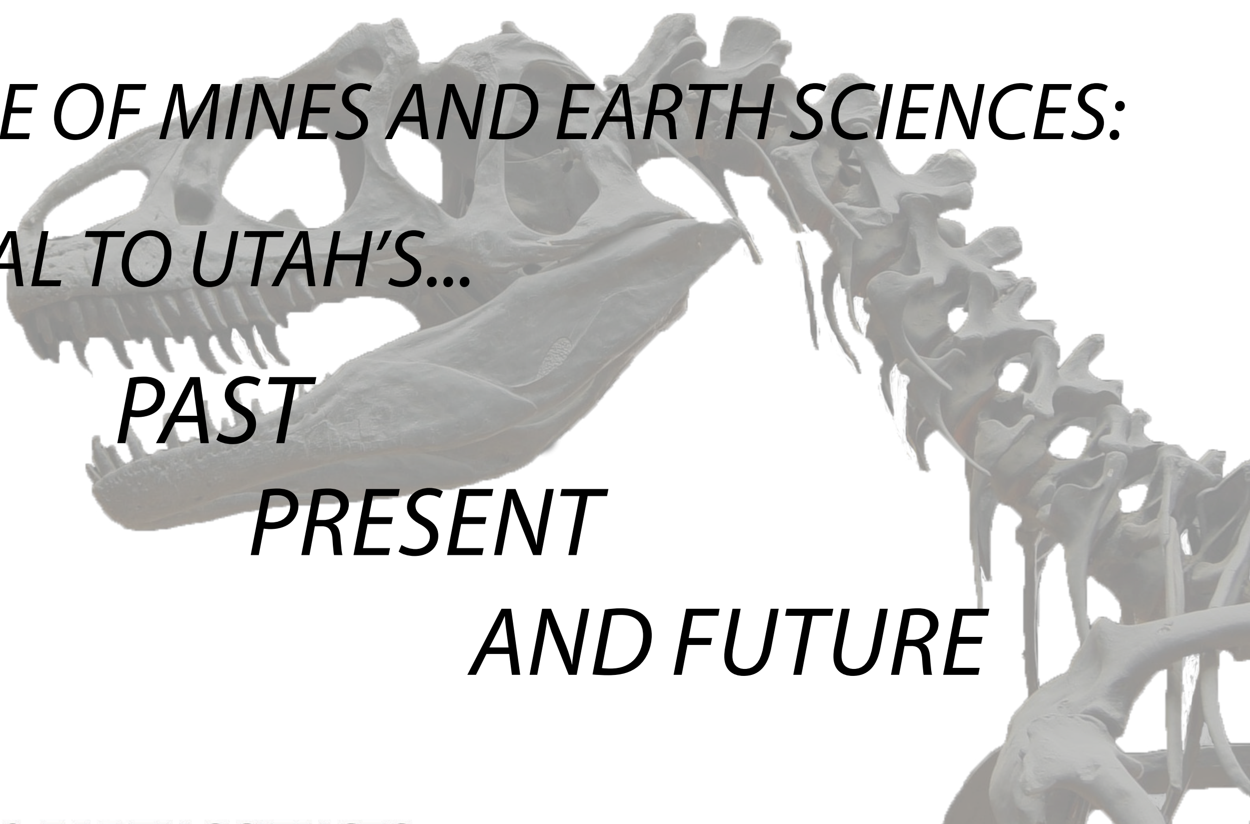
W H A T   O N

FALL 2022

EARTH

A PUBLICATION OF THE COLLEGE OF MINES & EARTH SCIENCES AT THE UNIVERSITY OF UTAH



COLLEGE OF MINES AND EARTH SCIENCES:

INTEGRAL TO UTAH'S...

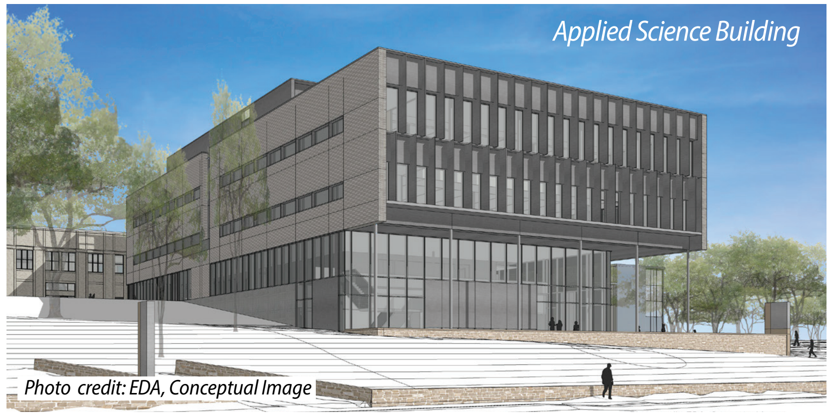
PAST

PRESENT

AND FUTURE

College of
MINES & EARTH SCIENCES
THE UNIVERSITY OF UTAH

Message from the Dean



Hello family and friends of the College of Mines and Earth Sciences (CMES). As we start our 2023 academic year, we are excited to be in the midst of a lot of change at the University, starting with a new President and a vision to move the University to a top 10 public institution. Equally important, there is a strong emphasis on community engagement and innovative approaches for enhancing student success from our new leadership.

With roots dating to the middle of the 19th Century, CMES has always been central to supporting the economic and environmental needs of Utah as well as serving as an important contributor to understanding Utah's geologic history. While the name of the "School of Mines" and its structure has changed many times in the last 125+ years, our mission, collaborative values, and commitments to our stakeholders and the state of Utah have not wavered (https://cmes.utah.edu/about/mission.php).

In this volume of What on Earth (WOE), you will learn about some of the important Utah-centric research that our faculty, staff, and students are currently engaged in, including efforts to understand the possible effects of climate change on our unique ecosystems, as well a new state-wide effort to develop innovative methods for producing critical raw materials from coal byproducts.

You will also learn about an important structural change that will align CMES with the College of Science. Interdisciplinary collaboration is increasingly essential as the problems we are tackling are not shrinking in their complexity. While the college will remain fully intact in name and structure, we are in the very early phase of merging our two great colleges into what will be a stronger, highly synergistic unit that will be better positioned to meet the goals of President Randall and address twenty-first century challenges associated with health, climate, resources, and workforce needs.

It is an incredibly exciting time for the merged college and we are already seeing the value of working together. We anticipate breaking ground soon on a new 140,000 square foot Applied Science Building, that will impact the education of thousands of students and will also be the home to our Departments of Atmospheric Sciences and Physics and Astronomy. Thanks to a generous donation from Clay and Marie Wilkes, the building will also house the new Wilkes Center for Climate Science and Policy. This year has also been one of our most successful years for hiring faculty as we will see at least seven new Assistant Professors join us between July 1, 2022 and 2023. You can read about some of these new hires in this issue of WOE, as well as many other stories about the innovative work and accolades of our incredible faculty, staff, and students in CMES.

As, always, if you are in the neighborhood, please stop by. We always love to hear from you. Here's to a healthy and productive 2023 academic year! -*Dean Darryl Butt*

CMES LEADERSHIP

Darryl Butt	Dean
Sivaraman Guruswamy	Associate Dean of Academics
Rajive Ganguli	Associate Dean for Assessment
TJ McMullin	Development Director
Keith Koper	Director, U of U Seismograph Stations
Brenda Bowen	Director, Global Change & Sustainability Center
Michelle Tuitupou	Director, Student Success
John Horel	Chair, Atmospheric Sciences
Bill Johnson	Chair, Geology & Geophysics
Tonie van Dam	Associate Chair, Geology & Geophysics
Michael Free	Chair, Materials Science & Engineering
Dmitry Bedrov	Associate Chair, Materials Science & Engineering
Charles Kocsis	Chair, Mining Engineering

COLLEGE OF MINES AND EARTH SCIENCES

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ON THE COVER: *This years magazine focuses on the history of the College of Mines and Earth Sciences. From the back of the magazine to the front, you can see the timeline of our past transition to current lab techniques, excavation, and architecture.*

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How 3D Modeling Helped U Geologists Teach During the Pandemic

By Paul Gabrielsen, science writer, Marketing & Communications

Photo credit: Kathleen Ritterbush

Geoscience is a three-dimensional discipline. So 3D modeling, in the form of virtual and 3D printed real-world models, has found a home in the Department of Geology and Geophysics. During the COVID-19 pandemic, geology and geophysics instructors expanded their 3D modeling efforts to continue to provide students a hands-on experience, while minimizing the number of hands on any one object.

