Mining Engineering’s Department News

Department Head Welcome
Greetings! What a year it has been! We had a new building open on campus (Coorstek), and the University is busily planning for more construction. This wonderful campus is getting even better, as are our superb faculty, staff, and students.

The department completed its part of the curriculum building for the Nazarbayev University project (Kazakhstan) and now we move on to mentoring and collaborating with faculty and students. We have renewed our own graduate course curriculum and have developed a NEW degree program — the Professional Master’s (PM) degree in Mining Engineering and Management. The PM degree will be launched on-line with two of the courses offered this Spring semester, 2019.

We again were ranked #1 in the world for Mining and Mineral Engineering by QS World University Rankings, and we have the exciting news that Pat Taylor, Corby Anderson, and Erik Spiller from Metallurgical and Materials Engineering will be relocating into our department on January 1, 2019. We continue to have lots of international visits — this year from Universidad Nacional de San Agustin (UNSA) and GERENS in Peru, Loeben in Austria, Universidad Catolica and Universidad Adolfo Ibanez in Chile, Chinese University of Mining and Technology, U. of Adelaide and Queensland in Australia, U. Lulea in Sweden, and from a government minister from Kenya. We started an internship program with CSN in Brazil and had visits from Shandong Gold (China) and Hexagon Mining. Very busy.

My own travels included the SME meeting (Minneapolis), the MEI2018 (Las Vegas), the Fox Conference and the Moles, the World Tunneling Conference (Dubai), ASCE (Pittsburgh), and the North American Tunneling conference (Washington D.C.). I was honored as Outstanding Educator by UCA/SME and as an SME Henry Krumb Lecturer, and I gave invited talks at the American Copper Council, OLLI, and Geo-Virginia. I continue to chair NIOSH’s Mines Safety and Health Research Advisory Committee and twice met in Washington as a member of the National Academy’s Committee on Geotechnical and Geological Engineering. I have also been appointed to the Sibanye-Stillwater Global Safe Production Advisory Panel in South Africa.

During the year, we completed Memoranda of Understanding (MOU) with Loeben for a dual degree program, and we have had planning discussions with various mining and investment companies. The department’s Industry Advisory Committee met twice in 2018, and we completed a Mines-mandated assessment by an external visiting committee and a self-study and assessment for our ABET accreditation. All goes well!

We are very active recruiting students and engaging our alumni — we hope to see you at the alumni reception at SME in Denver in February—Tuesday night as usual! Please plan to stop in. Our department can only accomplish all of these wonderful things because of your guidance and financial support. We thank you from the bottom of our individual and collective hearts. We invite your input, thoughts, questions and ideas, and we invite you to come visit! — Priscilla

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Our Faculty
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Assistant Professors
Elizabeth Holley
Rennie Kaunda
Eunhye Kim
Nicole Smith
Faculty Perspective: Dr. Jürgen Brune

Dr. Jürgen Brune is the recipient of the 2019 SME Health and Safety Division Research and Education Excellence Award. The Society for Mining, Metallurgy and Exploration (SME) presents this award to an individual or a research or educational institution exemplifying exceptional innovation and dedication toward advancement in technology or education for the protection and well-being of miners.

The Society for Mining, Metallurgy and Exploration (SME) is launching the new peer reviewed journal as its all-SME society journal in partnership with Springer, one of the world’s leading global research, educational and professional publishers. SME will start by publishing 70 peer-reviewed papers across six issues in even months, beginning in February 2019. Its scope will span the society’s broad fields of interest with three main sections: (1) Mining, (2) Mineral and Metallurgical Processing, and (3) Exploration. Dr. Brune is the Editor-in-Chief for the Mining section of the journal.

Dr. Jürgen Brune sent three Mines students to research internships at German institutions. Undergraduate Mining Engineering student Kinsley Costner studied at the Technical University Bergakademie Freiberg in Freiberg, Germany under Professor Helmut Mischo and presented this paper at the SME Annual Conference in Denver in February 2019. Petroleum Engineering graduate student Christina Suarez studied at the Technical University Georg Agricola in Bochum, Germany under Professor Jürgen Kretschmann. She wrote the paper "Coal Mining in Ruhr, Germany: Industry in Transition. An American Perspective" and will also present it at the SME Conference in February.

Engineering Physics graduate Dominic Martinez completed a research internship at the German Space Research Institute DLR in Braunschweig, Germany under Professor Cord Rossow. He conducted computational fluid dynamics studies on turbulence effects on supersonic military fighter aircraft in critical flight situations.

