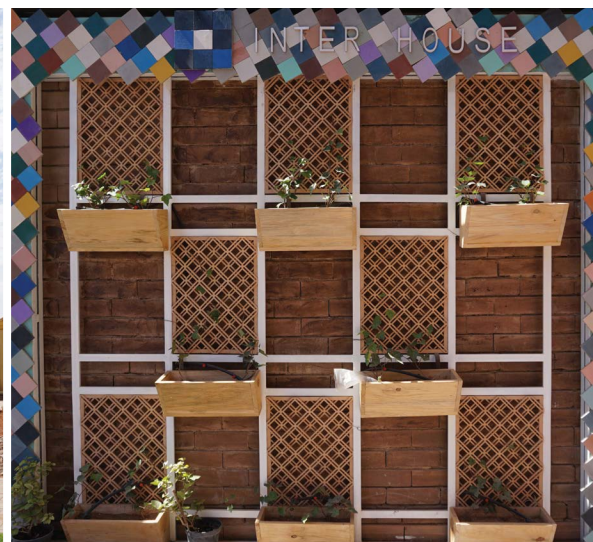
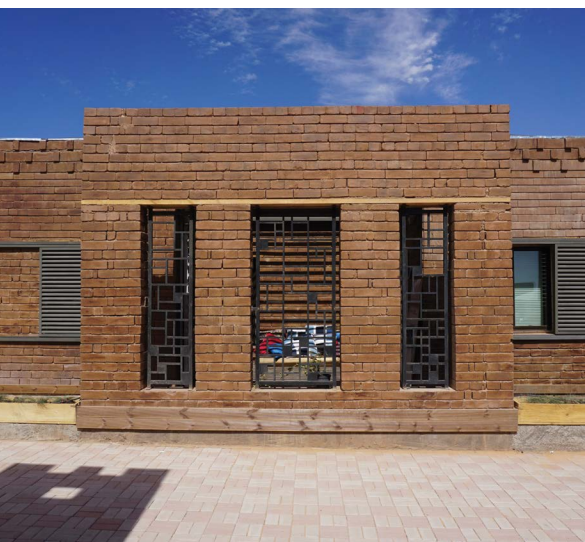
THE DETAILS: Judges evaluate the homes in 10 categories—architecture, engineering and construction, market appeal, social awareness, appliances, livability, sustainability, health and comfort, energy balance and innovation.

The U.S. Department of Energy Solar Decathlon began in Washington, D.C., in 2002, and has been held biennially in the U.S. in the years since. The last U.S. competition took place in Denver in 2017, with international competitions having been held in the Middle East, Asia, Europe and Africa over the last two years.

“Mines is so proud of our students for winning the Solar Decathlon Africa and showing off—on a global stage—their incredible leadership skills, problem-solving ability and commitment to sustainability,” said Mines President Paul C. Johnson. “Our students and their partners have notched a victory we intend to celebrate—for Mines and for engineers everywhere answering earth, energy and environment challenges.”

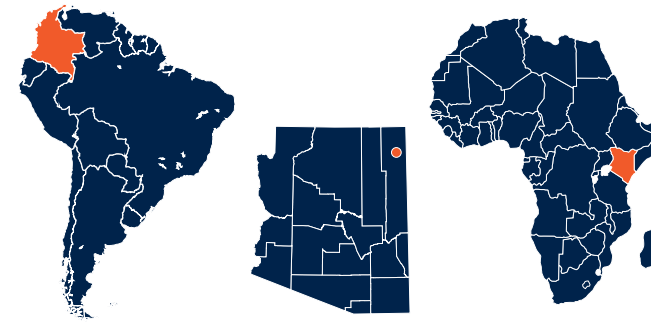
By **Emilie Rusch**

► To learn more about this project, check out the Mines Minute video on our website where student Katie Schneider describes the process of building the house and what made this project unique.



OUT IN THE FIELD

OREDIGGERS MAKE AN IMPACT
AROUND THE WORLD



Last summer, Mines students traveled with the humanitarian engineering program to different parts of the world to apply the knowledge and skills they gained in the classroom to real-life situations and participate in unique experiences that are only available outside of Golden, Colorado.

COLOMBIA

A multidisciplinary team of Mines undergraduate and graduate students and faculty spent two weeks in Colombia learning about local artisanal and small-scale mining practices and surrounding communities. The group worked with Colombian students and miners on projects related to mining safety, risk management and remediation techniques. Students also scouted out projects to bring back to Mines.

TSAILE, ARIZONA

A Mines student and faculty member visited the Navajo Nation to learn about the environmental, policy, societal and economic opportunities and challenges related to community development, mining and oil and gas that exist for the Navajo people and land. They also collaborated with international and local students and developed valuable communication skills necessary for developing trust and defining problems within a community.

KENYA

In collaboration with Purdue University, a group of Mines students and faculty helped teach young Kenyan students at an alternative school for former street youth engineering thinking and skills to empower them to be problem-solvers in their own communities. Projects included supporting the Kenyan students as they designed a refrigeration system for local fishermen, a home security system, a shared agricultural vehicle and a new hair salon.

► To learn more about humanitarian engineering at Mines and upcoming trips, visit humanitarian.mines.edu.

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ATHLETICS

HONORING OUTSTANDING OREDIGGERS

the six new Hall of Fame inductees who distinguished themselves either by virtue of their performance in competition or through their outstanding contributions on behalf of Mines Athletics.

Each inductee was selected by the Hall of Fame Committee and is a Mines alumnus or alumna who graduated five or more years ago, a former coach or administrator or an outstanding contributor to or supporter of Mines Athletics.

This year's inductees included:

CROSS COUNTRY/TRACK & FIELD

Heather Beresford '07 earned more all-America honors than any other female student-athlete in Mines history, standing on the podium nine times during her decorated cross country and track & field career.

Beresford is the only two-time cross country all-American in Mines women's history. She led the 2002 team to nationals for the first time and the 2005 squad that finished a program-best fifth at NCAA Championships. On the track, she earned seven more all-America medals, including two national runner-up finishes in the indoor mile and another in the distance medley relay. She also garnered a third-place finish in the outdoor 1500m.

Beresford's versatility on the track was impressive, and more than a decade after graduating, she continues to hold the program records in the indoor mile and outdoor 1500m, along with numerous top-10 performances. Her indoor mile time is still more than a second faster than any other runner in a program that has had five mile all-Americans since she graduated.



FOOTBALL

Quarterback **Clay Garcia '11, MS '12** had a decorated career for the Orediggers from 2008 to 2011 that included a pair of all-America nods and a spot as a finalist for the 2010 Harlon Hill Trophy. In two-plus years as the Orediggers' full-time starter, he threw for 7,657 yards and 61 touchdowns, completing 62.8 percent of his career passes. His 39 touchdown passes in 2010 at the time was tied for the program season record, and his 61 career scoring throws ranks fourth in Mines history. Garcia was the 2011 CoSIDA Academic All-American of the Year in football and the first student-athlete in Mines football history to be a two-time Academic All-American.

Garcia remains the only Mines football player to be a two-time first-team selection—something only seven student-athletes in Mines history, in any sport, have done. In 2018, Garcia was one of only 11 football players from Colorado to be selected to the National Football Foundation Colorado Chapter's 25th Anniversary Team, recognizing the state's best scholar-athletes over the past quarter-century.



Attend any Mines athletics event and you'll likely feel a surge of Oredigger pride. Whether it's the joy of an athlete making that game-winning goal to clinch the division championship or the excitement of spectators stomping their feet in the stands after a fourth-quarter touchdown, that sense of loyalty brings the Mines community together.

That pride was apparent at another athletics-related event this fall—the Mines Athletics Hall of Fame Dinner and Auction. More than 400 alumni, friends, current student-athletes and coaches filled Lockridge Arena in October to support

WOMEN'S SOCCER

The first Hall of Fame inductee from women's soccer, **Kayla (Mitchell) Jacobsen '10, MS '11** still holds one of the best scoring rates in RMAC history. The Mines record holder with 76 career goals, Jacobsen helped the Orediggers emerge as a power in the early days of the program and contributed to the team's first two NCAA Tournament appearances in 2008 and 2009.

Jacobsen is still second in RMAC history in scoring and in single-season goals—her 30 career game-winning goals remains the RMAC record a decade later. Jacobsen stands alone in the Mines record book in career goals, hat tricks (8) and points (170), and she is the only player in program history to score four goals in a game. Her streak of 10 straight games with a goal in the 2008 season is an RMAC record and ranks seventh in NCAA Division II history.

Jacobsen was women's soccer's first All-American and Academic All-American following her record-setting senior season in 2009 that also earned her Daktronics Regional Player of the Year, RMAC Player of the Year and RMAC Academic Player of the Year honors.



OUTSTANDING CONTRIBUTORS

Harold '68 and Patricia Korell were inducted in the Outstanding Contributors category for their longtime support of Mines Athletics and the university as a whole. The Harold M. and Patricia M. Korell Athletic Center, part of the Clear Creek Athletic Complex project, has had a huge impact on all Mines student-athletes since it opened in 2015, providing strength and conditioning, sports medicine and meeting spaces utilized by all Oredigger varsity teams.

The Korells have also supported the Korell Men's Basketball Scholarship, the Korell Scholarship Endowment and the construction of Marquez Hall, along with many other projects at Mines.

Photo by Thomas Cooper, lightboximages.com



GOLF

A star athlete from 2008 to 2012, **Jim Knous '12** stands as one of Mines' most accomplished golfers. As an Oredigger, Knous was an all-American in 2012, finishing tied for the lead at the NCAA Division II national championship. He was the 2012 RMAC Player of the Year, a two-time PING All-Region pick, and a four-time First-Team All-RMAC selection. As a senior, he finished second in the GolfStat D-II rankings and led the only Mines team to qualify for nationals in 2012.

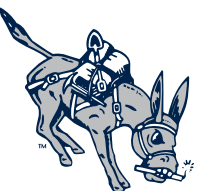
After Mines, his golf dream continued as a professional, with Knous working his way onto the Web.com Tour and, now, the PGA Tour. In fall 2018, Knous became the first RMAC alumnus to earn a full-time PGA Tour card, and he notched three top-15 finishes as a rookie in 2019.

Knous also mentors current Mines golfers as he continues to live and train locally.

By **Tim Flynn**

Photos courtesy of Mines Athletics

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



IT'S A BIRD! A PLANE! A LIZARD?

A RARE LIZARD FOSSIL IS ON DISPLAY AT THE MINES MUSEUM OF EARTH SCIENCE

A rare lizard fossil with extremely well-preserved skin—and a tiny fossilized gnat keeping it company—is now on display at the Mines Museum of Earth Science.

The specimen was discovered somewhere along the Utah-Colorado border, likely during a school field trip in the early 1950s, but has never received its due until now.

The reason? For decades, everyone thought it was a leaf.

“When we uncovered the fossil again from our collections three years ago, we looked at it some more and said, ‘That doesn’t look like a plant to us.’ We decided we needed to have someone take a look at it,” said museum volunteer Dennis Gertenbach ’74, MS ’77, PhD ’80. “The preservation is very, very unusual.”

Last year, Kenneth Carpenter, director and curator of paleontology at the Utah State University Eastern Prehistoric Museum in Price, Utah, correctly reidentified the fossil as a lizard due to the presence of scales. Ed Raines, collections manager of the Mines Museum of Earth Science, then discovered the gnat earlier this year.

The mix-up goes back more or less to the fossil’s discovery in sediments from ancient Lake Uinta, now known as the Green River Formation. According to museum records, the fossil was initially cataloged in the 1950s as a salamander, likely because of its flat head.

Then in the 1970s, someone from the University of Colorado took a gander and decided that no, the fossil was actually preserved plant material.