Sarah Lambart – Modeling rocks and minerals

Students of mineralogy and petrology traditionally learn to identify minerals and rock textures using hand samples and thin sections viewed through microscopes. For classes during the pandemic, both undergraduate and graduate students from the department worked on the development of a virtual library of rock, mineral, and fossil hand samples on Sketchfab, a 3D modeling platform.

In 2020–21, four classes used the digital library, in what assistant professor Sarah Lambart calls an "initial exploratory effort," that was partially funded by an internal University Teaching Grant. Instructors improved the scale and resolution of the library and are now working to redesign laboratory assignments around the digital models. "In particular," Lambart says, "we plan to couple the 3D models with images of petrographic (microscopic) thin sections from the same samples to provide multi-scale resources for these classes."

Future high-resolution additions to the collection will include samples from Utah with detailed petrographic, geochemical, and stratigraphic information. "We want to highlight Utah samples that students can relate to from places they commonly visit," Lambart says.

> *"The future is now, and if we can imagine it we can do it. There's no reason to grasp at straws for teaching — in person or online. We have the tools to put these specimens — animals, bones, rocks, etc. — directly in our students' hands."*

Jeff Moore – Modeling arches

It's hard to wrap a tape measure around a massive natural arch. That's why associate professor Jeff Moore and his research team use 3D modeling instead to capture the geometry and structure of arches and other rock formations. "We typically use drones to capture images of all angles of these features, then 3D modeling software to generate the geometries," he says. "We post these on Sketchfab, which helps us to be able to fly around each landform and look at it from all angles, as well as to share publicly. "The models have phenomenal scientific value and are relatively easy and inexpensive to produce.

The arch models have come in handy for outreach events. 3D printed versions give people a chance to touch and interact with a feature, Moore says, and during the COVID-19 pandemic the researchers have shared the virtual models with colleagues and students. It's a way for people all around the world to experience Utah's redrock landscape.

"Kids love the VR experience," Moore says. "They always giggle and holler at the sensation of heights they get when exploring 3D arch models."

Kathleen Ritterbush – Modeling anatomy

Associate professor Kathleen Ritterbush is a hands-on learner, and brings tactile experiences to her paleontology classes, whether it's a small class in a room with real fossils or an auditorium-style lecture hall with packs of toy dinosaurs. "I brought in 3D-printed bones to pass around, including skulls so the students could feel the different kinds of holes in the heads," she says. "But I wanted to do more."

So, Ritterbush designed and produced 3D-printed

Photo credit: Jeff Moore

models of animals, both dinosaurs and non-dinosaurs, with a range of hip and ankle conditions to teach anatomy. "You know how it looks like birds' knees are backwards? That's not a knee! It's an ANKLE!" she says — a concept difficult to convey on a 2D chalkboard or PowerPoint slide. The models come in two versions — one fully fleshed out and one showing the leg bone structure.

When COVID-19 precipitated a sudden move to online classes, Ritterbush commissioned 3D-printed skulls of Allosaurus, Utahceratops, wolf, and owl in durable resin for each student to keep, and used her custom hip-and-ankle models in "Café Dino" discussions, informal outdoor teaching sessions. "I also use the models when I Zoom, either recording explainers for my students or chatting with them about fossils live," she says. "People just learn differently with physical objects, even if they aren't holding it."

In 2022–23, with the World of Dinosaurs course continuing to be offered online, Ritterbush plans to continue providing skulls for students, as well as using her teaching models in Café Dino sessions and in the Evolving Earth course. "People love the models. They are silly, lifelike, evocative and fun," she says. "The future is now, and if we can imagine it we can do it. There's no reason to grasp at straws for teaching — in person or online. We have the tools to put these specimens — animals, bones, rocks, etc. — directly in our students' hands."

CMES 3600: Gender and Contemporary Issues in Mines and Earth Sciences

This class introduces students to foundational concepts and themes in the interdisciplinary field of gender studies, with a focus on contemporary issues at the personal, interpersonal, and institutional levels. The second half of the semester turns the Gender Studies lens to the fields of study and professional practice in the College of Mines & Earth Sciences. The focus of this course is on the social construct of gender and its applications to fields of study and professional practice in the College of Mines & Earth Sciences. It will also provide a framework for students to consider other aspects of identity (e.g., race, class, ability…) and their relevance to the fields of study and professional practice in the college.

CMES 2010: Energy & Society — Interdisciplinary Perspective

Energy moves through all of Earth's systems. Ancient solar energy is stored in geologic reserves. Plants convert sunlight to sugars, providing the basis for how energy moves through organisms as food. The human legacy on Earth is intertwined with both these energy sources, which we leveraged to generate stunning technological advances while also creating some of the most pressing environmental and humanitarian issues ever faced. This course promotes an understanding of where energy comes from, how it is used in human society, and the benefits and trade-offs to different types of energy production — cross-cutting concepts important to informed citizens in the 21st century.

Undergraduate Research Symposium

By Jake Luman, assistant editor

Photo credit: Morgan Leigh

Making Electric Car Batteries Last Longer

Materials science and engineering student **Erick Lawrence** worked with local startup company Storagenergy Technologies to research the factors that contribute to batteries' energy density and longevity. As battery technology develops and electric engines become increasingly viable for use in vehicles, the greatest challenge is increasing energy capacity without shortening the batteries' lifespan. To meet these challenges, Lawrence and Storagenergy experimented with the effects of battery binder grade and pressure density. "By densifying our cathodes and varying the binder grade," says Lawrence, "we were able to demonstrate small-scale long-term cyclability and energy densities far in excess of what internal combustion engines are capable of." Future work could demonstrate the effectiveness of these techniques on the battery scale used in electric vehicles and planes.

Protecting Teeth Using Metallurgy

When you hear "earth sciences," you might not think about the materials dentists put on your teeth — but metallurgical and materials research impacts almost every aspect of our lives. Metallurgical engineering student **Jenna Young** worked with adjunct associate professor of metallurgical engineering Krista Carlson and the department of biomedical engineering to research more durable alternatives to the material dentists use in pulp caps, which protect exposed pulp tissue and help tooth regrowth. Her work focused on isolating the factors that cause variability in a promising sodium silicate/calcium phosphate glass material, to more consistently reduce setting time on patients. "My experience with the pulp cap project was my first exposure to biomedical research, and it helped me gain interest in pursuing a career in the area," says Young.

Studying Ancient Volcanic Landscapes

Geology & geophysics student **Mallory Scofield**, alongside U professor of geology & geophysics Cari Johnson and Salt Lake Community College professor of geology Matthew Affolter, examined volcanic sands at a mineral level to understand the history of ancient landscapes. By studying volcanic lithic fragments (rocks eroded to the size of sand grains) under a microscope, the team hoped to establish correlations between lithic fragment traits and their volcanic origin. The results show promising trends, helping to direct future research. "My experience with this project allowed me to connect lectures from various courses and apply that knowledge in the real world," says Scofield. "It makes a huge difference seeing the processes in the field and I would strongly encourage all students to look for a UROP opportunity!"