Drs. Gregory Bogin, Jr. from Mechanical Engineering, Richard Gilmore and Jürgen Brune won a major research award from the private Alpha Foundation for the improvement of Mine Safety and Health. The award is for $680,000 over three years and supports two graduate students. Mines Researchers will construct a 100-ft long explosion tube at the CSM Edgar Experimental Mine in Idaho Springs to study the effects of methane-air explosions propagating through rock rubble. These experiments aim to quantify explosion hazards in underground coal mines and to develop strategies and best engineering practices to prevent such explosions in the future.

Dr. Jürgen Brune successfully completed a Summer course in Engineering Learning and a Fall course in Engineering Online Learning, both conducted by the Mines Trefny Center. Both courses focused on improving teaching skills for engineering courses and provide the qualification to teach the online courses that Mining Engineering will offer in the Professional Master’s degree program.

Dr. Brune was the invited keynote lecturer at the 2018 Aachen International Mining Symposium (AIMS) at the Technical University Aachen, Germany. His presentation was titled "The 4th Industrial Revolution in the Mining Industry" and outlined the disruptive changes and improvements that digital technologies bring to mining.

Dr. Brune also presented an invited keynote lecture at the 10th International Mine Ventilation Congress in Xi’an, China. The title of his lecture was "Digital Technologies in Mining with Special Consideration of Ventilation". Dr. Brune and his PhD graduate students Claire Strebinger and Aditya Juganda presented four research papers at this peer reviewed conference.

In May of 2018, the SME Underground Ventilation Committee elected Dr. Brune to be the U.S. representative on the International Mine Ventilation Council.

Faculty Perspective: Dr. Eunhye Kim

2018 has been a productive year as I have published five peer-reviewed papers and submitted eight manuscripts to SCI(E) journals with my graduate and undergraduate students. For teaching, I have taught “Introduction to Rock Mechanics” and “Tunneling” which deals with the fundamental theory of geomaterials as well as the application of these materials to geostructures. These classes are an important part of my work because not only do these topics lie in my current research area, but also because I employed various teaching techniques to enhance students’ meta-cognition, data analysis, and interpretation skills. In addition, I have launched my rock fracture mechanics database website with my student (Ryan Hunt) using machine learning mechanisms. Tune in for more exciting stories!
**Faculty Perspective: Dr. Elizabeth Holley**

This has been a big year for my Mining Geology Research Group. I have been honored to receive a National Science Foundation CAREER award supporting my research and educational outreach. The project focuses on the geology of Carlin-type gold deposits in Nevada, and for the outreach component we’ll be collaborating with Relay Graduate School of Education to bring more K-12 teachers to attend the Colorado Mining Association’s “All About Mining” teacher education program. In my group we have numerous other funded projects and exciting collaborations that are ongoing (see below). My graduate student numbers are holding steady at 8, with the graduation of Meriel Young (MS), Justin Lowe (MS), and the arrival of new PhD students Lukas Fahle from Germany and Alejandro Delgado from Colombia. The students who are here continue to make strong progress on their work, including a long list of accepted abstracts and manuscripts in review. Please see the list below for a look at our projects, funding and team.

On the teaching front, I took the Mining Engineering undergraduate students on four field trips as part of their fall geology course. They’re a great group, and they learned so much by working on open-ended questions at quarry, mine, and outcrop sites in the field. Last spring in my graduate Mining Geology course, the students formed interdisciplinary teams of mining engineers, geologists, metallurgists, and mineral economists to examine how geological uncertainty affects mine design. The students used an industry dataset from a world class gold mine to build 3D geologic models in the software Leapfrog Geo, and then they designed tests to examine how various geological assumptions impacted the block model and resource estimate.

**Faculty Perspective: Dr. Nicole Smith**

Greetings! This year has been very exciting, as I welcomed two new graduate students to my research group — master’s student, Isabel Casas-buenas Cabezas and PhD student, Gerardo Martinez. They will both be researching artisanal and small-scale gold mining (ASGM) in Latin America as part of our multi-year NSF funded project. Gerardo was also able to spend several weeks in Peru this year where he supported my State Department funded project addressing mercury use in ASGM and linking women small-scale miners to livelihood diversification activities (see photo). In May, I gave an invited talk at an ASGM conference in Lima organized by the Peruvian Ministry of Energy and Mines. Our mining and sustainable development project continues to grow, and this summer, Dr. Düzgün and I presented our research at the International Society for Research on Sustainable Development in Sicily. I also continue to remain active in the American Society of Engineering Educators, and at their annual conference in Salt Lake City, I delivered a workshop on project based learning and presented a paper on my research on ASGM. On the teaching front, I am excited to launch a new undergraduate course this Spring on Social License to Operate and continue to teach my graduate courses, Energy, Natural Resources and Society and Sustainable Development and Earth Resources.