The fossils are preserved on a slab of mudstone, said Rick Sarg, research professor of geology and geological

engineering at Mines. Both the lizard and the gnat are in quite remarkable condition. Scales are easily visible on the lizard’s skin, and the gnat’s wings and legs are also visible under magnification.

Ancient Lake Uinta was not a “normal” lake, Sarg said. Instead, it was alkaline, meaning that its waters had a pH of 9 to 12, with a near-saturation of sodium carbonate, sodium bicarbonate and calcium carbonate.

The pore spaces between the sand and silt grains of the sediments were full of these alkaline waters, Raines said. Additionally, the transition from mud to rock is a slow geologic process, as is the expulsion of pore water from the mud. So a creature buried in the sediments would have soaked in these chemicals for centuries.

“Ironically, these are the very chemicals that the ancient Egyptians used to mummify their pharaohs and other nobility,” Raines said. “Given the fact that each of ancient Lake Uinta’s fossil lizards has reasonably well-preserved skin, it is fair to speculate that the lizard and the gnat were mummified as a first stage in the fossilization process.”

By **Emilie Rusch**

► Interested to learn more? Go to mines.edu/museum for the Mines Museum of Earth Science's visiting hours.



A rare lizard fossil in the Mines Museum of Earth Science was originally identified as a leaf but has since been reclassified and put on display.

Photo by Vicknesh Balabaskaran

ADVISING ON A NEW LEVEL

MINES PROFESSOR JOINS THE WHITE HOUSE COUNCIL OF ECONOMIC ADVISERS



WHO: Ian Lange, assistant professor of economics and business, director of the Mineral and Energy Economics Program and faculty fellow of the Payne Institute for Public Policy.

WHAT: Lange was named to the White House Council of Economic Advisers, which provides recommendations and analysis based on research and empirical evidence and is responsible for assisting and advising in the creation of the annual Economic Report of the President. Lange will serve a one-year term as a senior economist on the council, with a focus on energy and environmental issues.

IN LANGE’S WORDS: “I am honored to have this opportunity to work for the people. My time at Mines has allowed me to interact with some amazing students, faculty and alumni. I plan to integrate all that I have learned from these people in order to provide objective advice on matters of economic policy. To bring my experience and knowledge back to the Mineral and Energy Economics Program, as well as other parts of Mines, in spring 2021 will be a privilege.”

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HOME SWEET HOME

THE POSSIBILITIES—AND REALITIES—
OF LIVING ON THE MOON

When humans return to the Moon, it may not be just for a quick visit. We asked Chris Dreyer, research assistant professor in mechanical engineering and a core faculty member in the Space Resources Program, what it could take to set up more permanent camp on the lunar surface—for researchers, tourists and perhaps, one day, residents.

Q: What are some key considerations for establishing human habitats on the Moon?

Dreyer: We want to create a habitable space that many people could live in, and they could stay there, continuously occupied for a long duration. During Apollo, they were there for a maximum of two weeks. Thinking ahead, we want locations where astronauts and maybe even tourists could stay for quite a long time. That changes what you do in the habitat. You really need to think about the radiation environment and exposure to micrometeorites—the Moon is getting hit all the time, with dust grains smaller than a millimeter as well as with bigger things that could blast a crater nearby.

Q: What might those first habitats look like?

Dreyer: A basic habitat might just be a cylinder sitting on the surface and covered in a meter of regolith. Something more advanced might take the regolith and fuse it by sintering or adding some other component to it, so you can build up structures using additive construction. Getting enough mass between your occupants and space so the radiation exposure is reduced when you're inside the habitat—that means thick walls and that's a challenge. In time, we could tunnel into the surface so you wouldn't necessarily have to cover the structures in regolith. This is also a reason why exploring the Moon's naturally occurring lava tubes is of interest—they are natural caves with protection from micrometeorites.

Q: Where on the Moon would we potentially build habitats?

Dreyer: There's been talk about the areas near the permanently shadowed regions. Just outside the permanently shadowed regions, there are a few special places where the



This rendering from the NASA 3D-Printed Habitat Challenge shows what a potential habitat could look like on the lunar or Martian surface.

Image courtesy of ICON/Logan Architecture

“We want to create a habitable space that many people could live in, and they could stay there, continuously occupied for a long duration.”

—Chris Dreyer, research assistant professor in mechanical engineering

sun is in the sky almost continuously. There are also studies that show if you erect a tall structure—100 meters from the surface—you really are in permanent sunlight. That's a big advantage for solar power.

If you are anywhere but these locations where the sun is always in the sky, another challenge would be surviving the lunar night. A lunar day is an Earth month—the sun is in the sky for two weeks and then it's dark for two weeks. During the night, it gets very cold. There's no atmosphere, so when the sun goes down, everything on the lunar surface is radiating to space. Space is 2.7 Kelvin (-454.75 degrees Fahrenheit). That quickly makes everything on the surface very cold. A habitat must be heated for the inside temperature to be comfortable. The thermal mass from thick regolith

walls helps with this. Or you could build the habitat underground where the temperature does not swing from hot to cold.

Q: How could habitats change as space exploration advances?

Dreyer: In the future, we want to be out in space all across the solar system on a permanent basis. In the exploration phase, it might look like an Antarctic base, where people could travel there and live for a time to do research. That means building up infrastructure and then building habitats that can be there for a very long time, are robust and can be a base of operations from which you can explore the region. This would be true of pretty much anywhere we'd go in space—the Moon, Mars. Over time, you build up all this infrastructure that supports their living in that location. Take McMurdo Station in Antarctica—it was a simple hut at one time and they've built it up to the point that it's a small city. There's always someone there, but there are no true permanent residents.

Beyond the exploration phase, you might have cities where people would live and consider themselves residents of the Moon. If you're going to do that, there would be a lot more infrastructure. You'll need access to resources to build the city and also to provide all the things people need if they live there permanently. You'd need spaces for agriculture and water processing, storage of water and air to replenish supplies when needed, key consumables.

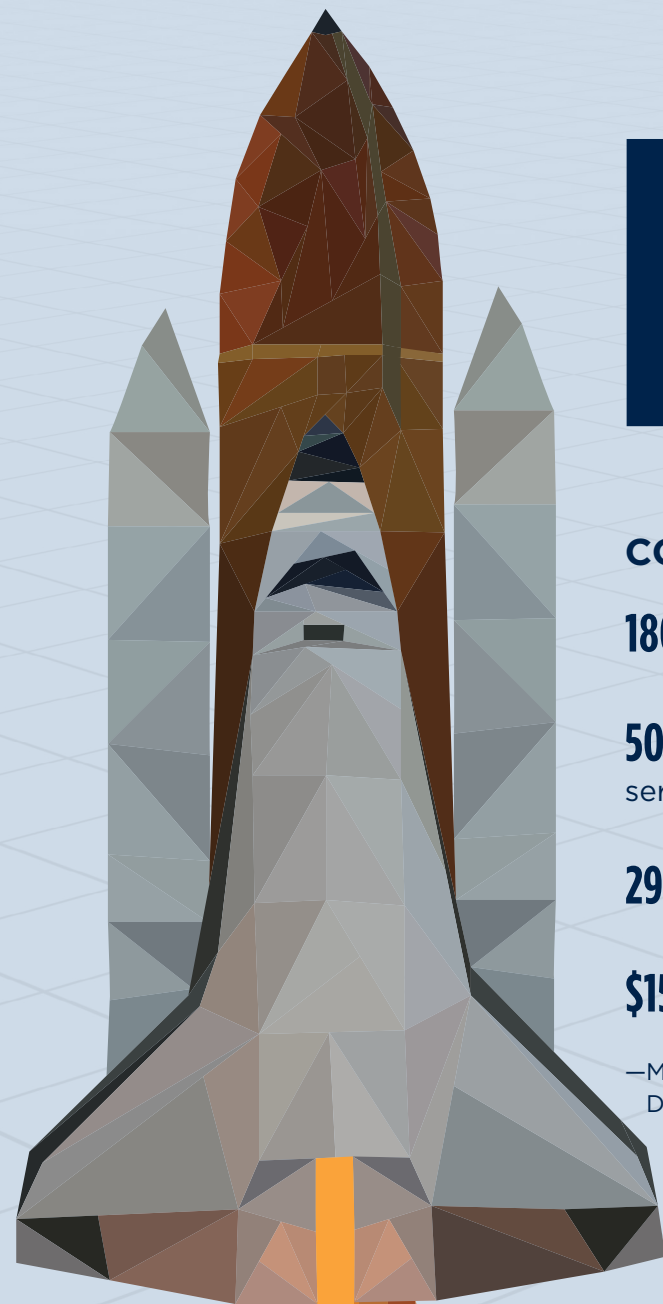
By **Emilie Rusch**



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500+ space-related suppliers and service providers

29,000 private jobs

\$15.4 billion in total output

—Metro Denver Economic Development Corporation

Colorado's aerospace economy is soaring, and Mines graduates are helping the industry rocket into the future.

By **Jenn Fields**

After more than three decades at Lockheed Martin, Paul Anderson '85 has plenty of well-known projects to reflect upon. Take the Mars rovers, Spirit and Opportunity, that roamed the red planet years longer than expected. "The mission was supposed to last 90 days," Anderson said of the little rovers that captured the public's imagination as they sent back images from Mars for six and 14 years respectively.

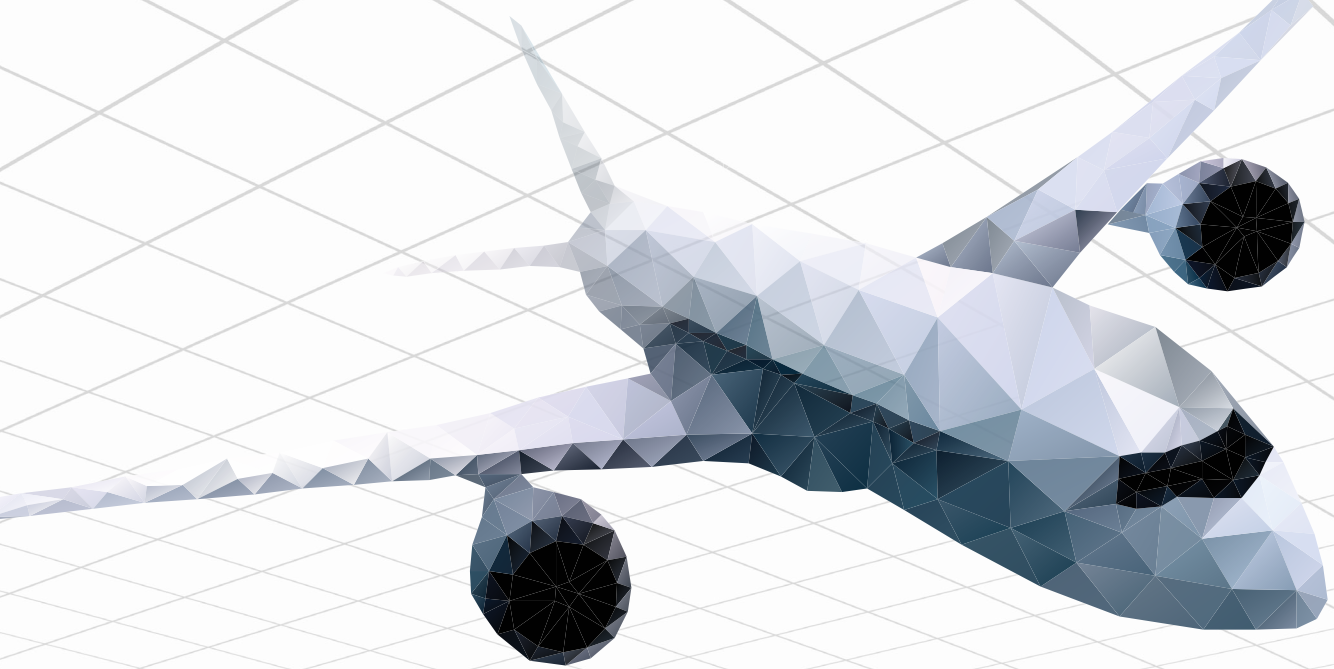
But there's little time for resting upon one's laurels in Colorado's booming aerospace economy. Anderson, a director on the Orion spacecrafts that will return people to the Moon for the Artemis program, paused for an interview after wrapping up yet another proposal for NASA and while waiting for the subsequent announcement: Blue Origin, Jeff Bezos' aerospace company, will partner with Lockheed and Northrop Grumman on a human-capable lunar landing system for Artemis. It meant Anderson would become the program director for the Artemis lander as well.