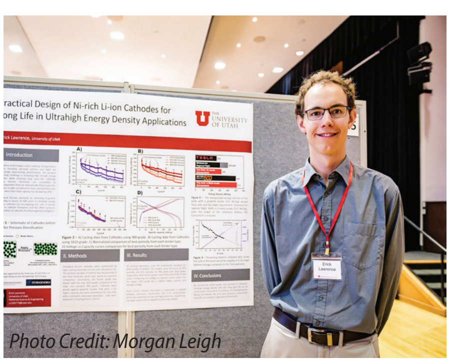


Photo Credit: Morgan Leigh

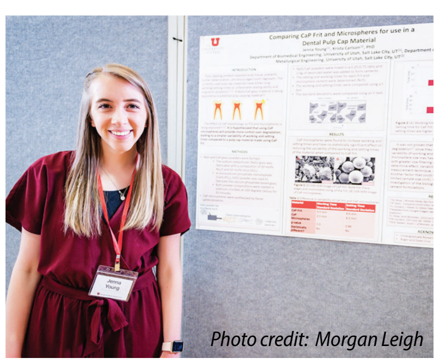


Photo credit: Morgan Leigh

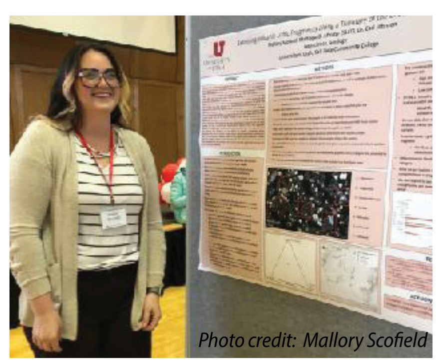


Photo credit: Mallory Scofield

Student Mapping Course in Copper Flats, New Mexico

Much of the Southwestern United States is dotted with porphyry copper deposits — large-volume copper ore bodies formed by processes involving magma chambers deep beneath the ore. This includes Utah, with the famous, massive open-pit Kennecott Copper Mine in the Oquirrh mountains, which has produced more copper than any other mine in U.S. history. Students interested in practicing their field mapping skills and in understanding the geologic processes that formed these deposits can apply to the Michael J. Fitzgerald Student Mapping Course, offered through the Society of Economic Geologists (SEG). This intercollegiate one-week intensive field course takes students to the Copper Flat porphyry-breccia system in New Mexico, where they study the site and practice field mapping with permission from THEMAC Resources, which operates the mine. Students are guided by a team of "SEG members who are senior in their career and have recognized expertise in the geology of the areas covered," according to SEG's website, including professor emeritus of geology and geophysics and adjunct professor of mining engineering Erich Petersen from the University of Utah.


Photo credit: Erich Petersen

This trip is supported by a generous donation from the trust of Michael J. Fitzgerald to support field-based geologic studies by students. The course most recently ran this summer from May 6–14, 2022, and will be offered again in the coming fall semester from October 22–30, 2022. Interested students who are active SEG Student Members and who have completed at least one field mapping course can apply through the society's website at www.segweb.org. *-Jake Luman*

GEO: 4500 Field Methods

Want to get some hands-on experience with geology? This spring, take education outside with Field Methods, a class that offers practical field skills applicable to geological, geoengineering, and environmental studies developed through weekly field exercises in the Wasatch Front area. Students learn firsthand how to conduct field research; they present their results orally in class and in written reports targeted to a variety of potential users, including professional colleagues, government agencies, and the general public. GEO 4500 is offered every spring semester.


Photo credit: Brenda Bowen

Bringing Ancient Animals Back to Life

In a university swimming pool, assistant professor and research associate professor of geology & geophysics Kathleen Ritterbush and David Peterman watch carefully as a 3D-printed coiled shell of an ammonite is released from a pair of metal tongs. The shell begins to move under its own power, giving the researchers a glimpse into what the oceans might have looked like millions of years ago when they were full of these ubiquitous animals.

The robotic ammonites allowed the researchers to explore questions about how shell shapes affected swimming ability. They found trade-offs between stability in the water and maneuverability, suggesting that the evolution of ammonite shells explored different designs for different advantages rather than converged toward a single best design.

"These results reiterate that there is no single optimum shell shape," says Peterman. *-Paul Gabrielsen*

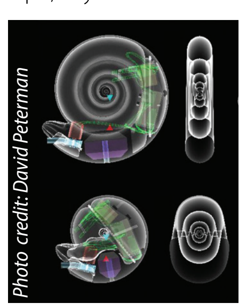


Photo credit: David Peterman


Photo credit: David Peterman

Outstanding Teaching Assistant Award — Emily Cunningham

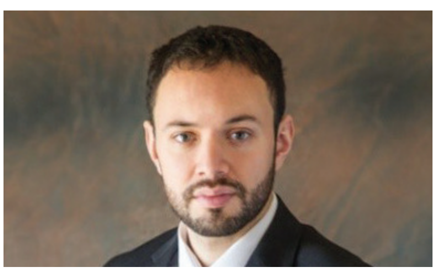
Emily Cunningham received the 2022 CMES Outstanding Teaching Assistant Award. This award honors the teaching and educational service of one graduate student each year in the College and is considered one of the highest CMES honors. Emily joined the U as a geology & geophysics Ph.D. candidate in 2021. She was nominated by multiple students for her exceptional work as a TA for Mineralogy, teaching the beginning of the course herself. Emily is also a recipient of the 2022–23 Schlanger Ocean Drilling Fellowship, a merit-based fellowship to conduct research in the International Ocean Discovery Program.

Valedictorian — Annika Edwards

Annika Edwards, a mining engineering graduate, was the 2022 CMES valedictorian. Her outstanding scholastic achievements are exemplified by the numerous merit scholarships and awards she received throughout her undergraduate career. She received the department's Outstanding Academic Award three years in a row and is the 2022 recipient of the Oblad Silver Medal of Excellence award. Beyond her academic success, Annika has played an active role in the college, serving as a CMES Student Ambassador and as Secretary for the SME Student Chapter. Annika, who was in Greenland with Dr. Rajive Ganguli during graduation, delivered her speech virtually.

Outstanding Undergraduate Research Award — Alex Dzubay

Alex Dzubay is a recipient of the 2022 Outstanding Undergraduate Research Award. The award recognizes one undergraduate student from each college to celebrate the impactful and diverse research performed at every level at the U. Alex, who graduated in geology & geophysics with honors, was nominated by mentors Dr. Jeff Moore and Dr. Kristine Pankow. Alex's research has focused on using seismic tools to measure the resonant frequencies of rock formations in Utah. This work provides a better understanding of the interior structure and stability of rock formations, as well as the impact of nearby human activity.



NAGT Outstanding Teaching Assistant Award — Kevin Mendoza

Kevin Mendoza, a Ph.D candidate in geology & geophysics, is a 2022 recipient of the National Association of Geoscience Teachers (NAGT) Outstanding Teaching Assistant Award. NAGT recognizes up to 30 undergraduate and graduate teaching assistants in geoscience education across the country each year. The award honors dedicated and innovative teaching contributions in the field and includes a one-year membership in the prestigious association. Kevin, who was the 2021 recipient of the CMES Outstanding Teaching Assistant Award, is the first student from Utah to be recognized by NAGT.

DOE Graduate Student Fellowship — Collin Anderson

Collin Anderson, a Ph.D. candidate in materials science & engineering, was awarded a prestigious three-year fellowship from the Department of Energy's Office of Nuclear Energy (DOE-NE) as part of the University Nuclear Leadership Program (UNLP). UNLP is supporting students across the country pursuing nuclear energy-related disciplines to help the U.S. meet the ambitious goal of 100% clean energy by 2035. Collin was selected for his work developing new, simple methods for recycling spent nuclear fuel. UNLP graduate fellows will receive $52,000 a year to fund their research, as well as a funded internship at a DOE national laboratory.