Dr. Nicole Smith (4th from left) with graduate students, Gerardo Martinez (2nd from left) and Michelle Schwartz (3rd from left) at the formalized CECOMIP artisanal and small-scale gold mine in Ananea, Peru.
Faculty Perspective: Dr. Sebnem Düzgün

Dr. Sebnem Düzgün established a Virtual Reality (VR) Laboratory in February 2018. It is equipped with two Oculus Rift VR systems linked with high-precision motion tracking that provides an immersive walking VR experience in a collaborative environment where multiple users can interact with each other. The VR laboratory has been expanding since its founding. More recently, a remote VR system and mobile VR equipment (Oculus Go) have joined the inventory.

Currently, Ph.D. students, Ergin Isleyen and Doga Cagdas Demirkan and undergraduate students funded by the MURF program, Nicholas Bellusci, sophomore MN student and Daghan Yigitbas, junior, ME student have been contributing to the research in the VR Laboratory. The team conducts research on scientific visualization, big data analytics, real time decision-making, individual vs. collaborative decision making, and training development via VR-based serious gaming in mining engineering and geosciences.

The team has been developing a highly realistic model of Edgar Mine, various mining hazards and big data visualizations in underground mines. Since the establishment of the Lab, six conference papers have been published or accepted for presentation in scientific symposiums. The team was awarded the outstanding paper award in The Fourth International Symposium on Mine Safety Science and Engineering (ISMSSE2018) held in Beijing, China in October.

The VR Laboratory at Mines also attracted the attention of several major companies, namely, Newmont, Freeport-McMoRan and Caterpillar. The Mines community is also very interested in the developments in the VR Laboratory, including President Paul Johnson (see photo). Dr. Düzgün and her research team also organized a workshop in September at Mines on potential deployment of VR in the mining industry. They hosted Erika Fretheim, Mine technology Manager of Freeport-McMoRan, Leon P. DuPlessis, Chief Engineer in Mine Technology from Freeport-McMoRan, Michael Murphy, Chief Engineer Mining Technology Enabled Solutions of Caterpillar, Lia A. DiBello, CEO of WTRI, and Sterling Chamberlain, CTO of WTRI. The workshop developed a road map for our future collaborations.

For more details about the VR lab visit the link
https://prezi.com/view/SpJQXdIsmWcq4zGvT6/

Above: President Paul Johnson with the VR equipment looking at the Edgar Mine model developed by the VR team.

Below: Australian undergraduate students looking at the stress distribution around the tunnel.
As we approach the end of the year 2018 and reflect back on the activities and achievements, there are many reasons for celebrating the year and being thankful. I started the year with being awarded a NASA Early Stage Innovation (ESI) grant related to drilling on the Moon and Mars as a principal investigator (PI). This is great news on many levels, not only the prestige of a NASA-ESI grant, but also in getting more involved with the interdisciplinary activities of The Center for Space Resources and participating in the growth of the center. The CO-PIs on this grant include Dr. Chris Dreyer of MechE and Bill Eustes of Petroleum Eng.

Part of my spring semester and early summer was dedicated to preparing the self-study report for the Mining Engineering Program, as part of the ABET campus visit in October. The visit was a part of ABET accreditation of the program, along with 11 other programs on campus, for next 6 years. While we are waiting for the final report by the visiting team, there should not be any major issues for the renewal of our accreditation.

This year I participated in several national and international conferences and meetings on mining and tunneling where I offered several papers and presentations. One of the highlights of the summer was winning three awards (including the overall competition award) in the NASA-RASCAL competition related to designing a mission to retrieve core samples of frozen soil from the polar region of the moon by a team of CSM students that I supervised. Another notable event was hosting 22 students and several faculty from China University of Mining Technology for 3 weeks. The activities included 32 hours of MSHA miners safety training, hands on experiences in Edgar Mine, and lectures on various mining related topics by several faculty in the mining department.

EMI has been involved in several projects related to excavation of various materials for mining and civil applications, and I have actively participated in these projects. We have had some discussions for long term engagement with De Beers on their research on various modern and novel excavation techniques for mining Kimberlite, and hopefully this prospect will come to fruition in early 2019.