"This is a time of change like never in history," Anderson said of the billionaire-fueled space race that has transformed the industry and has become a key driver of Colorado's economy. "Colorado aerospace is just exploding," Anderson said.

Aerospace is a powerhouse in the state, with more than 180 aerospace companies and more than 500 space-related suppliers and service providers that have generated 29,000 private jobs and \$15.4 billion in total output. Between 2012 and 2017, the industry logged a 6.1 percent employment growth rate in Colorado, according to a report from the Metro Denver Economic Development Corporation.

From innovations in the booming small-satellite sector to science missions to human space travel, multiple factors have come together to strengthen the industry, which has long been a strong player in the state's economy. "Private business, defense business, NASA business—all of it creates an ecosystem that's growing, it's dynamic, it's robust," said Jay Lindell, aerospace and defense industry champion for the Colorado Office of Economic Development and International Trade.

Private space ventures are still just a slice of Colorado's out-of-this-world aerospace industry, which is approximately 80 percent funded by the federal government, Lindell said. California still outpaces Colorado for total aerospace jobs, but Colorado is tops in aerospace employment per capita.



“There’s long been an aerospace presence, like Lockheed, here in Colorado. If you’re going to be in the industry, and if you’re a smaller supplier providing tooling or small piece parts and materials, being close to some of the big competitors is helpful.”

—Beth Hutchinson '07
Engineering Operations Specialist
United Launch Alliance

LEGACY COMPANIES, STARTUPS SOAR

Aerospace stalwarts such as Lockheed, Ball Aerospace in Boulder, Sierra Nevada Corp. in Louisville and Northrop Grumman, which has offices from Colorado Springs to Boulder, have served as anchors for the industry in Colorado. But a business-friendly environment, with low corporate taxes and economic incentives, has drawn companies to the state and helped homegrown aerospace startups gain a foothold on the Front Range, where those smaller shops often do business with the titans.

Startups pour all their energy into innovations that go into bigger projects—like a cutting-edge additive manufacturing process that can create a much-needed part on a launch vehicle. The synergy is so mutually beneficial that Boeing started a venture capital fund for startups in 2017, and Airbus has had one since 2014.

“There’s long been an aerospace presence, like Lockheed, here in Colorado,” said Beth Hutchinson '07, an engineering

operations specialist at United Launch Alliance. “If you’re going to be in the industry and if you’re a smaller supplier providing tooling or small piece parts and materials, being close to some of the big competitors is helpful.”

OEDIT estimates 84 percent of Colorado’s aerospace companies are small businesses.

“What really sells Colorado is other businesses,” Lindell said. “Business-to-business connections, whether it be at a symposium or conferences or businesses that have a supplier relationship or another relationship, they talk at forums and the next thing you know, they go, ‘Well, why don’t we just move our business?’”

The state also offers incentives. OEDIT’s Advanced Industries Program offers accelerators from proof-of-concept grants to collaborative infrastructure funding, as well as tax credits and procurement help. Since the Advanced Industries Program’s inception in 2013, it has given \$14.4 million in funding to aerospace companies—more than 20 percent of the program’s total funding.

AN EDUCATED WORKFORCE

Colorado’s tech sector and its educated workforce also make it an appealing place to plant an aerospace company. Forty percent of Coloradans have at least a bachelor’s degree, making the state second in educational attainment only to Massachusetts.

The tech sector is another catalyst for the aerospace boom, Lindell said. “Satellites, all their control and operation is enabled by software, but all the data that’s downloaded from these satellites, whether it’s geospatial data or communications data, gets downloaded and turns into real information,” he said. “So data analytics is big business in Colorado.”

And then there are the universities.

“Mines has just been in the middle of this thing that exploded around them, providing all of these engineers,” Anderson said. “The industry just started siphoning all these graduates, and you’re seeing Mines respond to that.”

The school doesn’t have an aerospace-specific program, but hundreds of alumni work in the industry. To create a more direct link between those alumni and current students, the current administration and alumni (including Anderson) launched an Aerospace Interest Group in 2017 to bring students and alumni in the industry together at events, such as the one they’ve dubbed Trajectories.

“Mines has a reputation as one of the top schools in the country, if not the world, but because Mines doesn’t have a pure aerospace degree path, I don’t think people are quite as aware of how successful Mines alumni are in the industry,” said Hutchinson, who is involved with the Aerospace Interest Group.

Anderson’s own experience in leadership at Lockheed shows why it doesn’t seem to matter that Mines doesn’t have an aerospace program. Around 15 percent of Lockheed’s hires are aerospace engineers, and the other 85 percent are from other disciplines, he said. His own career started after earning a degree in electrical engineering at Mines 34 years ago.

“Mines teaches you how to learn and how to work hard. Those two things combined, you can go wherever you want.”

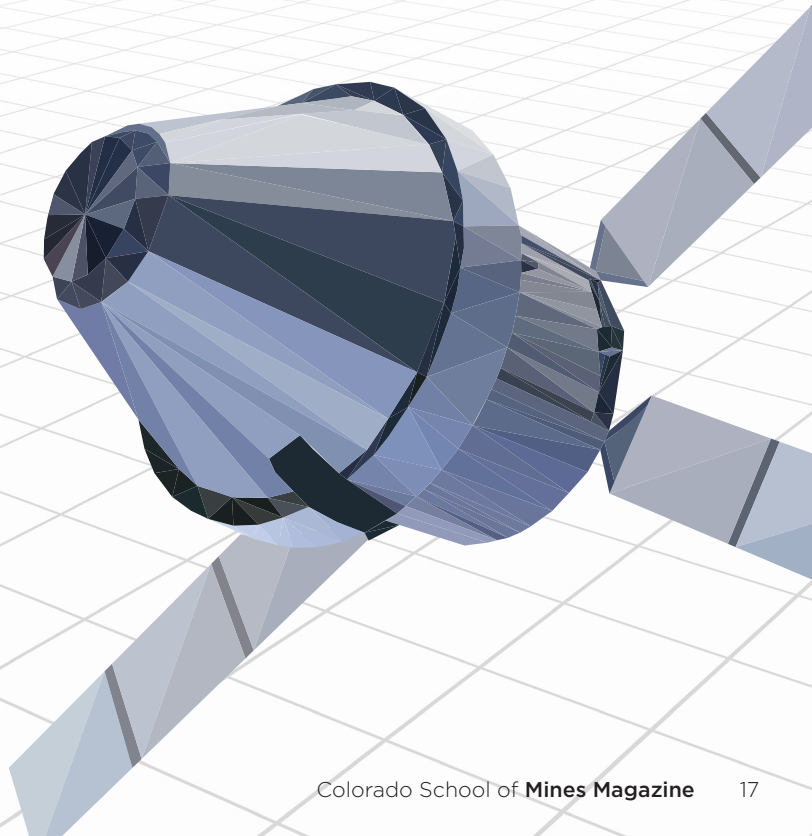
—Sean Zeeck '10
Mechanical Engineer
National Center for Atmospheric Research

A VISIBLE BIG BANG

Colorado’s aerospace companies are at the nexus of several projects that will become national news over the next few years. In 2021 alone, two major projects with deep Colorado ties are scheduled to launch. Sierra Nevada’s Dream Chaser, a winged space plane that resembles the old Space Shuttle but with sleeker lines, will first ferry cargo, then human passengers, to the International Space Station. And the James Webb Space Telescope, which NASA bills as the successor to the Hubble, will relay images of deep space back to Earth.

As a subcontractor to Northrop Grumman, Ball Aerospace designed and built the optics and mirror system for NASA’s James Webb Space Telescope. The 18 segments of the Webb’s massive primary mirror unfold into shape after takeoff. It’s the world’s largest infrared telescope, and it will be the largest mirror ever flown in space. Ball says the Webb will detect objects that are 400 times fainter than what Earth-based and space telescopes can. It’s designed to capture the birth of stars and search for light from the Big Bang.

“It’s a phenomenal program, it’s a great team and it’s exciting science,” said Dan Porpora '06, MS '07, a program manager in civil space business at Ball Aerospace who has been working on the telescope for most of the past 10 years. “Our portion of the telescope that Ball provided has been delivered. We are now officially an observatory,” he said. Ball is working with Northrop and NASA on testing now.



AEROSPACE ALLEY

Colorado has the **2ND-LARGEST AEROSPACE ECONOMY** in the U.S.

500+ COMPANIES AND SUPPLIERS PROVIDE SPACE-RELATED PRODUCTS AND SERVICES

190,290 PEOPLE ARE EMPLOYED IN SPACE-RELATED JOBS

\$3.5 BILLION ANNUAL PAYROLL

84% OF COLORADO'S AEROSPACE COMPANIES ARE SMALL BUSINESSES

4 PROFESSIONAL ASSOCIATIONS:

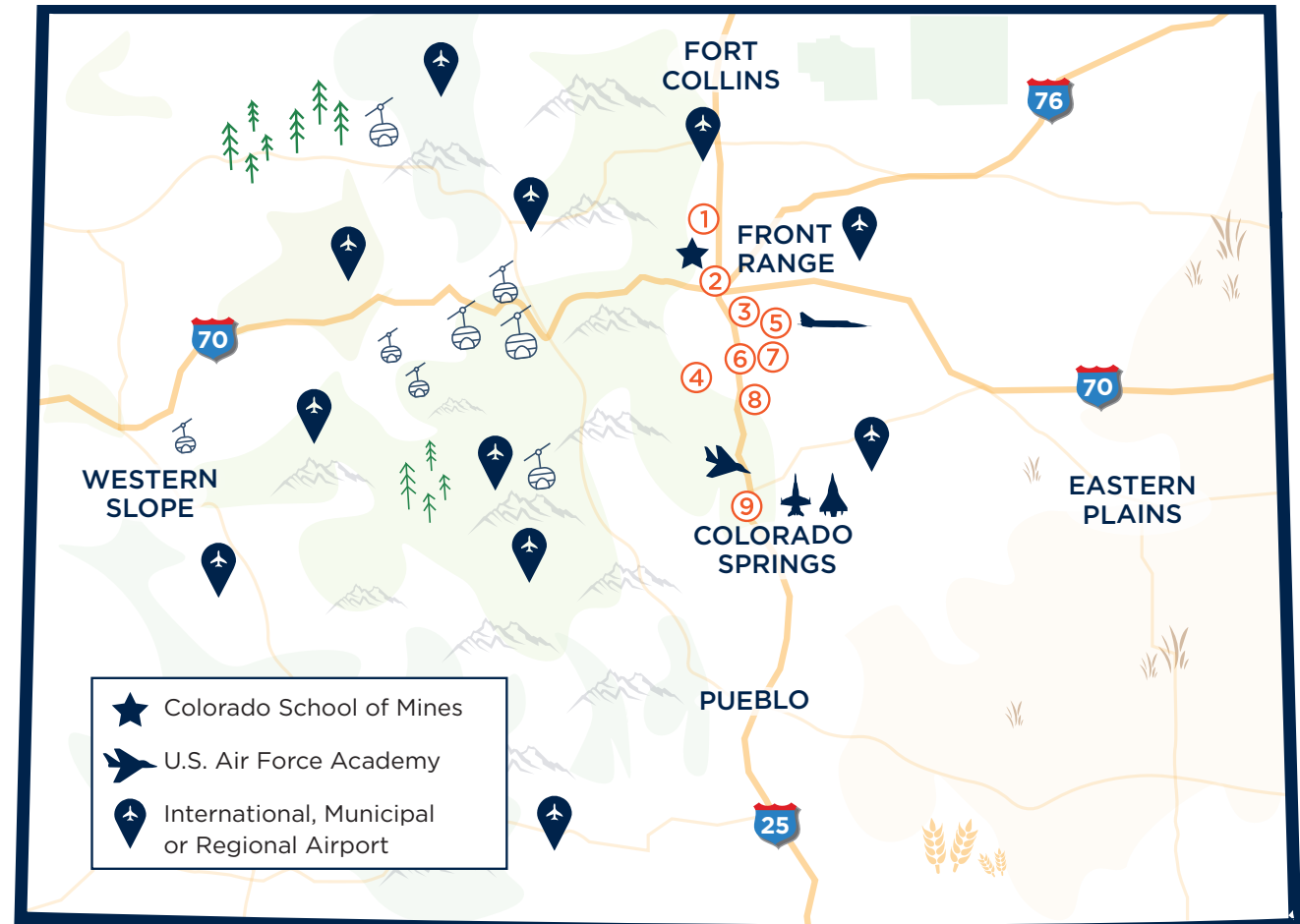
- Colorado Space Coalition
- Colorado Space Business Round Table
- Colorado Space Grant Consortium
- Spaceport Colorado