CLAS Tinker Field Research Grant — Santiago Jurado

Santiago Jurado received the Center for Latin American Studies (CLAS) Tinker Field Research Grant for 2021. The grant provides funding to U graduate students for travel and field-related expenses to support innovative and critical research performed in Latin America; it is supported by the Tinker Foundation and by generous donations from the Ed Espetin Endowed Fund. Santiago is a Ph.D. candidate in geology & geophysics; his research topic for the grant is "Contaminant Removal and Precious Metal Recovery by Lateral Channel Filtration in Mining-Impacted Rivers." CLAS wrote that they were "impressed with [his] innovative topic."

Rosenblatt Prize for Excellence — Thure Cerling

Dr. Thure Cerling, Francis H. Brown Presidential Chair, distinguished professor of geology & geophysics, distinguished professor of biology, and former department chair of the Department of Geology & Geophysics is the 2022 recipient of the Rosenblatt Prize for Excellence. The Rosenblatt Prize is the University of Utah's highest faculty accolade and is presented annually to a faculty member who transcends ordinary teaching, research and administrative efforts. "Dr. Cerling has made important and impactful contributions to science using isotope geochemistry to learn about natural processes," said Taylor Randall, president of the University of Utah.

Distinguished Researcher Award, Francis Brown Presidential Endowed Chair — Kip Solomon

Dr. Kip Solomon, professor of geology & geophysics, was the 2021–22 recipient of the U's Distinguished Research Award. The award recognizes outstanding achievements in research, evaluated on the impact of their work on their field. Dr. Solomon has also been approved by president Taylor Randall to be the next Francis Brown Presidential Endowed Chair. This prestigious position is one of the most meaningful at the University of Utah. Needless to say, Solomon will have a great Impact on many and carry on a fantastic legacy of impact at the University of Utah.

AAPG Grover E Murray Memorial Distinguished Educator Award — Marjorie Chan

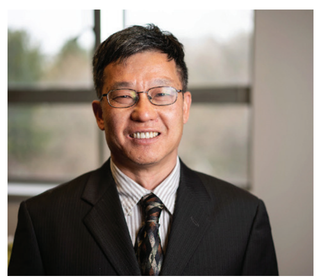
Dr. Marjorie Chan, distinguished professor of geology & geophysics, received the 2022 American Association of Petroleum Geologists (AAPG) Grover E. Murray Memorial Distinguished Educator Award. One award is given by the association each year in recognition of distinguished and outstanding contributions to geological education, including exceptional teaching and counseling of future geoscientists at the university level as well as contributions to the education of the public. Chain served as department chair from 2002–2007 and oversaw the construction of the award-winning Frederick Albert Sutton building.

SEPM Dickinson Medal — Cari Johnson

Dr. Cari Johnson, professor of geology & geophysics, was the 2021 recipient of the Society for Sedimentary Geology (SEPM) Dickinson Medal Award. This award recognizes excellence in geoscience research, with significant contributions to the field through innovative and pioneering work and impactful publications in the field. The award was named after influential sedimentary geologist William R. Dickinson.

Outstanding Research Award — Jeff Johnson

Dr. Jeffrey Johnson, associate professor of mining engineering, received the 2022 Outstanding Teaching Award. This student-driven award is considered the highest teaching honor in the College of Mines and Earth Sciences. One student stated, "Dr. Johnson is outgoing and enthusiastic about what he teaches. His enthusiasm is contagious, which has helped me learn the material, not just memorize for a test, and enjoy the subjects he teaches.



Distinguished Professor of MSE — Feng Liu

Dr. Feng Liu, Ivan B. Cutler professor of materials science and engineering, has been named a distinguished professor. The title of Distinguished Professor is a prestigious honor granted to faculty who meet the highest standards of scholarship, international stature, and dedication to teaching and service. Liu served as department chair of MSE from 2011–2019.

NOAA Science Advisory Board — Zhaoxia Pu

Dr. Zhaoxia Pu, professor of atmospheric sciences, was selected by the National Oceanic and Atmospheric Administration (NOAA) to join their Science Advisory Board. Pu is one of four university professors nationwide newly selected for the board. The Science Advisory Board comprises 15 members with balanced representation among preeminent scientists, engineers, educators and science policy experts.

Photo credit: Lauren Birgenheier

U Researchers to Study Potential of Uinta Basin with 1.5M Grant

By Paul Gabrielsen, science writer, Marketing & Communications

The United States Department of Energy has awarded the University of Utah $1.5 million to study the potential of transforming coal-associated mineral resources in Utah and western Colorado's Uinta Basin region into high-value metal, mineral, and non-fuel carbon-based products. Coal has historically been used for combustion and energy generation but may additionally host critical minerals and rare earth elements that have been overlooked and are valuable non-fuel products in our modern society.

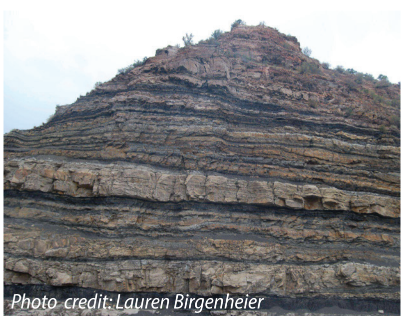


Photo credit: Lauren Birgenheier

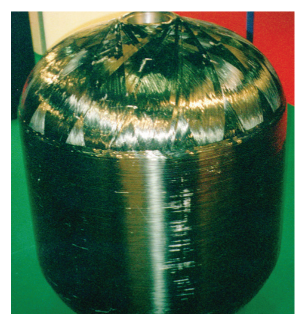
The award is part of a $19 million initiative, with awards to 13 projects across the country, aimed at developing domestic production of rare earth elements and other critical minerals as well as important advanced materials such as carbon fiber and polymers.

The project includes 25 organizations and 30 team members and is led by Michael Free, chair of the Materials Science & Engineering department. The geology portion of the project is led by Lauren Birgenheier, associate professor of geology and geophysics. Other portions of the project are led by Prashant Sarswat, research associate professor of materials science and engineering, Tulinda Larsen, executive director of the Utah Advanced Materials and Manufacturing Initiative (UAMMI), and Jim Patten, JWP Consulting, LLC.

"This project is designed to help make the transformation of resources into valued products, and in the process diversify the economic base of the region and expand job opportunities while simultaneously supplying our country with critical resources," Free says.

Many modern technologies, including clean energy technologies, depend on rare earth elements and critical minerals to comprise batteries, magnets, solar panels, and other components. The United States currently imports most of these rare earth elements and critical minerals, leaving the supply chain vulnerable to natural and political disruptions.

"Rare earth elements and critical minerals are needed to build and run our cell phones, computers, and cars," Free says. "Carbon fiber composites are needed in a variety of products and industries, and particularly in the aerospace industry. Polymers are used in nearly everything we use."



"Importantly," Birgenheier adds, "rare earth elements and critical minerals are used in many renewable energy technologies. As such, the project is part of an innovative energy transition that is already underway."

According to the Department of Energy, the U's project will "quantify, assess, and plan to enable the transformation of Uinta Basin earth resources such as coal, oil shale, resin, rare earth elements and critical materials into high value metal, mineral and carbon-based products that can be used in advanced products such as carbon fiber composites in aircraft and high-powered magnets and batteries in electric vehicles."

U researchers will better characterize the geologic resources in the basin and develop improved technologies for transforming the raw materials into commercially viable products. Free says that producing these materials and minerals in the Uinta Basin will help diversify the demand for them as the need for fossil fuel declines while reducing reliance on imported minerals.