Meanwhile, I am chairing the 4th international conference on TBM in Difficult Ground (TBM-DiG) that will be hosted by CSM in November 2019 and all the preparation work is well underway. As a pleasant ending to a rather successful year, I recently accepted the role as one of the chief editors of Tunneling and Underground Space Technology (TUST), which is the most reputable scientific journal in the field of tunneling. I will start in this position in January 2019. I would like to wish all the readers and alumni of our great program a happy and successful New Year 2019 and look forward to hearing from you, or better yet, seeing you all on campus.
Student Field Trips

**Denver Machine Field Trip**

The MNGN414 Mine Plant Design students went on a field visit to Denver Machine, a specialty machine shop that has been in business for over 100 years and caters to the mining, oil and gas, power and other heavy industries. Denver Machine has facilities to repair large components for major mining equipment.

One of the more unusual pieces of machinery is a 20-ft diameter carousel lathe. Students learned about maintenance and maintenance planning from the owners, Eric and Scott White who are both Mines graduates. Their father, Jim White, is also an alumnus.

**West Elk Mine Tour**

The MNGN316 Coal Mine Design students went on a field trip to see Arch Coal Inc.’s West Elk underground longwall mine. Longwall mining is a highly advanced underground mining method that is most productive and has excellent safety records.

Students saw the remote controlled shearer cutting coal and automated hydraulic shield support advancing to control the roof and supporting the mining face. Students met with John Poulous, the mine engineer and Mines graduate.

**Henderson Mine Tour**

The MNGN424 Mine Ventilation students took a field trip to see the main ventilation fan installations at the Freeport McMoRan Henderson mine.

An underground visit was not possible due to major construction for a new panel development. Mines graduate and mine manager, Dave Loring, welcomed the students and led the visit.

Students saw one of the largest, dual main fan installations, natural gas heaters to warm up the intake air in winter to prevent ice build-ups in the shaft, high voltage power distribution and electronic monitoring and control equipment for the fans.

Henderson has a ventilation-on-demand (VOD) fan control system that directs fresh air to the underground workings based on actual need.
Mine Rescue Student Chapter

The Mines Student Mine Rescue Team had an exciting year. In March, the team competed at the Nevada Regional Mine Rescue contest in Winnemucca, Nevada against 11 other mine rescue teams, ten professional, corporate teams and one other collegiate team. The coed CSM Blue team finished 9th overall. The contest was judged by volunteers from the federal Mine Safety and Health Administration. The Student Mine Rescue team also completed a firefighting training with Newmont’s Mine Emergency Response Team. In April, three members of CSM Mine Rescue Blue Team went to Pennsylvania to visit the Matterhorn Mining Boots Factory in Martinsburg PA where each team member had the opportunity to custom-build a pair of mining boots for themselves.

In February 2019, the Mines Mine Rescue Team will host the Biennial International Collegiate Mine Emergency Response Development (MERD) at Mines. Collegiate mine rescue teams from U.S. and international universities will meet to compete and learn valuable emergency response skills. The teams will receive professional support from Newmont, Barrick, MSHA, and Colorado Front Range Mine Rescue, as they will supervise the competition.

WIM Student Chapter

Women in Mining (WIM) held two meetings this year. The first meeting was a resume workshop with Amanda Reid from Caterpillar. It was a phenomenal experience as members got one-on-one attention to perfect their resumes. WIM’s second meeting was combined with the SME student chapter and brought in a panel to present on the different paths in the mining industry. The student chapter is off to a good start and is looking forward to their future meetings and activities.

Currently there are 8 students involved in the WIM student chapter. We hope to add many more students in the future!
Congratulations to the Mines SME Student Chapter for winning first place in the 2018 SME Outstanding Student Chapter Contest!

The award along with a check for $500 will be presented at the 2019 SME Annual Conference and Expo in Denver, February 24-27, 2019. This contest is held each year among the national and international SME student chapters and is based on an evaluation of the chapters’ activities during the 2017-2018 academic year. We give a big thanks to last year’s SME Officers: Evan McCombs, Tyler Rockley, Kinsley Costner, Carson Eltz, Marie Hetherington, Roland Daniels, Myles Brandt, Nathan Smythe and Christine Peterson, for their contributions.