9 OF THE NATION'S TOP AEROSPACE CONTRACTORS HAVE SIGNIFICANT OPERATIONS IN THE STATE:

- 1 Ball Aerospace
- 2 Maxar Technologies
- 3 Boeing
- 4 Lockheed Martin
- 5 Raytheon
- 6 Harris Corporation
- 7 Sierra Nevada Corporation
- 8 United Launch Alliance
- 9 Northrup Grumman

3 SPACE-ORIENTED AIR FORCE BASES:

- ✈ Buckley Air Force Base
- ✈ Peterson Air Force Base
- ✈ Schriever Air Force Base



The complexities of building a groundbreaking, space-traveling research instrument like the Webb are in the engineering, but making every system on the telescope work requires another skill students learn at Mines, Porpora said: working on a team. “It’s a lot of communication. It’s a lot of conversations with people about, ‘Can you do this, can you not do this, will this break your design, will it cost \$20 million if we do this.’” The cross-disciplinary education Mines offers makes graduates especially well-suited for jobs in the industry, he said.

“What Mines has to offer is a really great academic program and leadership characteristics, which is something I consistently see from Mines graduates,” said Michelle Magnetti, Ball’s director of human resources, who has been recruiting in aerospace in Colorado for 15 years.

An engineering degree from Mines has landed some alumni in research institutions as well. Sean Zeck ’10 is a mechanical engineer at the Earth Observing Laboratory at

the National Center for Atmospheric Research in Boulder, where he designs one-off instruments and prototypes for researchers. One of the bigger projects he’s working on is Airborne Phased Array Radar, a souped-up radar system that will fly on NCAR’s C-130. “If we can learn more about a storm with better instruments, then that can give us better data about how the storm came to be and what it’s going to do.”

Zeck took a circuitous path into aerospace, from his mechanical engineering degree to the oil fields of the Middle East, then back to Colorado for a master’s in mechanical engineering with a focus on aerospace at University of Colorado-Colorado Springs. He likes to share his story with the students he meets at Aerospace Interest Group events—students who might be nervous about that big transition from college to their career. “In the end, Mines teaches you how to learn and how to work hard. Those two things combined, you can go wherever you want.”

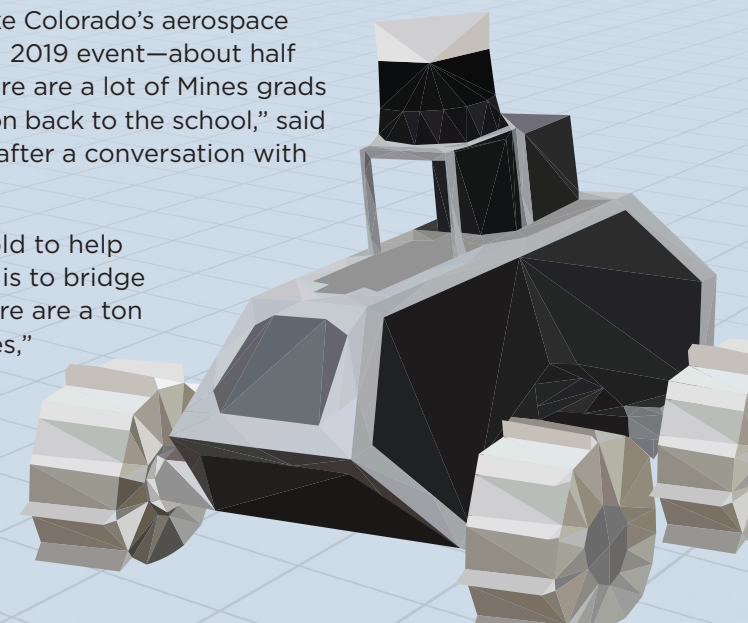
Illustrations by Christina Vessa

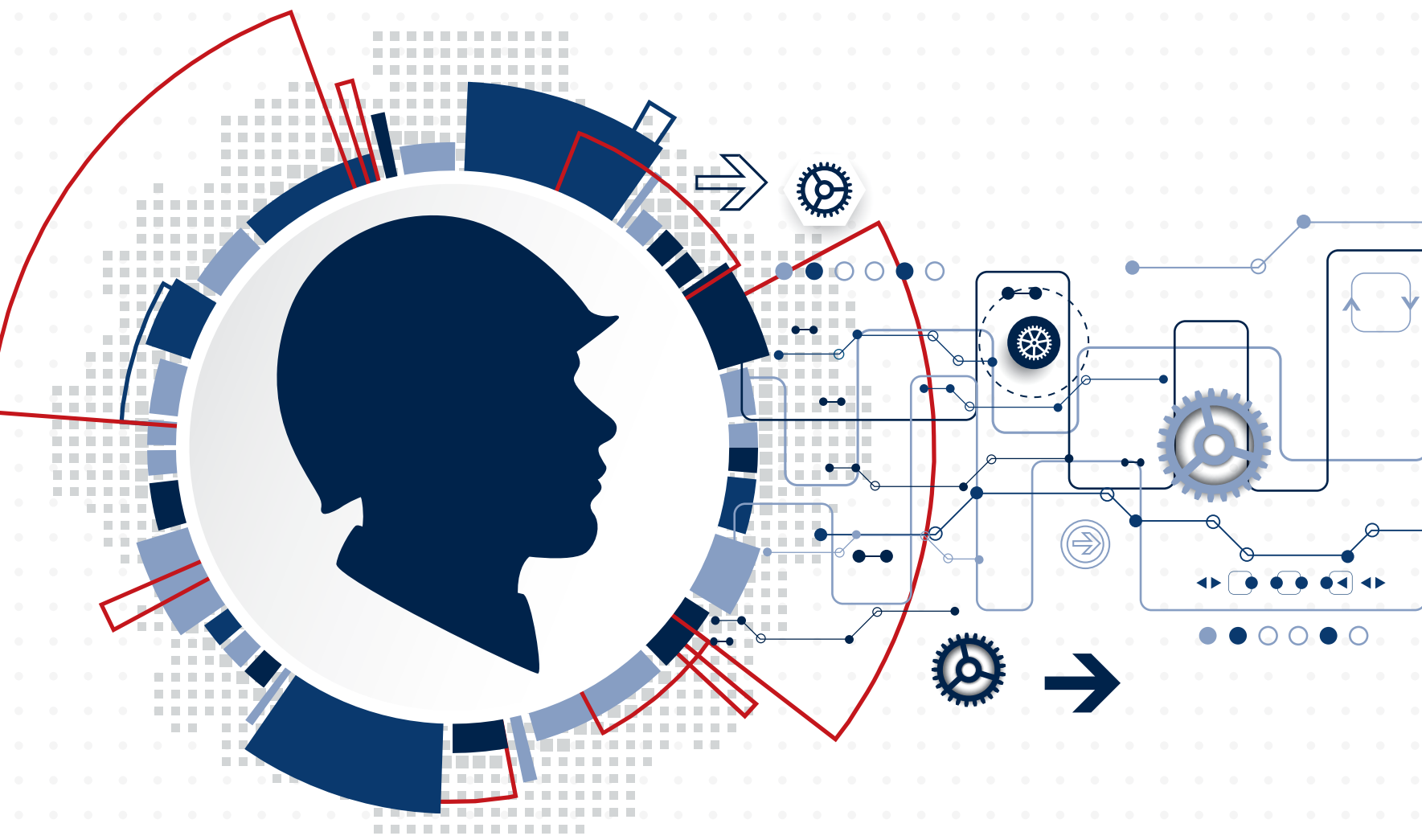
MINES AEROSPACE INTEREST GROUP: ON A TRAJECTORY TO CONNECT

The Mines Aerospace Interest Group launched their first Trajectories event in 2017 to bring students and industry professionals together, and just like Colorado’s aerospace industry, it’s growing. Three hundred people attended the fall 2019 event—about half students and half industry professionals, Anderson said. “There are a lot of Mines grads working in aerospace, but they didn’t have a natural connection back to the school,” said Anderson, who helped launch the Aerospace Interest Group after a conversation with Mines President Paul C. Johnson.

Since the first event, more Mines alumni have entered the fold to help students make connections in the industry. “Our whole point is to bridge the gap between students and industry to show that yes, there are a ton of Mines grads that are in aerospace, and very successful ones,” Zeck said.

The next event is in April 2020, at the national Space Symposium in Colorado Springs. To learn more about the Aerospace Interest Group, visit weare.mines.edu.





JOINING FORCES

Military veterans find support at Mines and careers at national labs

By **Natalie Gross**

One of Marine Corps veteran Michael Knight's dreams is to work for the National Renewable Energy Laboratory when he graduates with his PhD in materials science in 2021.

And it won't just be his degree from Mines that'll help him get there. National laboratories, a network of scientific research institutions for the federal government, are also looking for military training in future hires and the skills such as leadership, problem-solving and tactical thinking that come along with it.

"One of the main benefits is you already know [veterans] have this mindset that they want to serve their country, they want to accomplish a mission, and that's the objective of the national labs as well," Knight said. "A lot of them have worked in classified environments before—they understand those types of things. It just makes sense—if they're an engineer and a veteran, why not seek them out?"

And that's exactly what the national labs are doing through a growing partnership with Mines and other higher education institutions to recruit veterans to their ranks.

A PLACE EXCLUSIVELY FOR VETERANS

Mines recently opened a new Veteran Resource Center to serve student veterans on campus. Operated by the Mines Veterans Alliance, the resource center will serve as the hub for all veteran activities, including being a space for student veterans to come together to share experiences, study for classes, find resources to help them succeed at Mines and more. The center also hosts rotating office hours for various campus departments, encouraging veterans to use services they need but may not be familiar with.

“My one piece of advice for student veterans who are just starting at Mines would be to go above and beyond,” said Michael Knight, a U.S. Marine Corps veteran and president of the Mines Veterans Alliance. “Don’t just show up for classes—actually interact with other students. Having a community is hugely important to success.”

To hear more from Knight and to learn more about the services now available through the Veteran Resource Center, watch the video on our website.

For more information about Mines veterans services, go to mines.edu/veterans.

In November 2019, nine labs participated in a Vets2STEM event on the Mines campus, where Colorado student veterans, as well as other members of the military community, were invited to learn more about their work and job opportunities. These include 10,000 open positions in engineering alone.