CMES Integral to Utah's Mining History

Formally established in 1901 and with geology instruction dating back to the University of Utah's original founding in 1850, the College of Mines and Earth Sciences is one of the oldest institutions at the U and has played a key role in the history of the university — and the state itself. As the mining and materials needs of Utah and the world have changed, so has CMES, evolving in leadership, departments, and even the name of the college itself.

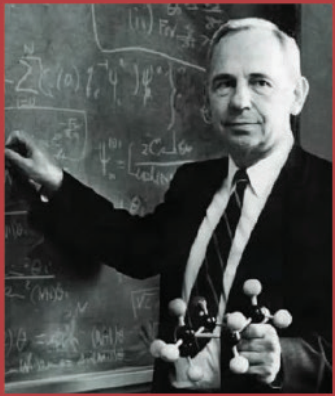
The University of Deseret began offering geology courses in the mid-19th century, before it became the University of Utah, and even before Utah achieved statehood. In 1890, John Park, the first president of the university, was also granted the new position of Deseret Chair of Geology & Mineralogy, solidifying geology instruction as an official department. The second president, James E. Talmage, also taught geology and was a professor of metallurgy. In 1901, the Utah legislature outlined the need for an official school of mines in the state's constitution, forming the State School of Mines.

The "State School of Mines" has gone by many names over its history. In 1913, it became the School of Mines & Engineering, encompassing the mining and metallurgical engineering instruction offered in the college today as well as the departments that, in 1947, split off to become the College of Engineering — making the School of Mines & Engineering the College of Mines & Mineral Industries. It wasn't until 1988 that the school officially became the College of Mines and Earth Sciences (CMES), a title that reflects its roots and ongoing work in mining engineering as well as the research our faculty perform everywhere on Earth, from pole to pole and from deep underground to the upper reaches of the atmosphere.

The college has also undergone several departmental shifts, offering new subjects and changing shape to adapt to the evolving needs of the world. The School of Mines & Engineering originally consisted of departments of mining, metallurgical, civil, electrical, mechanical, and commercial engineering, as well as the Department of Chemistry, which soon moved to the School of Arts and Sciences. In 1948, as most of the engineering departments became the College of Engineering, the Department of Geology transitioned from the School of Arts and Sciences to the newly named College of Mines and Mineral Industries, and the Department of Meteorology (now the Department of Atmospheric Sciences) was formed.

With a storied past across three centuries, the College of Mines and Earth Sciences is set to continue making history into the 21st century. The merger between CMES and the College of Science is part of a long tradition of collaboration and interchange between the colleges (see pg. 18). While the College of Mines and Earth Sciences will retain its name, the increased funding and collaborative opportunities offered by the merger will help the college continue to make a name for itself in real-world research. The materials used in clean energy sources such as solar panels come from the Earth, which means it's crucial to find sustainable and efficient ways to extract them. As Governor Spencer Cox said in his 2022 State of the State Address, "28 of the world's 35 most critical minerals can be found right here in our state." CMES researchers are leading the way in driving Utah, and the world, into the future. *-Jake Luman*

CMES History



Creation of the Graduate school by Henry Eyring, Metallurgy and Chemistry

1850
University of Deseret courses in Geology

1892

1901
State School of Mines established through Utah Legislature

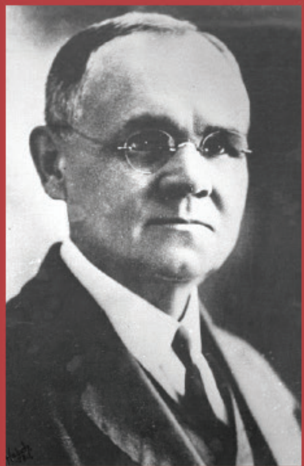
1946
Creation of the Graduate school by Henry Eyring, Metallurgy and Chemistry

1850
University of Deseret Established

1890
Deseret Chair of Geology & Mineralogy est.

John Park, President and first chair of Mining Department.

1894
James Talmage, President, taught geology and was a professor of Metallurgy



Installs 1st seismograph on campus in 1907

1913
School of Mines & Engineering

1947
Split from College of Engineering to become The College of Mines & and Mineral Industries

1966

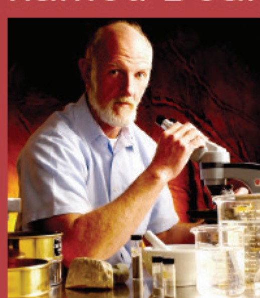
Seismograph Stations established. 3 stations to 230 today from AZ to Yellowstone.

1988

College of Mines and Earth Sciences

1991

Frank Brown named Dean



2002

Marjorie Chan 1st female Dept. Chair

2009

Sutton Building 1st LEED Certified on lower campus.

Beacons of Excellence Award, 2017

2016

Darryl Butt named Dean

2018

Metallurgical Engineering Merges with Material Science.

2021

U researchers awarded grant for $1.5 Million to transform coal associated mineral resources.

The Future of the Great Salt Lake as the Lake Diminishes

By Paul Gabrielsen, science writer, Marketing & Communications

University of Utah President Taylor Randall and Brad Wilson, speaker of the Utah House of Representatives, met with legislators, scientists, and Great Salt Lake advocates on June 23, to spark conversations to help save the lake, which reached its lowest recorded level last year.

"It's a hemispheric event," Randall said of the decline of the lake, "occurring right here in the state of Utah."

The meeting, part of the first leg of Randall's Utah Across Utah Tour, took place at the George S. and Dolores Doré Eccles Wildlife Education Center in Farmington, Utah. Outside the window, pelicans, herons, ibises, and avocets flew by while the meeting participants discussed how to find solutions to save the declining Great Salt Lake on which industries and ecosystems rely.

"This is what we're talking about, folks," Wilson said, gesturing to the ponds outside the window and the mountains of Antelope Island in the distance. "I grew up next to the Great Salt Lake. So it's not just important to me from my legislative role, it's important to me personally."

After outlining the threats to Utah's economy, health, and quality of life from a declining lake, as well as the actions taken in the 2022 legislative session, Wilson turned to the group, which included leaders of the Friends of the Great Salt Lake, the Great Salt Lake Alliance and Great Salt Lake Advisory Council, hydrologists from the U.S. Geological Survey, former chair of the Department of Atmospheric Sciences Kevin Perry, Dean of the College of Science Peter Trapa, and others, including leaders of the Utah Department of Environmental Quality and Utah Department of Natural Resources.

"What can we all do around this?" Wilson asked.

Utah Senate President Stuart Adams echoed the call for solutions. "You're very smart people," he said. "I'd like to know your highest priorities. If we can somehow put that list together of serious ideas, we can have a clearer path."

> **"*We need the academics to identify, to understand, what those critical research questions are, help us answer them, and then feed that back to policymakers who are just begging for good information.*"**

Rep. Ray Ward explored the concept of a baseline or other simple metric of the lake's level and condition that could help the general public understand current conditions.

"We could think of what would make sense for a baseline and then speak of it in terms of the amount of water that's already gone compared to that," he said. "If we are able to say, 'Look, it's not something that's happening in the future.'"

Randall mentioned the wide range of expertise at the University of Utah related to various aspects of the Great Salt Lake, and Trapa added that the U's expertise in Utah's environmental issues, including wildfire risk and air quality, has been built in the state's natural laboratory. "Higher education is uniquely positioned to leverage our expertise for exactly this: helping provide prioritization of ideas and solutions," he said.

Perry has extensively studied the potential for dust generation on the dry lakebed. His research, recently highlighted by AP News and The New York Times, demonstrates the threat a declining Great Salt Lake poses to the health of Utah citizens. As more and more of the lakebed is exposed, wind begins to erode the protective crust formed by lake deposits. Underneath this crust is toxic dust composed of naturally occurring arsenic as well as dangerous heavy metals, byproducts of historic mining activity in the state; this dust can be kicked into the air by wind and breathed in by people living in the valley.