The Mines Student Chapter has an active program that features bi-weekly dinner meetings with renowned industry executives and outreach programs presented to local middle and high schools, girl and boy scouts and other youth activities. During Fall 2018 semester, the Mines SME student chapter participated in the 2018 Mining Hall of Fame dinner and awards ceremony, the joint SME Colorado Section meeting, the Henderson Sustainability Challenge, the NWM Association annual meeting, the Cross Mine visit and the 2018-19 SME and NSSGA Student Design competition.

The SME 2018-19 Officers are Marie Hetherington (President), Carson Eltz (Vice President), Alexandra Murray (Treasurer), Ashlyn Hohenshelt (Secretary), Indira Gregorio and Dakota Locklear (Mineral Education Coalition Chairs), Stela Cayatte and Leila Mateus (Social Chairs) and Chamir Bello (Campus Relations Chair).

The picture to the left is the SME 2018 Young Leaders. 3rd from the left in the back row is current Mining Engineering PhD student, Benjamin Teschner.

Mining Competition Student Team

The Mining Competition Team had a big year as they competed in the 40th International Mining Games that took place at the Camborne School of Mines in England over Spring Break, March 29-31, 2018. There were teams from 40 mining school from around the world. Teams faced off in seven events: mucking, handsteel, swede saw, trackstand, jack leg, surveying and gold panning.

The Mining Competition Team send six student to compete and spent many hours preparing for the games by practicing on a course they set up at Mines. The games are a valuable way to recognize traditional mining practices.

The Colorado School of Mines co-ed student team consisted of Carson Eltz, Colton Aldridge, Alexandra Murray, Stephen Simmons, Marie Hetherington and Roland Daniels. The co-ed team placed 4th overall in their division.

Mines has been elected to host the International Mining Games in 2020.

Watch the BBC broadcast that showcased this year’s international mining games. https://vimeo.com/262637624
New Programs in Mining Engineering

Launch of the ERDE Program

The Mining Engineering Department is excited to launch a new MS and PhD program in Earth Resources Development Engineering (ERDE) in Fall 2019. We will continue to offer our Mining Engineering graduate degree in its current form for students who want to focus on mine design, project feasibility, and operations.

The department has accumulated information from potential student and our IAC, where we believe that there are many students within the region and globally who are and will be interested in the ERDE degree.

Our new ERDE program will allow us to expand our graduate studies into new and important areas that require interdisciplinary skills and knowledge to address some of the major contemporary challenges that mining operations face.

Students in the ERDE program will have the opportunity to focus on topics such as, social license aspects of mining, artisanal and small-scale mining, new concepts and applications for resource exploration, sustainable development and mining, occupational safety and health, and development and applications of new technologies including robotics, big data, and IOT.

New courses have been or are being developed each semester in these areas, and students entering this program do not need to effectively complete undergraduate mining engineering coursework if they enter with an engineering degree in another discipline.

Launch of the Professional Masters in Mining and Management

The Mining Engineering Department received Board of Trustee approval in February 2018 to launch an innovative new online graduate degree program. The Professional Masters in Mining Engineering and Management (MP-MEM) is an advanced degree that focuses on the practical integration of the technical, financial, management and other linked disciplines that make up the mining industry today.

Successful candidates for the program will have an undergraduate degree in engineering and at least five years of professional experience in the mining sector. Applications are currently being accepted.

Those interested in learning more should visit https://mining.mines.edu/professionalmasters/. Interest and questions can be sent to PM-MEM@mines.edu.

We thank our Professors of Practice, Barbara Filas and Robert Reeves, for their hard work in developing this program as well as their continued efforts as this new program fully launches.

"This is a one-of-a-kind program that wraps the business and management elements into a mining engineering degree that emphasizes where the industry will be in the future instead of where it has been in the past"

- Dr. Priscilla Nelson, Professor and Department Head, Mining Engineering
Edgar Mine Update

It has been quite an exciting year at the Edgar Experimental Mine. We continue to see increased utilization of the facility in classes taught, research projects and training events. The Edgar partners with the State of Colorado to provide realistic underground rescue training for miners from across the United States. Research interest continues to be at a high level and more departments within Mines are utilizing the site for lectures and laboratory to enhance the students educational experience.

We have seen the completion of two research projects and the award of several more. This next year will be filled with setup activities for methane flame propagation testing and Wi-Fi networks underground. Both projects will enhance understanding and work towards solutions to complex issues faces in underground environments. Researchers from Colorado State University have also used the Edgar facility to complete testing of respirable dust particulate sampling underground. Their findings will be presented at the 2019 SME annual meeting.