Beth McCormick, director of strategic workforce development for California's Lawrence Livermore National Laboratory, which helps maintain the nation's nuclear stockpile, said veterans tend to stay in these jobs longer than other employees, which is another reason they're attractive candidates. And in partnering with schools such as Mines, the labs can ensure they're getting candidates with the right education.

What makes Mines a good go-between is its focus on “mission-related” work, said Sridhar Seetharaman, associate vice president of research at Mines. “It's not for the sake of science. Most of the work is done for an application, a practical application that impacts something or the other. I think that resonates with veterans.”

Seetharaman is currently working on ways to help more veterans get a Mines education, such as scholarships and fellowships to fund their education for a fifth year of schooling after the 36 months of Post-9/11 GI Bill entitlement runs out. He said the school is also considering giving credit for specialized military training, as other universities have done, and granting credit for paid internships at national labs, which will help stretch the benefit a bit further.

Knight said Mines is becoming increasingly welcoming to veterans in other ways, too. Since he started in 2017, Mines has added veterans to the list of students who get priority registration and created parking spots for Purple Heart recipients. And as of last summer, the school now has a Veteran Resource Center on campus.

“Mines is really turning a new chapter in supporting veterans,” Knight said. “We have tons of support from the administration, and the sky's the limit.”

We talked with recruiters from various national laboratories at the Vets2STEM event in November 2019 to get their thoughts about what veterans bring to the table in a national lab setting and how schools like Mines facilitate the transition between military service and a national lab career. Here's what they had to say:

What makes a military veteran an attractive candidate for a position in a national lab?

“Usually our nation's veterans will leave service with a tremendous amount of skills and talents that they can then provide to some of the training or workforce needs we have at the laboratories. As an example, we have several service members who are leaving the Department of Defense and have a strong niche in cybersecurity, which is one of the areas we are looking to increase within our national labs. It only makes sense to go where we know that talent is, and that's within our veteran community.”

—**Tony Lona**
Veteran and Disabilities Recruiting Specialist
Sandia National Laboratories

“Their unique skill sets. They've been out there—they've seen some of the things we're trying to work on and know how to do the hands-on, applied type of work that we're looking for. And because of their military history and the experience they have, they bring a unique perspective and some really interesting ideas and can contribute in a really big way.”

—**Marissa Reigel '05, PhD '09**
Group Manager, Energy and Material Science Directorate
Savannah River National Laboratory

How do universities like Mines help facilitate the transition from the military to a national lab?

“Partnerships with universities are critical to our workforce. They're our national ambassadors. They are developing the students with pedagogy and academia, and being able to transfer those skills to the workforce is definitely critical to what we need. We're partners in that experience—universities develop students academically, and then the national labs provide the opportunities where they can really get a hands-on experience.”

—**Colette Flood**
Manager of Workforce Development and Education
Lawrence Berkeley National Laboratory

“Mines is a great university to prepare students for national laboratories because of the challenging curriculum. Mines obviously has a great reputation for being an academically challenging institution. Those challenges will be very correlated to what you're going to be doing at a national laboratory day in and day out.”

—**Neil Altomare**
Operations Engineer
Sandia National Laboratories

A lot of students dream of joining SpaceX or Tesla, Google or Boeing. Why might they look to a national lab instead?

“I know that a lot of students want to work at some of the big-name companies—SpaceX, Tesla, Google or Amazon. They can have really great careers there. But I think the mission impact, the things we do at the national labs, change the world for the better every day.”

—**Zachary Tudor**
Associate Director, National and Homeland
Idaho National Laboratory

A NEVER-ENDING STORY

THE MINES HISTORY ARCHIVE MAKES THE SCHOOL'S STORY COME ALIVE

After nearly 150 years, countless students passing through campus and an ever-expanding footprint in Golden, Colorado, Mines sure has a lot of stories to tell. But keeping track of those stories—not to mention determining fact from legend—is quite the challenge. Fortunately, the Mines History Archive at the Arthur Lakes Library is on hand to record, preserve and share them all.

While Mines has kept track of the university's history since the school was first founded, the official archive wasn't established until 2015, when librarians saw the need for a repository dedicated to telling the stories of past students and campus life throughout the years.

"Stuff" was shoved in the mining history archive," said Lisa Dunn, the library's archivist, speaking of random bits of student history that had been shared by former graduates and didn't have an official place to be filed away. "But I was getting more and more questions about Mines history, and we really had enough to have our own archive."

A space was carved out in the library to preserve artifacts, programs, yearbooks and other historical items from the school's past to begin intentionally storing and recording Mines stories, and the archive has been slowly growing ever since, not only with physical artifacts but also a digital archive where people can view scanned photographs and documents.

And there's certainly plenty of interest in the archive and sharing stories from alumni and others connected to the Mines community. This past fall, an event was added to the Homecoming lineup, inspired by the popular TV show *Antiques Roadshow*, where antiques owners could bring in items to be appraised by experts. While the Mines event didn't offer appraisals, alumni could view items from the Mines history archive and hear from Dunn about how historical artifacts make the Mines story come alive. Alumni also had the opportunity to bring their own Mines memories—photographs, memorabilia, pamphlets—to reminisce and share the parts of Mines they knew as a student.

It's those personal stories that Dunn said really tells the most about a particular time, and preserving the original sources of those stories and artifacts lends authenticity to an archive. "It's not me making something up or writing an article where things can be left out or mistakes made," Dunn said. "Almost every history leaves something out—it's an editorial choice—and that's why it's good to have multiple histories, so you can get different viewpoints and see what was important to people."

"Our history helps shape who we are," Dunn said about the importance of historical archives. "In whatever way, it's part of what made us who we are now."

But when asked about the biggest challenges of the archive, Dunn said it's the gaps in the archive's knowledge. While there are a lot of great artifacts currently in the archive, most are from the early 1900s. Dunn said there's not enough from beyond the 1930s for her to get a firm grasp on what life was like for students throughout the latter half of the 20th century. She would really like to know more about campus life, student organizations and department histories.

"I would love to have more alumni histories about their experiences here or their job histories. Things that just talk about what life was like and what people were concerned about."

—Lisa Dunn, Arthur Lakes Library archivist

"I would love to have more alumni histories about their experiences here or their job histories," Dunn said. "Things that just talk about what life was like and what people were concerned about."

And accounts from students who graduated within the past few decades have been the hardest to get, because many people don't see their experiences as old enough to be "historical" or of use to an archive. But Dunn said it's all part of the Mines story and has to be preserved.

"People think they led an ordinary life," Dunn said. "But when you look at it from a perspective of years, it was not ordinary."

By **Ashley Spurgeon**

- ▶ To donate materials to the Mines History Archive or learn more about a particular piece of Mines history, contact Lisa Dunn at 303-273-3687 or ldunn@mines.edu.

THE MINES HISTORY ARCHIVE IS HOME TO A LOT OF INTERESTING ARTIFACTS FROM THROUGHOUT THE SCHOOL'S HISTORY. WE ASKED ARCHIVIST LISA DUNN TO SHARE MORE DETAILS ON A FEW OF HER FAVORITE ITEMS.



Charles N. Bell '06 scrapbook and Mines stadium blanket
The scrapbook and photo album collection in the Mines history archive were collected from Mines alumni and includes scenes from the Mines campus and student activities. Dunn said the items in this collection represent the views and interests of students during their time at Mines, making each a "slice of life" of the university at that time.

"Scrapbooks are the life that isn't recorded anywhere else, and that's why I love them," Dunn said. "This is the students' view of Mines—this is how they saw the school and themselves, which is really important. Scrapbooks bring their own context with them."

The stadium blanket was used during football games in the 1930s and bears the appliques of an "M" and a leather football.



Photograph of the Mines baseball team

Baseball has been part of Mines history since the formation of the Jarvis Hall White Legs baseball team in the early 1870s. By 1887, the baseball team belonged to the State League, which included Jesuit College and Denver High School.

"Mines is not usually seen as a baseball school," Dunn said. "But baseball was the school's first foray into sports. It's interesting to see that Mines believed in athletics and sports right from the start."



Bishop George M. Randall communion chalice

This chalice originally belonged to Bishop George M. Randall, the missionary bishop of the Episcopal Church. Randall was the founder of the Jarvis Hall Collegiate School, the precursor to Mines located south of Golden in 1869. Every year, Mines lends this chalice to the Calvary Episcopal Church in Golden.

"What I like about the chalice is that the Episcopal Church asks to borrow it for one of their ceremonies every year, and it means a lot to them," Dunn said. "It's a shining example of what archives should do—they should have connection with the present."



Senior Stetson

This senior Stetson belonged to Charles R. Ewing from the Class of 1900. The Stetson features signatures from Ewing's classmates.

"Senior Stetsons were *the* hat," Dunn said. "Only seniors were allowed to wear them. It's a good contrast to the freshman cap, which was a scruffy miner's cap with a tag and holder in the front."

HOMECOMING HIGHLIGHTS

FAVORITE MOMENTS FROM THIS YEAR'S CELEBRATION OF OREDIGGER SPIRIT

There's nothing like the excitement of Homecoming at Mines. Alumni were welcomed back to Golden in October to celebrate the Oredigger spirit and reflect on days past, and current students participated in the traditions that have become signatures of the Mines experience. We've highlighted some of the weekend's best moments.



HOMECOMING DISTINGUISHED LECTURE FEATURING MAE JEMISON

When was the last time you looked up? That was the question posed by Mae Jemison, this year's Homecoming Distinguished Lecturer. The entrepreneur, physician and former NASA astronaut gave an inspiring talk about how innovation starts by looking up. Through a discussion about interstellar travel, building a better future and choosing the person you intend to be, Jemison encouraged the audience to be aware of how what we do impacts everyone and that together, we can make amazing things happen.



BOOTS & BARRELS ALUMNI PARTY AND AWARDS

An alumni-exclusive event that brought Mines graduates together for an evening of reconnection, Boots & Barrels was a celebration of alumni accomplishments and Oredigger pride. This year, five alumni were recognized for their contributions to the Mines community:

- Ken Brettmann '84, Outstanding Alumnus Award
- Kendra L. Lema '96, Melville F. Coolbaugh Award
- Damian Friend '75, Alumnus of the Year
- Christina Volpi '12, Young Alumnus of the Year
- David Mayer '80, Academic Support Award
- Tiffany Brewster '07, M Club Leader Award



HOMECOMING 5K

Orediggers of all ages came out in force for the annual Homecoming 5K. 280 alumni, students, faculty and staff enjoyed the 3.1-mile jaunt around the Mines campus, enjoying scenic views of Clear Creek and the new additions to the Mines landscape.



TAILGATE AND FOOTBALL GAME

You can't have Homecoming without the ultimate celebration of school spirit at a tailgate and football game. Going head-to-head with Fort Lewis College, fans had plenty to cheer about as the Orediggers beat the Skyhawks 42-0.



SUNRISE M CLIMB

All Orediggers are introduced to the M Climb in their first year at Mines, carrying a 10-pound rock up to the M on Mt. Zion. Alumni had the chance to relive the tradition with a sunrise hike or retrieve their rock if they didn't complete the reverse M Climb as a senior.



MINES ANTIQUES ROADSHOW

New to the Homecoming lineup this year was the Mines Antiques Roadshow, an event where alumni could learn about the Mines history archive and the library's mission to preserve the story of Mines students and alumni. Learn more about the school's history archive on page 24.

50TH CLASS REUNION

An essential part of Homecoming is the opportunity to reconnect with former classmates and share memories, but the reunion is even more special when marking a milestone year, like the 50th class reunion. Members from the Class of 1969 reunited to reminisce on their time at Mines and careers.