Based on Perry's studies, the Farmington Bay area of the lakebed, which has the greatest potential to impact residents as a dust source, is the easiest quadrant to remediate by raising lake levels. "But unfortunately it's 10 feet," he said. A lake level elevation of 4,200 feet "would cover 80% of the dust hotspots that I've measured out here in Farmington Bay itself."

Representative Tim Hawkes commented on lawmakers' hunger for good data to help make decisions. "So for academia to really feed into that," he said, "we need the academics to identify, to understand, what those critical research questions are, help us answer them, and then feed that back to policymakers who are just begging for good information."

In response to a question from Rep. Ward about quantifying the amount of water needed to maintain healthy lake levels, hydrologists Christine Rumsey and David O'Leary from the U.S. Geological Survey previewed upcoming webtools and models of the lake in development. "The intent of that is to integrate groundwater levels, lake levels, evaporation, and surface water inflows to get at some of those questions," O'Leary said. Rumsey added that a tool to help the public understand the impact of lake level on lake resources is coming this summer.

Other participants raised water pricing, reserving a portion of water for the lake and education as additional potential solutions.

"We obviously are all committed to this issue here for a variety of reasons and all the right reasons," Wilson said in closing. "I'm not going away on this issue and I know that you aren't. Let's continue to work together and find solutions. . . . We've consistently been able to do things that seem really, really hard. This is one of those. It might be one of the biggest. But it's well worth the effort."

U Scientists to Study Southern Ocean Cloud Formation with $526K Grant

Thanks to a $526,000 grant from the U.S. Department of Energy, professors of atmospheric science Jay Mace and Gannet Hallar will study data from the Southern Ocean, which surrounds Antarctica, as part of ongoing efforts to understand how ocean processes impact clouds in that relatively untouched part of the planet.

Different ocean processes at different seasons affect the formation of clouds and precipitation over the Southern Ocean, which then affects the energy and water cycle of the ocean and the landmasses within it. In the austral summer, sulfur from biological blooms affects cloud reflective properties; in winter, particles of sea salt produce different clouds. Not much is known about these processes.

"In many ways, this is pure exploration since data collected in the Southern Ocean is so rare," says Mace. Much of the data comes from research vessels, including a 2018 expedition which Mace joined for two months as part of the Measurements of Aerosols, Radiation and Clouds over the Southern Ocean (MARCUS) project.

Mace and Hallar will analyze the data sets from the MARCUS project and other Southern Ocean monitoring projects MICRE and AWARE, in conjunction with NASA satellite measurements, to learn how small airborne particles called cloud condensation nuclei control clouds and their reflectivity and influence precipitation in the Southern Ocean. They hope to help refine atmospheric models in order to accurately capture and represent these processes.

"Understanding the processes are important because the energy budget of the Southern Ocean affects the uptake of carbon dioxide from the atmosphere, and also the precipitation influences the mass balance of the ice sheets," Mace says. "The Southern Ocean is also thought to be the last vestiges of the pristine Earth since it is so removed from human pollution."

In addition to this work, Mace has submitted a proposal, funded by a seed grant from the U Vice President for Research office, to head back to sea in 2022 to collect additional data. Mace and Hallar's research is exemplary of the global work CMES conducts, from atmospheric scientists in the Southern Ocean to mining engineers in Greenland and geologists in the Arctic Ocean. In order to understand our interconnected Earth, U scientists are studying its complex atmospheric and geologic processes from pole to pole. *-Paul Gabrielsen*

Photo credit: Jay Mace

Photo credit: Zak Podmore

Deltas of Sediment are Pushing into Glen Canyon as Lake Powell Disappears

By Zak Podmore, originally published in The Salt Lake Tribune

Photo credit: Zak Podmore

As the Colorado River approaches the still waters of Lake Powell, the pace of the current quickens.

The river picks up sediment until it is as dark as espresso and as thick as a chocolate milkshake. Great expanses of cracking mud, half a mile wide, stretch beyond the river banks, devoid of a single plant or blade of grass.

Then, when the river meets the reservoir, everything goes still. Flocks of white pelicans alight on sandbars where the current ends.

The silt drops from the water almost immediately and the water turns to a chalky turquoise. Within ten miles, Lake Powell is as clear as a reef in the Bahamas, shelves of sandstone visible ten feet below as bass zip through the shadows. All of the sediment has drifted to the bottom of the lake.

The transition zone between flowing river and reservoir is what scientists refer to as the delta, and it's migrating toward the Glen Canyon Dam as Lake Powell has dropped to record low levels.

A separate delta is moving down the San Juan River to the south, a tributary to the Colorado that carries less water but more sediment.

"Rivers are generally very efficient transporters of sediment, whereas large bodies of water (lakes, reservoirs, oceans) are very good at trapping sediment," said Cari Johnson, geology & geophysics professor at the University of Utah. "Where those two very different sets of processes meet is the delta, which makes it all the more important to study this large and highly mobile slug of sediment."

Johnson and her students are currently analyzing the pace at which both deltas have advanced since 2000, a period of time that has seen plummeting water levels on Lake Powell thanks to high water use in the Southwest and the driest period in the Colorado River basin in at least 1,200 years.

Using publicly available satellite imagery, Johnson's team have calculated that the delta of the San Juan has moved by an average of over 120 feet per day over the last 22 years, pushing a mass of sediment dozens of miles downstream into areas that were once covered by Lake Powell.

"We're seeing pretty remarkable rates of change in where that delta front was sitting," Johnson said, "on the order of 10, 20 kilometers [six to 12 miles] in a year, or in a couple of years, moving up or down."

Deltas are highly dynamic and mobile, Johnson said, eroding into themselves and then getting flooded again if the reservoir level rises.

Photo credit: Zak Podmore

Hannah Hartley, a master's student studying geology and sedimentology at the university, played a key role in the project when she began comparing satellite images from the lower San Juan for a class. Two images taken in March and June of 2017 showed a dramatically different location for the delta after the spring runoff brought up reservoir levels.

In the span of four months, the delta had moved by nearly 12 miles. Hartley has continued to research the delta movement with Johnson since completing the class project.

The upper reaches of the reservoir have been so filled with sediment that the location of the deltas is determined by a number of factors. Lake Powell is currently filled to less than a quarter of its capacity, but the deltas are dozens of miles downstream of where they would have been when the reservoir first filled to its current level in the 1960s.

"The river is not just dropping the sediment into a bathtub," Hartley said, "it's actively modifying the bottom of the tub and filling it up as well."

As the rivers move into the historic reservoir bed, they flow high above their historic channels on top of thick lake deposits, some of which are over 100 feet deep. Because the old channels are filled, the deltas can keep moving downstream even if reservoir levels are stable.

Delta movement can also be sporadic, Johnson and Hartley said, staying relatively static for a while and then moving rapidly as reservoir levels drop or as rivers run high.

"Lake Powell is unique in the way that it's shaped," said Casey Root, a hydrologist for the U.S. Geological Survey's Utah Water Science Center. "It's extremely long and extremely thin, so it naturally buffers the dam against sediment simply by keeping the deltas really far away from the dam."

The reservoir's decline has exposed sediment in Cataract Canyon and elsewhere, allowing it to wash downstream. The Moab-based Returning Rapids project is documenting how that process is exposing rapids in lower Cataract that were once buried in muck, but that sediment isn't leaving the system; it's moving downstream and filling new areas.

If Lake Powell stays low or continues to decline, which is likely according to climate models, it will lose storage capacity more quickly as the deltas move into the lower reservoir. Root compared the way rivers move sediment to a snow shovel that fills with snow and then pushes it out to the sides, filling bays and side canyons.

Because the deltas' movement are influenced by so many factors, Johnson said it's difficult to project how quickly they'll move into areas of the reservoir that were once available to houseboats.