Petroleum, Geology and Mining continue to host classes and laboratory events for students at the facility. This next year we will be including Geo-Physics as well. Work is underway to construct a flow-loop project which is a joint venture between the Petroleum Engineering and the Geo-Physics departments. This flow-loop will study pressure and flow as well as micro-seismic events as simulated in a petroleum well.

In July 2018, Edgar Mine Superintendent Clint Dattel, with the assistance of several students, hosted 23 students and 2 faculty members from China University of Mining and Technology at the Edgar. The week consisted of training and hands-on experience in: drilling, bolting, mucking, tramming and core drilling. This event helps make our educational reach worldwide. Professor Zhang of CUMT said, "The three-week summer program at Mines was a unique experience for both our students and faculty. They are very happy with the MSHA miners safety training, hands-on experiences in Edgar Mine as well as lectures by Mines professors. I thank you and your colleagues for all the hard work put in developing the program."

We are looking forward to another year of improvements, education and training here at the Edgar Experimental Mine.

Scholarships and Fellowships

We continue to support our students through scholarships and fellowships. We are thankful for the generous contributions from our partners that make these awards possible. The following scholarships were awarded:

EMCIS Update

The EMCIS program within the Mining Engineering Department completed the first year of the 3-year, $1.445 Million grant from CDC NIOSH Mining in support of its continuing efforts to enhance the quality and availability of health and safety training for Western mine workers. The grant PI is Hugh Miller and the Co-PI is Michelle Reiher. The primary goals of the grant include providing workers with relevant knowledge regarding the hazards associated with working at mine sites and effective controls for reducing risk for injuries and illnesses.

As part of this effort, a comprehensive approach to meeting the safety and health training needs of the Western mining industry will be employed by providing a high quality, interactive training experience that targets several audiences, including: mine workers, trainers, safety and health professionals, mine management, and mining engineering and geology students. In addition, this training program is designed to service underrepresented industry sectors such as contractors, consultants, suppliers and equipment manufacturers. This approach strongly encourages trainees to become active participants and take ownership in improving the health and safety conditions where they work. Over the past year EMCIS has reinvigorated the Part 48 training by updating the training materials to include new interactive activities, games and presentations.

Additional initiatives also include fostering relationships with the OSHA Rocky Mountain Education Resource Center, a part of Red Rocks Community College, and continuing discussions with the International Union of Operating Engineers concerning a training program.

Earth Mechanics Institute (EMI) Update

EMI has been fairly busy in 2018. Along The year started with being selected as the recipient of one of the NASA Early Stage Innovation (ESI) grants. This grant is for ~$500k and will last for two years. It is focused on material characterization while drilling on the Moon and Mars. The PI of the project is Dr. Rostami and the Co-PIs include Dr. Chris Dreyer of The Center for Space Resources and Dr. Bill Eustes of Petroleum Engineering. As part of this project, a Robodrill has been designed and fabricated and is ready to drill into various formations, including frozen lunar regolith simulants.

Another interesting project was the work for Tennessee Valley Authority (TVA) on a full-scale cutting test of hard limestone to evaluate the possibility of excavating this formation on the embankment of Boone Dam in Tennessee. The testing involved measuring rock mechanics properties of the samples and casting and performing linear cutting tests in the samples using a conical tool as well as a strawberry style cutter with tungsten carbide inserts.

We are waiting for some samples from a silver mine in Mexico to perform full-scale cutting tests on ore and host rock formations, as part of assessing the performance of a new underground mine development machine for The Robbins Co. This unit will be able to excavate rectangular shape drifts in hard rock formations for the designated mine. Moreover, initial discussions and meetings have been held with De Beers to work on the development of new excavation units for mining in Kimberlite.

The lab space inside and outside EMI has also seen some interesting activities. We have set up a small 7x14 ft (2x4m) test bed containing lunar regolith simulants for trying various rovers and pieces of equipment that are destined to work on Lunar soil. On EMI’s north pad, a team of students from various departments are working on a large 3D concrete printer to make lunar habitats with sizes of 10x10x8 ft (3x3x2.5m) using concrete as the building material or ultimately, a mix made of Lunar or Martian regolith and a suitable resin. The test bed and 3D printer are the ongoing collaborations with Center for Space Resources on campus. We are also waiting on the delivery of a new drill hammer from Epiroc to enhance and update the percussive drill/driver at EMI. The new COP 1240 hammer will be used on several upcoming projects at EMI that requires percussive drilling capabilities. The donation of the hammer was made possible through support of Mr. Shawn Cheney of Epiroc who is a member of EMI Industrial Advisory Committee (IAC) and Jess Kindler, president of Epiroc, who are both CSM alums.
AXPRO Update