ADDING UP THE SMALL WINS

SEAKR ENGINEERING'S CHAD FISHER '95, PHD '00
TALKS PROFESSIONAL SUCCESS

It's no secret that aerospace is rapidly changing and evolving, particularly in Colorado. But through it all, SEAKR Engineering has remained a steady, constant presence.

The Centennial-based company, founded in 1983, designs, builds, analyzes and manufactures spacecraft payload processing systems and avionics. We sat down with Chad Fisher '95, PhD '00, SEAKR Engineering's executive vice president, to glean insight into how to be successful in this ever-changing industry.

Q: How do you maintain a long-term vision for SEAKR Engineering in the face of the aerospace industry's rapid growth and evolution?

Fisher: We don't really look at it as change, but rather, opportunities for growth. SEAKR was started in 1983 to create enabling space electronics using commercial technologies. We see significant opportunities to grow by focusing on what we are good at, which is to provide industry-leading processing systems to enable payloads and mission success. There is a lot of talk about "NewSpace" and the use of commercial technologies in space, but we've been pushing the envelope on using commercial technologies for a long time, and we have built a wealth of knowledge on how to do so successfully, as proven with our 297 successful systems on orbit.

Q: What are the strongest qualities you've seen in leaders?

Fisher: First, the best leaders are personally committed and are willing to roll up their sleeves and work hard—leading by example has significant positive impacts on teams and organizations. Second, I'd say the ability to listen and digest information. A leader is someone who desires input from teams and organizations. And third, an unwavering, tenacious positive outlook—there will be challenges and tough spots to work through, so a strong leader needs to keep the organization motivated and positive to achieve breakthroughs.

Q: How do you measure professional success?

Fisher: The measure of a person's professional success is derived from what they helped create that didn't previously exist. That can range from products delivered to company

“**Surround yourself with people you can learn from and who believe in you—Mines is a great place to start surrounding yourself with great people to support you.**”

operations that enable the workforce to be more productive. I am hopeful that my biggest success is yet to come. There's a lot yet that I want to accomplish and be a part of creating.

Q: When you look back on big wins in your career, what do you remember?

Fisher: Instead of big wins, they are all small ones that add up over time. I do have a few big failures that stick out, and the lessons I've learned from those are more important than the wins. And, some failures that seemed big at the time don't seem that way anymore, but were just steps to get where I am. I've certainly learned not to be afraid to fail.

But when it comes to wins, it's remembering all the people who supported and enabled me along the way—my family, professors, mentors and colleagues. Surround yourself with people you can learn from and who believe in you—Mines is a great place to start surrounding yourself with great people to support you.

Q: What would you tell a student who is considering Mines?

Fisher: Sometimes, students have a clear idea of an engineering discipline they want to pursue, and sometimes, they aren't sure or they might discuss a career in medicine or a desire to pursue an MBA. In all cases, I tell them that I recommend Mines because students there receive a solid technical foundation and are taught how to think and how to approach and solve open-ended challenges, which is enabling in any profession the student ends up pursuing.

Interviewed by **Sarah Kuta**
Photo by Mark Stevens Photography



CHAD FISHER '95, PHD '00
Executive Vice President, SEAKR Engineering

FISHER'S QUICK TIPS FOR SUCCESS

Focus on what you're good at.

Listen and digest information.

Surround yourself with supportive people who will teach you new things.

Don't be afraid to fail and learn from those failures.

Keep an unwavering, tenacious positive outlook.

Lead by example.

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ALUMNA PROFILE

TRUST IN FAIR MARKETS

“At Mines, we got a good mix of theory and applications. The field work—visiting offshore rigs and mining operations—that exposed us to infrastructure, was huge. Mines should keep doing that and keep encouraging women to get involved in engineering economics and give students a holistic education.”

—Diana Moss PhD '89
President, American Antitrust Institute
Photo courtesy of Diana Moss



It's not every day that antitrust issues are in the public spotlight, but with big tech in the political hot seat, questions about whether tech companies have become too large and too consolidated are debated in the news and at the dinner table. For Diana Moss PhD '89, president of the American Antitrust Institute, it's a chance for her organization to shine in its mission to educate the public and protect consumers and businesses.

“The focus is really on big tech, and it's a big issue—it garners a tremendous amount of media attention,” Moss said. “But I always remind people to keep their eye on the ball. As a competition advocate, we follow all industries, and we see tremendous consolidation and concentration across the board.”

Moss has been at the helm of the AAI, a nonprofit engaged in research, education and advocacy on antitrust issues, since 2015. She came to the organization in 2001 after years of work in energy markets, policy and regulation.

“Regulation and antitrust are stepsisters,” she said. “They're both tools for ensuring that markets function competitively. But regulation prevents bad things from happening—like monopolization or collusion—before they happen, whereas antitrust addresses those problems after they happen.”

Moss began her education with an interest in political economy and energy. Growing up with a father who worked at Sandia National Laboratories as an engineering physicist—and designed the family's solar home—and a mother who was a nurse, she always had a strong interest in science and math. After earning a bachelor's degree in political science at University of New Mexico and a master's in international studies at University of Denver (her thesis was on U.S. nuclear energy policy, which was a hot topic after the Three Mile Island and Chernobyl disasters), she began working on her PhD in mineral economics at Mines in the late 1980s.

“I came in to study energy economics, which overlaps with natural resource economics,” she said. “The engineering economics of the resource, transportation, telecommunications and digital technology industries are important to know if you want to be involved in problem-solving and policymaking.”

After earning her doctorate, she worked in regulation and antitrust in energy and other industries, eventually taking a position in the Office of Economic Policy at the Federal Regulatory Commission under the Clinton administration, where she was the lead economist on the mergers team.

Moss shifted to the Washington, D.C.-based AAI when it was only two years old to establish their energy agenda but didn't stop there. “I quickly branched out to telecom, airlines, health care, food and agriculture, big tech.”

Lately, it's those big tech conversations that have kept her busy fielding a lot of questions. “I just came out with an article in *The Antitrust Source* that unpacks the implications of Elizabeth Warren's proposal to break up big tech companies,” she said. “If politicians are going to go down the road of breakups, let's make sure we understand why, as well as the consequences of restructuring and regulating them.”

And Moss' interdisciplinary education at Mines—especially understanding how engineering ties into economics, politics and social policy—has helped her navigate these complex issues throughout her career. “At Mines, we got a good mix of theory and applications. The field work—visiting offshore rigs and mining operations—that exposed us to infrastructure, was huge,” she said, reflecting on her course of study. “Mines should keep doing that and keep encouraging women to get involved in engineering economics and give students a holistic education.”

By **Jenn Fields**

'DiggerDial

Student Calling Program

“I hope you answer the call. Mines alumni are so generous, it's fun to reminisce about their experience and share what it's like to be a student today. Thank you for connecting with me and helping us reach our goals.”

Madison Goyeau
Computational Science
and Mathematics,
Economics Minor
Class of 2021



Connect with bright students like Madison and learn how 100% of your support makes a direct impact on their future.



ACCESS



STUDENT LIFE

INNOVATION
AND RESEARCH

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OREDIGGERS GIVE BACK

SUPPORTING FAMILIES
AND STUDENTS

When Jennifer Steans and Jim Kastenholz's son came to Mines, they had to do some math. Not to see how many credits he'd need to take or how many days of sun he'd experience in Colorado. Instead, they calculated how much they could give back to the university.

"There's a math formula," said Steans. "What does it really cost annually to educate a student at Mines? The tuition is much less than that cost, so we were going to make up the differential of that through our philanthropy."

Their son, Nick, is set to graduate in May 2021. The couple has been involved on campus since he was a freshman and are currently serving as Family Fund co-chairs. Through this role, they engage and educate other families on ways they can provide scholarship, technology and innovation support to Mines students, clubs and organizations. Many families are surprised to find just how impactful the Family Fund can be for Mines students—and how rewarding giving back can be for other families as well.

"The more involved you get, the more you do feel like [your student] belongs here," said Steans. "For those of us who didn't go to Mines, by getting more engaged, you get more of a sense of belonging, and it helps you understand where your student is."

They are very grateful for the Mines community and the supportive environment Nick has experienced on campus, which helped him find his footing after a tough academic year. They want to make sure families know that a Mines education is rigorous but that their students have many resources, such as advising, tutoring services and mental health counseling.



Jennifer Steans and Jim Kastenholz give back to Mines in many ways, including being co-chairs of the Family Fund and supporting #idigmines Giving Day.

“For those of us who didn't go to Mines, by getting more engaged, you get more of a sense of belonging, and it helps you understand where your student is.”

—Jennifer Steans

Not only do the couple give their time and talents by being leaders on the Family Fund, but they also supported Mines and students through leadership gifts during #idigmines Giving Day 2019. And they will continue this support by playing a major role in this year's #idigmines Giving Day on February 6, 2020 and donating toward the grand bonus.

"There's such an overall sense of gratitude for what the university is doing for the students. We want to spread that goodness around," Kastenholz said. "Every time I find myself on the Mines campus, I get energized because I look around—and I know it's cliché—but you see the future and you can't help but feel good."

By **Anica Wong**



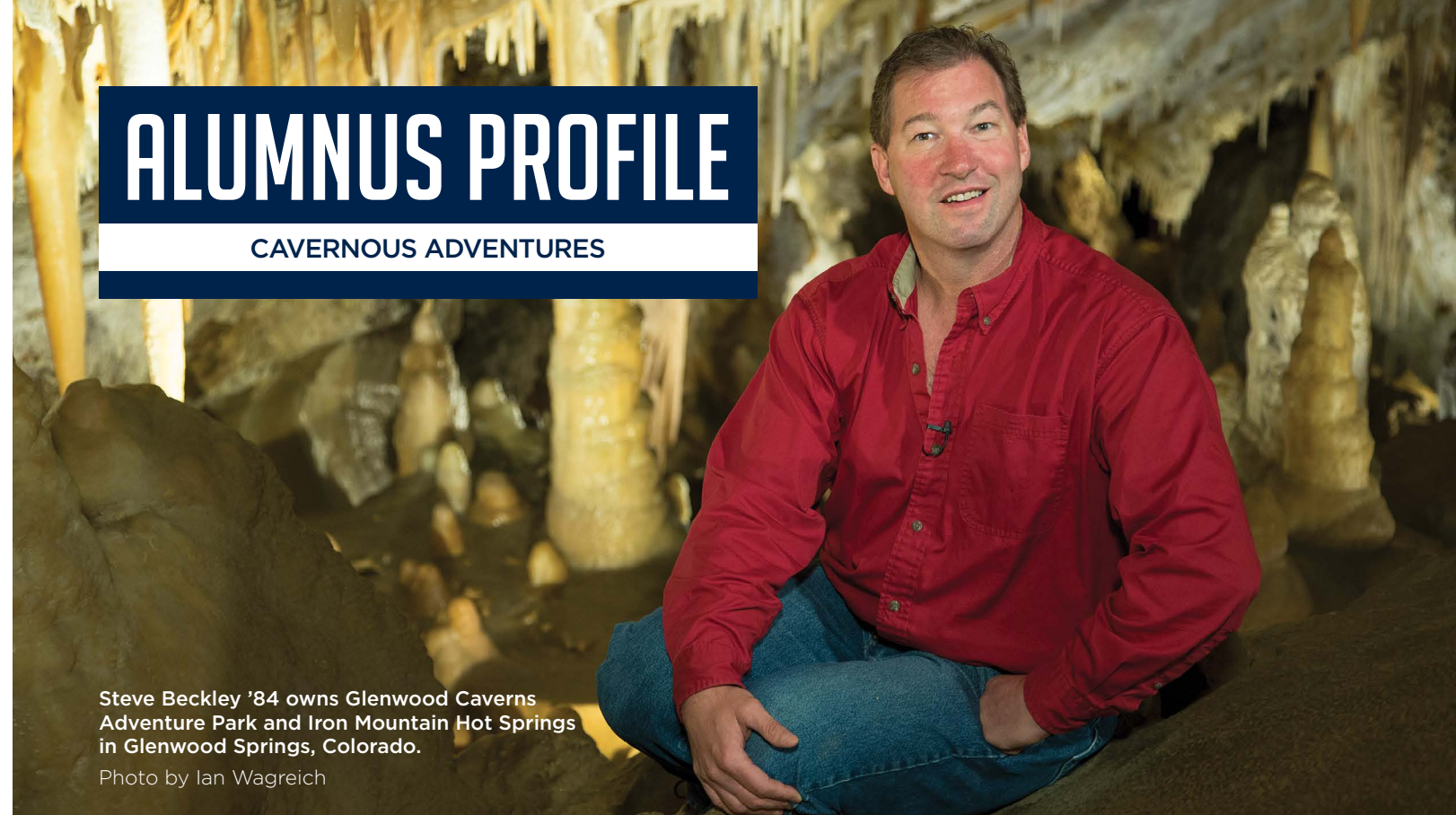
ARE YOU AN OREGIVER?