The delta of the Colorado River is over 125 miles from the dam, but the San Juan delta has been marching closer to the confluence with the Colorado in recent years and is now just 27 miles away. If the San Juan delta reaches the main channel of the Colorado, would it deposit so much sediment in the canyon that it would divide the lake into two? It's difficult to predict.

"I can see that being a problem for water travel as you get just a pile of mud building up in one specific location [such as at the confluence] and no way of modifying that," Hartley said, "no natural force coming along and washing some of it downstream."

But that's not likely to happen soon, Hartley said, especially if the reservoir levels stabilize or come back up. Lake Powell can only drop by 160 more vertical feet before the water level reaches the lowest outlets on the Glen Canyon Dam.

Photo credit: Zak Podmore

A Profile of Bingham Canyon Miners

Did you know that in the early 20th century, the Kennecott Copper Mine employed miners from 49 countries? Or that its employees ranged from only 15 years old to nearly 80? Malcolm McKinnon Professor of mining engineering Rajive Ganguli and Chair of the Department of Mining Engineering Michael Nelson, alongside Dr. Rambabu Pothina from the Department of Mining Engineering's Artificial Intelligence group (ai.sys), analyzed over 40,000 records from the mine from 1898-1928 as part of the "Mining the West" digital exhibit. A collaboration between J. Willard Marriott Library Special Collections and the Utah Museum of Fine Arts, "Mining the West" showcases primary source material from the past two centuries to "illustrate the technological, economic, social, and environmental implications mining has had, and continues to have, on the American West and its people," according to the exhibit's home page.

Ganguli, Nelson, and Pothina's contribution, titled "Profile of Bingham Canyon Miners," highlights demographic data of miners employed by the copper mine in the early 20th century. Their findings feature information such as age, country of origin, surnames (the most common being "Smith"), and even reasons miners were terminated — including "Got into a mortal brawl at 'Blue Goose,'" "Quit to go to war," and "Discharged for talking too much." The team hopes that by analyzing this data, they can gain insight into mining history and the miners who shaped it. "As someone new to Utah, I was surprised by the diversity of the workforce," says Ganguli. "I hope that the exhibit will help us all in thinking about our history a bit more accurately."
-Jake Luman

U Professor Featured in Air Quality Documentary

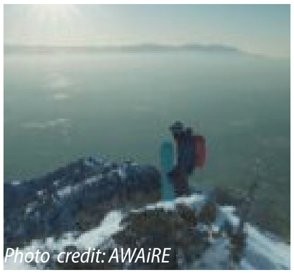


Photo credit: AWAiRE

Research assistant professor of atmospheric sciences Daniel Mendoza is one of four featured subjects in a new documentary, AWAiRE, directed by Jack Hessler from WZRD Media, that explores the impacts of air quality along the Wasatch Front.

Mendoza says that his role in the film, which has been in production for around two years, provides the scientific perspective as well as an explanation of how air pollution disproportionately affects different communities.

"The idea was to try to understand air quality on a more personal level," Mendoza says. "We wanted to make this documentary really feel like you're talking to someone and having a conversation. It is a Utah story told by people who live in Utah from different backgrounds."

The 17-minute film, which premiered on Sept. 28, 2021, at Wasatch Brewery in Sugarhouse, aims to inspire and empower viewers to take small actions to improve air quality.

"Too many times we think that we're too insignificant and cannot make a difference," Mendoza says, "but by showing how each of us as individuals are collectively working towards solving this problem, I think that everyone can find a place." *-Paul Gabrielsen*

Watch Documentary Here

Dr. Sarah Crump joined the Department of Geology and Geophysics as an assistant professor as of July 2022. She completed her Ph.D. in geological sciences at the University of Colorado Boulder. Crump's research focus is the sedimentary records of past warm periods and episodes of abrupt climate change. "The commitment to interdisciplinary, societally relevant research and top-notch education makes CMES an excellent fit with my own values," says Crump. "And it's hard to imagine a better backyard as an earth scientist!"

Dr. Brijes Mishra joined the Department of Mining Engineering as an associate professor as of January 2022. Mishra completed his Ph.D. in mining engineering at West Virginia University in 2007. He was previously employed as an associate professor of mining engineering at West Virginia University, where he contributed to geomechanical research and mentored future generations of mining engineers. "The U is quite popular in the field of rock mechanics," says Mishra. "In addition, Utah is rich in minerals and has different levels of mining activity which was quite attractive for a researcher!"

Dr. Xinbo Yang joined the Department of Materials Science & Engineering as an assistant professor of metallurgical engineering as of July 2022. She is currently working on a project funded by the U.S. Department of Energy to develop and optimize a process to extract rare earth elements from coal. Yang completed her Ph.D. in mineral processing engineering at the University of Kentucky in 2019. "I was drawn to the University of Utah for the advanced research facility, admirable colleagues, and excellent student quality," says Yang.

Dr. Jiaqi Jin joined the Department of Materials Science & Engineering as an assistant professor of metallurgical engineering as of July 2022. Jin, previously a research assistant professor, completed his Ph.D. in metallurgical engineering at the U in 2015. Before joining U faculty, Jin worked as a metallurgist in mine sites in Colorado, Nevada, and Arizona. His research expertise includes surface chemistry of minerals and fluid flow through porous media.

Dr. Jessica Haskins joined the Department of Atmospheric Sciences as an adjunct assistant professor as of July 2022 and will become a full assistant professor in January 2023. Haskins completed her Ph.D. in atmospheric sciences at the University of Washington in 2020. Her research focuses on chemical pathways that drive variability in air pollution. "I was drawn to the university based on the outstanding historical reputation of the Department of Atmospheric Sciences and the University's proximity to some amazing outdoor recreation," says Haskins.

Juan Carlos de Obeso will join the Department of Geology and Geophysics as an assistant professor in January 2023. He completed his Ph.D. at Colombia University in 2019. His research focuses on hydrothermal alteration peridotites/basalts. "I look forward to working with faculty, staff and students to develop new collaborations and train the next generation of Earth Scientists. On top of all these, we are surrounded by beautiful geology all around, being a geologist and an avid outdoor person I cannot think of a better place to be." Juan Carlos says.

New Geology and Geophysics Department Chair

Dr. William "Bill" Johnson was appointed Chair of the Department of Geology and Geophysics July 1st, 2022, taking the place of distinguished professor of geology and geophysics and distinguished professor of biological sciences Thure Cerling after 6 years of service. Johnson, a professor of geology and geophysics and adjunct professor of civil and environmental engineering, completed his Ph.D. in civil and environmental engineering at the University of Colorado Boulder in 1993 after earning his M.S. in geology at Dartmouth College. Johnson's career at the University of Utah began in 1995; his research, focusing on environmental contaminants in aquatic and ground systems, has attracted numerous awards and funding for further study, including the Department of Geology and Geophysics' Outstanding Faculty Research Award in 2000 and 2011.

Cerling served as department chair for two terms from 2016–2022, and was recently awarded the Rosenblatt Prize for Excellence, the U's highest award for faculty (see pg. 7 for more information). As chair, he instituted faculty mentorship initiatives, improved faculty diversity and department internal communication, and created community outreach programs.

HAPPENINGS

Mining Engineering Students Take Greenland Trip

Last year, the Department of Mining Engineering was selected by the US Department of State for a $1.2M cooperative agreement to assist the Greenland School of Minerals and Petroleum (KTIR) in developing their mine training programs as the country's mining sector takes off. The team, led by Malcom McKinnon Professor of Mining Engineering Rajive Ganguli and former chair of the Department of Mining Engineering Michael Nelson, helped KTIR upgrade their offerings, developing six courses, providing training in mine search and rescue, and advising the school on the design and construction of an underground mine training facility. This summer, Dr. Ganguli took seven students to Greenland to get firsthand experience in mine training.