Dr. Petr and his Advanced Explosive Processing Research Group (AXPRO) have had a very successful 2018, and we are pleased to share some of our activities and accomplishments. Our biannual Practical Explosives Training School (PETS) short course is expanding its focus towards different industries, and we will begin two new explosives training courses with Freeport-McMoRan’s Henderson Mine, the National Forest Service, and the Washington Department of Labor and Industries. This development illustrates the expanding need for explosives safety and regulations training in a growing explosives engineering industry, which AXPRO is excited to accommodate. Additionally, we have continued to teach courses for both degree-seeking and continuing-education students with our High-Speed Research and Experimentation (HSI), Flash X-Ray and Ultra-High-Speed Imaging Methods for Research and Experimentation (XUHSI), and Special Use of Explosives courses. For these courses, AXPRO has worked with the Missouri University of Science and Technology (Missouri S&T) and developed a long-distance learning program for Missouri S&T graduate students in the Explosives Engineering program. Additionally, we will be offering a numerical modeling course for Missouri S&T students in Summer 2019. This Summer 2018, AXPRO was proud to celebrate our 10-year anniversary of collaboration with the Colorado Department of Transportation (CDOT) on educating CDOT employees in avalanche mitigation methods with explosives. AXPRO also continues to work with CDOT and the Transportation Avalanche Research Pool (TARP) on conducting cutting-edge research on new explosives technologies for avalanche mitigation worldwide.

We are also eager to share the progress of our new graduate program in Materials Science, the Materials Science Graduate Program with emphasis in Energetic Materials (Explosives). Professional students are currently being recruited from U.S. National Laboratories, government agencies, and private-sector companies. The program is continuing to grow, and we expect new student enrollment in the next semesters. For more information regarding AXPRO activities, please visit our AXPRO website at http://axpro.mines.edu/.

University of Leoben and Colorado School of Mines Dual Degree Signing

In December 2018, Mines approved dual Master’s degree program with Montanuniversität in Leoben, Austria, in the Mining and Petroleum Engineering departments. Leoben has strong programs in both fields, and students who join the dual degree program will have the opportunity to complete a Masters’s degree at Colorado School of Mines and at Leoben.

Students will complete two semesters of graduate courses at Mines and then go to Leoben where they will complete another semester of coursework followed by a Master’s thesis.

The Mines and Leoben programs complement each other well and we expect it to become a viable program over the coming years.
The Henderson Mine, which is owned and operated by Climax Molybdenum Company (CMC), a wholly owned subsidiary of Freeport McMoRan, Inc. (FMI) is located in Clear Creek County, 9 miles west of Empire, Colorado on the east side of the Continental Divide. Freeport-McMoRan has ongoing planning efforts for the eventual closure of Henderson. There is significant infrastructure at both the mine and mill that could be repurposed. The mine-impacted water could be beneficially reused instead of treated and discharged to a surface water body. Freeport McMoRan came to Mines in January 2018 to engage multidisciplinary and diverse teams of students in a design competition. The students were charged to imagine out of the box concepts for the repurposing of the Henderson Mine surface infrastructure and land area. This first competition would be focused on the surface land and facilities east of the continental divide.

The competition started on campus August 25th at a day-long “hackathon” meeting that included nearly 150 people and ultimately 24 Mines student teams pitched concepts for the sustainable repurposing of the mine’s surface facilities and properties. The students’ initial proposals included everything from resorts, education and recreation to business development, data centers and ecological enhancement – all responsive to the charge that they “Develop a concept for sustainable repurposing of the Henderson Mine surface facilities and land holdings that provides a socioeconomic benefit to the surrounding communities, is economically sustainable, socially acceptable and provides a positive and lasting legacy in the state of Colorado.”

The final phase of the competition happened on campus on the morning of December 7th, “dead day” before final exams. The 1st place team won $25,000; 2nd place won $15,000 and 3rd place won $10,000. Due to the immense student effort, Freeport McMoRan decided before they announced the winners that each student on the 4th and 5th place team would receive $500. The winners of the Henderson Challenge were:

1st Place: Mo Data
2nd Place: H.E.A.T.
3rd Place: Composting & Mushroom Farm

The premise of the Summit was that maximizing sustainable mine closure outcomes requires a business-connected approach that takes full advantage of ongoing human and economic occupation of former mine sites. The keynote talk was by Dana Crawford and Mary Jane Lovelie – all about the Argo Mill and the involvement of developers in mining repurposing. Panels provided industry and regulatory agency perspectives on repurposing, and breakout discussion activities generated input that Mines will use in developing a framework for mine planning decisions that can take many mining projects “Beyond Closure.”