OreGivers donate their time, talent and treasure to Mines and through Mines. Many support the university through financial gifts, while others volunteer their time on campus and serve their communities, using their talents and resources to embody the spirit of giving. The Mines community has a service-oriented culture, built on gratitude for what we have received and a desire to pay it forward. **Orediggers are OreGivers.**

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ALUMNUS PROFILE

CAVERNOUS ADVENTURES



Steve Beckley '84 owns Glenwood Caverns Adventure Park and Iron Mountain Hot Springs in Glenwood Springs, Colorado.

Photo by Ian Wagreich

Imagine a theme park: roller coasters, laser tag, a themed thrill ride featuring a 110-foot drop—and 4 miles of cave to explore. Once a deserted mountaintop in Glenwood Springs, Colorado, Glenwood Caverns Adventure Park, founded by Steve Beckley '84 and his wife Jeanne, now boasts cave tours, six thrill rides, various family attractions, shopping, dining and live music.

Beckley first got the idea to open the caves to the public when he was still a student at Mines. "I found a book in the library called Caves of Colorado that discussed a cave above Glenwood Springs," he said. Upon reading about how beautiful the cave was, Beckley decided he had to see it. He wrote the cave's owner asking for access but didn't receive a response.

The next year, Beckley graduated with a degree in petroleum engineering and began his career with Amoco in New Orleans. Though he pursued other endeavors, "I kept the cave always in the back of my mind," he said. "I always said, someday I'm going to own this cave and develop it into something where I can show people how amazing caves are."

Years later, he finally connected with the cave's owner, who allowed Beckley to see the property in 1994, then sold it to him in 1998. Shortly after, the Beckleys moved to Glenwood Springs and opened the caves to the public.

The original business, Glenwood Caverns and Historic Fairy Caves, featured only cave tours, with buses to bring guests up the mountain; a tram added in 2003 provided year-round access. As the site gained attention, the average wait time for a tour grew to be several hours long. To give

the guests something to do while they waited, Beckley installed rides and other attractions, including the country's first alpine coaster.

In 2015, the Beckleys also opened the nearby Iron Mountain Hot Springs, a luxury resort with sixteen natural mineral pools along the Colorado River. Together, the attractions welcome more than half a million people a year.

Although his career has deviated from the traditional industry-driven path, Beckley said he used his knowledge from Mines to develop both of his businesses. For example, the Glenwood Caverns land was originally thought to have only one mile of cave, but the Beckleys discovered and opened up another three. "That was all done with mapping and by understanding how caves form and the geology of the limestone," said Beckley.

Beckley's technical knowledge also comes into play at the Iron Mountain resort. "We've taken the hot springs to the next level in technology," he explained. "We're moving fluids, making heat transfers, snow-melting all our sidewalks, heating our showers, recovering heat with a big heat pump. Those are all ways of thinking I learned at Mines."

So what's next for Beckley? While he wants to add more lodging at the hot springs and more rides at the caverns, he has bigger plans. "We're also looking at purchasing other hot springs around the U.S. and developing those," Beckley said. "We think there's a huge market for that model."

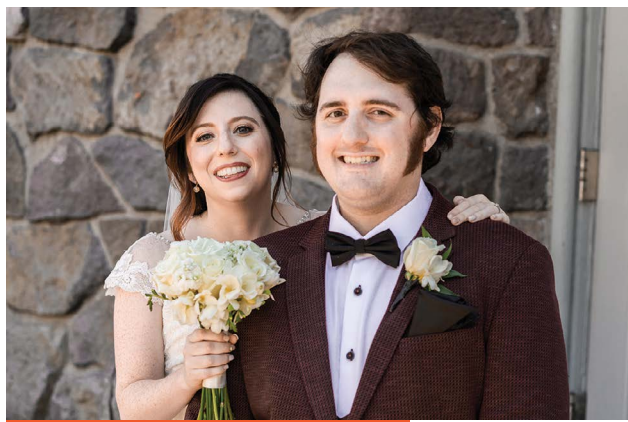
By **Amanda Schuster**

WEDDINGS



GETTING HITCHED

Molly Clark '17 and Justin Fantasky '16 were married on June 22, 2019 in Castle Rock, Colorado. Justin and Molly met at Mines and were both involved in the Mines Activities Council and Greek Life. Several Mines alumni were in the wedding party, including Jordan Daubenspeck '16, Amy Young '17, Giselle Krebs '17, Justin Dearden '16, MS '17, Christian Wert '15 and Stuart Farris '16.



MINING ENGINEERS GET MARRIED

Melissa Anderson '15 and Devin Weekley '15 were married on August 8, 2019, at the Timberline Lodge in Mt. Hood, Oregon. Both graduated from Mines with bachelor's degrees in mining engineering.



LOVE AT 8,296 FEET

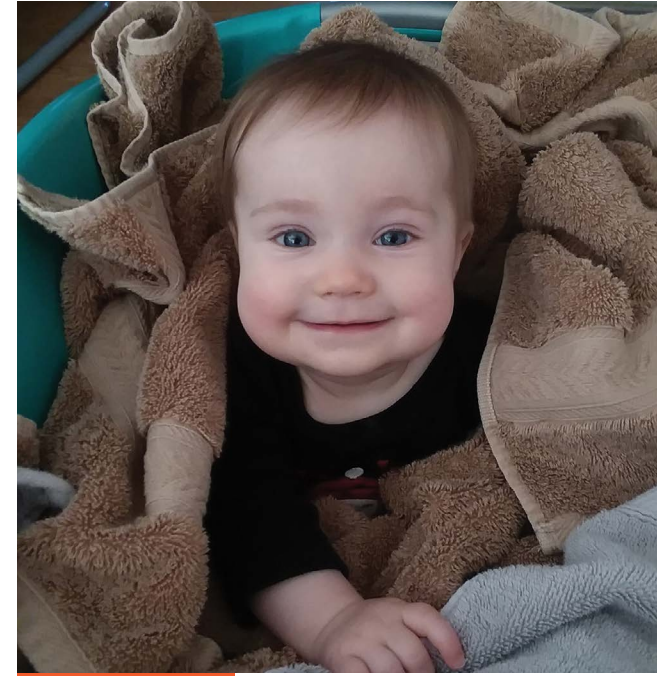
Kara Ninke '14 and Josh Ho '14 were married on June 6, 2019, at Della Terra Mountain Chateau in Estes Park, Colorado. The couple started dating during their sophomore year at Mines. Josh surprised Kara with a romantic proposal at Clear Creek in Golden, Colorado. Scott Dunagan '14 and Tamer Elsayed '14 and current Mines students Grace Ho and James Ho served as members of the wedding party. Josh is a drilling engineer at Hess Corporation and Kara works as a planning engineer at Noble Midstream Partners.



STARTING A LIFE TOGETHER

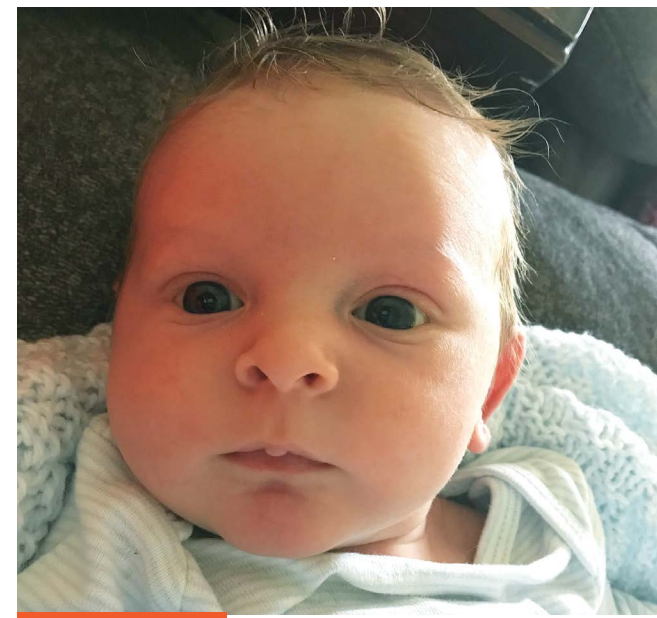
Chelsea Murnan '12, MS '14 and Shawn Makarsky were married in Silverthorne, Colorado, on October 12, 2019. More than 10 Mines alumni were in attendance, including Chelsea's bridesmaid and Alpha Phi sorority sister, Kayla Rankin '13. The couple now lives in Houston, where Chelsea works as an environmental engineer with Flint Hills Resources, and Shawn is an environmental information management consultant for Jacobs Engineering Group.

BABIES



SMILES FOR DAYS

Matt Nichols '09 and Mikayla (Buenger) Nichols '09 are excited to announce the birth of their daughter, Claire Raphaela Nichols, on March 1, 2019.



FAMILY OF THREE

Jonathan Albright '10 and Ashley Albright welcomed their first child, Gabriel John, on October 9, 2019.



EXPANDING THE FAMILY

Gretchen (Wright) Phillips '13 and Ryan Phillips '13 welcomed Samson Robert Phillips on April 10, 2019.



A NEW ADDITION

Jeremy '07 and Yvonne Bodemann welcomed their first baby, Noah, into the family on September 8, 2019.



RAINBOW BABY

Wells Calloway Barnard was born on July 22, 2019, to Ashley (Reed) Barnard '12 and Levi Barnard.

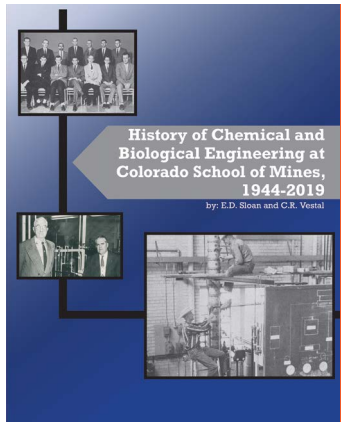
IN OTHER NEWS



EDUCATOR OF THE YEAR

Roxann Hayes '95 received the National Society of Professional Engineers—Colorado's University Educator of the Year Award in October 2019. Hayes received the award in recognition of her integration of "real world" design applications and experiences in the undergraduate and graduate

civil engineering courses she teaches at the University of Colorado Denver. She invites industry experts into her classroom and creates field trips for students to learn about transportation challenges and solutions firsthand.



HISTORY OF CHEMICAL AND BIOLOGICAL ENGINEERING

Dendy Sloan, professor emeritus of chemical and biological engineering, and Chuck Vestal '62, MS '69, PhD '74 published *History of Chemical and Biological Engineering at Colorado School of Mines, 1944 to 2019* in November 2019. The book details the

75-year history of the Chemical and Biological Engineering Department at Mines, including department head tenures, department and degree name changes and the current curriculum. The book is available as a free download at chemeng.mines.edu or can be purchased in print on Amazon.

► To submit an announcement for publication in the magazine, visit minesmagazine.com/submit-an-announcement.

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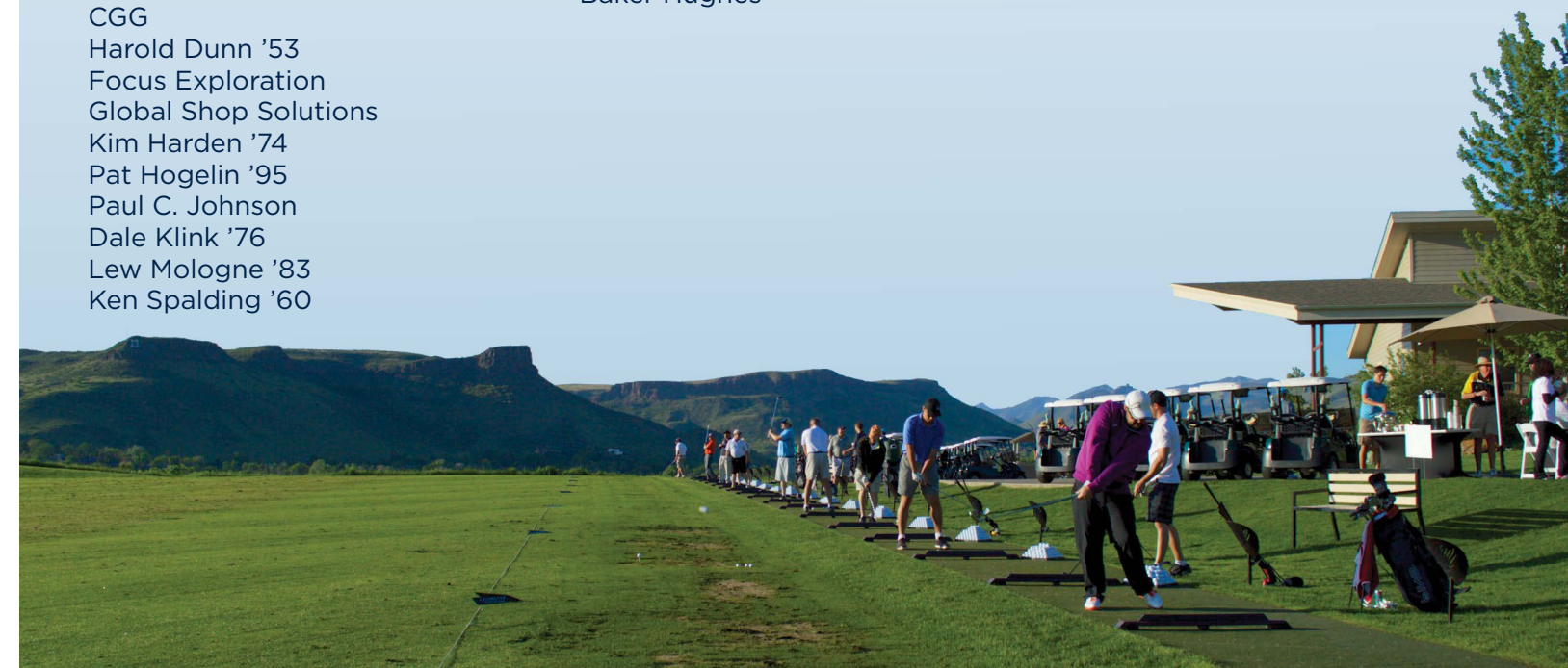
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IN MEMORIAM

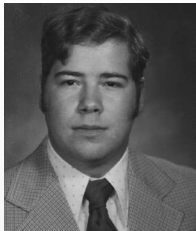
“When you are sorrowful look again in your heart,
and you shall see that in truth you are weeping
for that which has been your delight.”

-Kahlil Gibran



DOLLY A. CRAIG '73, '80, MS '02, PHD '05, MS '06 died August 13, 2019. She earned her first Mines degree in engineering chemistry in 1973 in a class with only 10 women and was on the cheerleading team. She returned to Mines in 1980 to earn a bachelor's degree in chemical and petroleum refining engineering.

She began her career working at Phillips Petroleum. Dolly also received two master's degrees from Mines—one in mineral economics and the other in international political economy of resources. She also completed a PhD at Mines in 2005. Dolly held significant positions in her illustrious career and received many accolades, including being the first woman drilling manager at Phillips; serving as the first woman president of Phillips Canada; and becoming the first woman president of SPE, AIME and the Mines Alumni Association. In addition, Dolly served two terms on Colorado's Oil & Gas Conservation Commission at the governor's request. She also taught petroleum engineering as an adjunct professor at Mines and served two terms on the school's Board of Trustees.



STEVEN M. GOEBEL '81 died June 29, 2019. He was born in 1959 and graduated from Mines with a bachelor's degree in mineral engineering in 1981. Steven spent his career working for Xcel Energy and IBM Corporation. He retired from IBM in 2015 and served as a consultant for the company until his passing.



GERALD E. GOULD '47 died October 8, 2018. Born in 1923, Gerald graduated from Mines with a professional degree in mining engineering in 1947. He served in the U.S. Navy and spent his career in the mining industry, and was one of several Mines alumni who formed the Minerals Exploration Research Company. Gerald

worked as a regional mining engineer for the U.S. Forest Service for more than 30 years.



DAVID B. JENSEN '83 died October 26, 2019. David was born in 1960 and received a bachelor's degree in petroleum engineering from Mines in 1983. As a student, David served as student body president and ran track. As a senior, he was recognized as the outstanding graduating senior in petroleum engineering. He began his

career working for Superior Oil and worked as a petroleum engineer for 36 years. He obtained a professional engineer certification in petroleum engineering in 2018.



JAMES B. PAGE '71 died July 30, 2018. Jim was born in 1949 and graduated from Mines in 1971 with a bachelor's degree in mining engineering. He went on to earn a master's degree in petroleum engineering and degrees in law and medicine. He also served in the Army Reserves for 20 years and retired as a

captain. Jim enjoyed all of his careers and relished learning.



ZELL E. PETERMAN '57 died July 21, 2019. Born in 1934, Zell graduated from Mines with a professional degree in geological engineering in 1957. He joined the U.S. Geological Survey in 1962 and researched geochronology of geologic terrains, focusing on Precambrian basement rocks, and was considered a pioneer in

many geologic disciplines of geochronology, geochemistry and applied isotope geology. In September 2002, Zell was awarded the Distinguished Service Award from the Department of the Interior. He also established ZEP LLC, a consulting company for engineering and professional geologic services.



AZRA N. TUTUNCU died in September 2019. Azra was the Harry D. Campbell Chair of Petroleum Engineering at Mines and director of the Unconventional Natural Gas and Oil Institute. At Mines, Azra taught Reservoir Geomechanics, Advanced Well Integrity and other advanced petroleum engineering

courses. An expert in unconventional gas and oil shale, she conducted fundamental and applied research jointly with the oil industry, federal and state government agencies and other countries on better characterizing conventional and shale reservoirs and applying advanced technologies for extracting oil and gas in the most environmentally sensitive ways possible to minimize the footprint of these operations while optimizing production.

JAMES M. WARFIELD '50, MS '51 died July 6, 2019. Born in 1923, Jim was a second lieutenant in the U.S. Army Air Corps, serving as a bombardier with the 366 Bombardment Squadron. He was also involved in photomapping and intelligence-gathering flights in Europe and North Africa. Jim completed a bachelor's degree in 1950 and a master's degree in 1951 in metallurgical engineering at Mines and began his 31-year career with Caterpillar Inc. He worked as a lab engineer, inspection technician and inspection foreman. He also served as a quality assurance manager until he retired in 1982.



EDWIN "NED" T. WOOD '48 died August 24, 2019. Ned attended Dartmouth College for one year before transferring to Mines, where he graduated with a professional degree in mining in 1948. As a Mines student, Ned was a member of the Tau Beta Pi fraternity. He went on to earn a master's degree in geology from Stanford

University. He worked as a geologist early in his career and eventually became the senior executive vice president of AMAX Iron Ore Corporation. He became the managing director of AMAX Australia Ltd. in 1981. He retired in 1985.

► 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 weare.mines.edu/givingguide.

Compiled and written by **Ashley Spurgeon**

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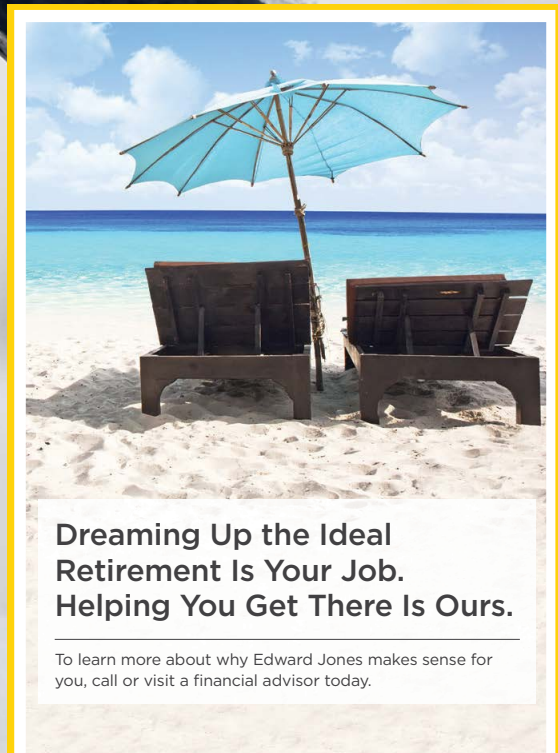
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MINER'S PIC



MT. ZION ON A MICRO SCALE

Due to their unique electrical properties, ceramics are invaluable in many technologies, such as gas sensors, fuel cells and batteries. However, their conductivity is much higher in the grains—the crystallites that form during the cooling of many materials—while the grain boundaries—the interfaces between crystallites—are electrically resistant and limit the material's overall performance.

As part of his doctoral research to better understand this phenomena, George Burton PhD '19 viewed a sample of a composite ceramic-ceramic membrane—which can separate and purify hydrogen gas from syngas and would be an energy-efficient and low-cost alternative to current methods—through a focused ion beam microscope, and something felt familiar.

“Basically, the focused ion beam microscope is a nano-machining tool that can etch very specific areas of a material and allows for lifting out minuscule pieces of

your sample—in my case, typically plucking out grain boundaries of interest,” Burton explained. “One day, I was looking at my sample and noticed that the grains kind of looked like mountains. I even found one grain that looked like Mt. Zion with a tiny crack running next to the grain, which reminded me of Clear Creek.”

Inspired by the familiar landscape, Burton loaded an M into the microscope's software, and the focused ion beam rastered over the designated area of one particular grain and sputtered away the material to form a representation of the iconic M that overlooks campus but with one key difference—Burton's version is roughly three microns across, 30 times smaller than the width of a human hair and invisible to the naked eye.

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BAT VISION: TURNING SCIENCE FICTION INTO REALITY

Bats are master navigators in the dark. What if mine rescue first responders were, too?

Inspired by a bat's echolocation abilities, Mines researchers are developing a wearable, augmented-reality display that will let emergency responders "see" as they enter a dangerous situation at a mine. The project uses machine learning-enabled acoustic imaging to create a map of the surrounding space that will appear on a display inside a helmet so first responders can safely navigate zero-visibility corridors.

"Bat vision" will be a major advancement in mine rescue, helping to save the lives of miners and first responders alike.

► Read more about the bat vision project and watch a video at minesnewsroom.com.



Mining PhD student Doga Cagdas Demirkan tests out a wearable augmented reality display as Mines Professors Sebnem Duzgun and Andrew Petruska watch the transmission.

Photos by Colorado School of Mines