Find out more about the Mines Summits past and future at https://mining.mines.edu/mine-summit/.
### Ongoing Research Grants Awarded to Faculty

<table>
<thead>
<tr>
<th>Project Title</th>
<th>Amount</th>
<th>PI or CoPI from MN</th>
<th>Sponsor</th>
<th>Project Dates</th>
</tr>
</thead>
<tbody>
<tr>
<td>UICRC: Pre-proposal Phase II Renewal Colorado School of Mines: Center for Manufacturing &amp; Materials Joining Innovation Center (Ma2JIC)</td>
<td>$100,000</td>
<td>Vilem Petr</td>
<td>National Science Foundation - NSF</td>
<td>8/15/2018-7/31/2020</td>
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<tr>
<td>CAREER: Did Carlin Gold Come from Magmas</td>
<td>$211,363</td>
<td>Elizabeth Holley</td>
<td>National Science Foundation - NSF</td>
<td>2/1/2018-1/31/2023</td>
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<td>PIRE: Sustainable Communities &amp; Gold Supply Chains: Integrating Responsible Engineering &amp; Local Knowledge to Design, Implement &amp; Evaluate Sustainable Artisanal Mining in Latin America</td>
<td>$4,000,000</td>
<td>Nicole Smith</td>
<td>National Science Foundation - NSF</td>
<td>1/1/2018-12/31/2022</td>
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<tr>
<td>Explosive Safety Training with Colorado School of Mines</td>
<td>$51,277.02</td>
<td>Vilem Petr</td>
<td>CDOT</td>
<td>6/24/2018-6/23/2019</td>
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<tr>
<td>Material Characterization while Drilling on Lunar/Martian Surface</td>
<td>$199,676</td>
<td>Jamal Rostami</td>
<td>NASA</td>
<td>1/15/2018-1/14/2021</td>
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<tr>
<td>Development of an Integrated Approach to Stress-Related Ground Hazards in Underground Mines</td>
<td>$249,239</td>
<td>Elizabeth Holley</td>
<td>CDC</td>
<td>9/15/2018-9/14/2019</td>
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<td>Henderson Sustainability Challenge</td>
<td>$150,000</td>
<td>Priscilla Nelson</td>
<td>Freeport McMoran &amp; Climax Molybdenum</td>
<td>6/1/2018-1/30/2019</td>
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<tbody>
<tr>
<td>University Transportation Center for Underground Transportation Infrastructure (UTC-UTI)</td>
<td>$1,402,200</td>
<td>Priscilla Nelson</td>
<td>Department of Transportation</td>
<td>11/30/2016-9/30/2022</td>
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<td>University Transportation Center for Underground Transportation Infrastructure (UTC-UTI)</td>
<td>$1,416,900</td>
<td>Priscilla Nelson</td>
<td>Department of Transportation</td>
<td>10/11/2017-9/30/2022</td>
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<tr>
<td>Hybrid Numerical Simulations of Microstructure Effects and Stress State During Hydraulic Fracture Propagation</td>
<td>$110,000</td>
<td>Kennie Kaunda</td>
<td>American Chemical Society</td>
<td>9/1/2017-8/31/2019</td>
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<td>Enhanced Safety and Health Training for Western Mine Workers</td>
<td>$482,000</td>
<td>Hugh Miller</td>
<td>National Institute for Occupational Safety and Health</td>
<td>9/1/2017-8/31/2019</td>
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<td>Analysis and Optimization of the Use of O’BellX® Avalanche Control System</td>
<td>$170,000</td>
<td>Vilem Petr</td>
<td>CDOT</td>
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<td>Characterization of Pressure Wave Cleaning Technology for Boiler and HRSG Applications</td>
<td>$134,289</td>
<td>Vilem Petr</td>
<td>Electric Power Research Institute</td>
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<td>Explosive Safety Training with Colorado School of Mines</td>
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<td>Material Characterization while Drilling on Lunar/Martian Surface</td>
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<td>Development of an Integrated Approach to Stress-Related Ground Hazards in Underground Mines</td>
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<td>Elizabeth Holley</td>
<td>CDC</td>
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