"After visiting KTIR last year, I was very impressed with their hands-on drilling and blasting training, which also included ground vibration monitoring," says Ganguli. "I thought it would be neat if our students could go there and get trained on these topics in a week-long short course." With KTIR's location and unique opportunities for hands-on experiences, students were able to take mining principles out of the classroom and onto the field — "Not being a vocational school, we can neither run drill rigs on campus, nor set off explosives" says Ganguli, but in Greenland, the group was able to drill holes, set up ground monitoring instruments, and load mining blasts.

The group also got to enjoy the gorgeous landscapes of Greenland and the Arctic. "On the first day of our visit to the site," says Ganguli, "some whales were blowing off mist in the background as we discussed our training."

"Our generation of mining engineers will be minimizing emissions, protecting the environment and local communities and keeping workers as safe as possible to ensure that mines are good neighbors," says Ian Sutcliffe, a mining engineering student on the trip. "This is one benefit of studying at the U, where the education we offer may include experiences that grow from collaboration," says Ganguli. "Without the international partnership we developed with KTIR, this would not have been possible." *-Jake Luman*

Photo credit: Dr. Ganguli

Photo credit: Dr. Ganguli

Photo credit: Dr. Ganguli

College of Mines and Earth Sciences to Merge with the College of Science

By Paul Gabrielsen, science writer, Marketing & Communications

Photo credit: Matthew Crawley

The University of Utah College of Mines and Earth Sciences began the merging process with the College of Science on July 1, 2022, a move that will unite well-funded programs, build synergy and cooperation between faculty, and create a much stronger base for science and mathematics education at the U.

Deans Darryl Butt of the College of Mines and Earth Sciences and Peter Trapa of the College of Science have worked with university administration and members of both colleges to plan the details of the merger. The College of Mines and Earth Sciences will retain its name and identify as a unit of the College of Science and all faculty, students, buildings and research programs in both colleges will continue in the combined unit.

"Both of these colleges are leaders in student enrollment and research, providing valuable direction on some of the most important issues we face today," said U president Taylor Randall. "I am confident this union will elevate both programs and provide more opportunities for collaboration and student access to classes."

How it happened

The two colleges have a long history of collaboration, but as they came together in 2018 to begin planning for a new Applied Sciences Building, which will bring together departments from both colleges, the deans and faculty members discussed interdisciplinary collaborations and joint courses of study, leading to the proposal of merging the colleges.

In developing the merger plan, the colleges have met with university administrators and faculty and staff from both colleges. Each department in both colleges conducted an advisory vote from their faculty, with a strong majority of voting faculty being in favor of a merger.

"The alignment of COS and CMES to form a stronger and more synergistic organization would elevate the reputation, and likely national rankings, of the respective programs as the joined faculty become more comparable in size and scope to many peer colleges in the Pac-12," said Butt. "The union will strengthen the STEM fields at the U, and provide a greater student experience through enhanced advising, tutoring, research opportunities and interdisciplinary programs."

What will and won't change

The yearlong Phase 1 of the merger, which began July 1, 2022, involves integrating non-academic functions of the College of Mines and Earth Sciences, such as accounting and marketing. The deans will work to enhance communication and collaboration in the united college, and continue working with faculty, staff, students and university leadership to streamline the merger.

Students attending classes in either of the colleges this fall likely won't notice anything different — buildings, faculty and programs will remain as they are. Students working towards existing degrees will still receive those degrees from their respective colleges. No programs will be changed and no staff positions will be eliminated.

Leadership will also look much the same, with department chairs remaining in place, and Butt remaining as dean of the entities comprising the College of Mines and Earth Sciences as the colleges consolidate.

After that, as Phase 2 begins, the unified college will report to a single dean and changes to the governance structure of the college, developed in Phase 1, will be finalized and submitted to faculty, student and administration stakeholders for final approval.

Future endeavors, such as a major in earth and environmental science currently under consideration, will utilize resources from both colleges. But the College of Mines and Earth Sciences will remain as a distinct unit within the College of Science, strengthened by the merger and well-positioned to meet its future mission to the state of Utah as the land grant school of mines.

"This is an innovative solution to combine the resources of two historic colleges in a way that preserves the identities and missions of both while elevating them to the top tier of science colleges in the United States," Dr. Butt said.

U Professor Embarks on Arctic Research Cruise


Photo credit: Peter Betlem & IODP

Pilot whales, northern lights, breakfast every day overlooking the ocean—it sounds like a dream Scandinavian cruise, but not one you'll find on any travel site. In 2021, assistant professor of geology and geophysics Sarah Lambart embarked on a scientific mission to explore the geologic history that shaped the continents as we see them today. That mission took her past the Arctic Circle aboard a research vessel equipped with a drill rig that pulled up sediment and rock cores from the deep ocean floor, giving Lambart and her colleagues an insight into volcanic activity on Earth 60 million years ago.

The expedition was organized by the International Ocean Discovery Program (IODP), "an international research collaboration that coordinates seagoing expeditions to study the history of the Earth recorded in sediments and rocks beneath the ocean floor," according to the program home page.

Lambart's cruise aboard the vessel JOIDES Resolution was IODP Expedition 396 and sailed from Aug. 6 to Oct. 5, 2021. After departing from Reykjavík, Iceland, the ship stopped at 10 drilling locations off of the coast of Norway. Lambart was part of the international scientific team that described and documented the cores of sediment and rock that the drilling rig brought up from the ocean floor.

The mission explored a geological event of excess volcanic activity associated with the breakup of North America and Europe and the formation of the North Atlantic Ocean, beginning around 60 million years ago. The North Atlantic break-up event generated a volume of magma that is too high to be explained by the type of volcanic activity that occurs along the Mid-Atlantic ridge today. Several processes can potentially explain this excess magma, but the relative importance of each remains unresolved. Soon after this enormous magmatic break-up, the global surface temperature rose by about 5 °C (9 °F). This event, called the Paleocene-Eocene Thermal Maximum (PETM), is probably the best ancient analog of modern climate change, but the link between volcanic activity and the PETM around 55 million years ago has yet to be established.

To describe hard rock samples, the scientific team would prepare thin sections — slices of rock only 30 microns thick (an average human hair is 50 microns, Lambart said) and so thin that when glued on a glass slide and polished, they allow light through. When viewed through polarizing filters in a microscope, the various minerals in the sample show off a brilliant collage of colors. Petrologists can learn a lot about the history of the rock from the minerals present and their textures.

Unlike the mariners of previous eras who were completely isolated during their voyages, the passengers on the JOIDES Resolution kept in regular contact with the rest of the world. Scientists and IODP staff conducted virtual ship tours and live broadcasts with classes. Lambart participated in seven of these broadcasts, including three with the Department of Geology and Geophysics.

"This was an extremely successful expedition," said Lambart. "We drilled 21 holes and recovered more than a mile (about 2 km) of cores." But with a wealth of information in the cores that is only starting to be investigated, she said, "this is only the beginning." *-Paul Gabrielsen*

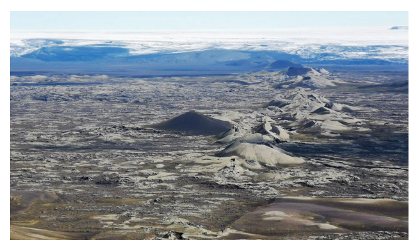
U Professor Talks Dinosaur Movie Accuracy With Vanity Fair

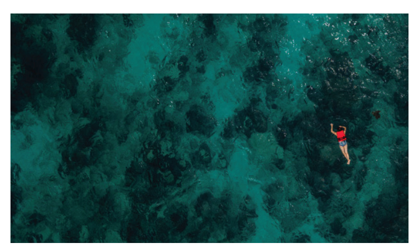
How realistic are Hollywood's dinosaurs? Associate professor of geology and geophysics Mark Loewen sat down with Vanity Fair to discuss the accuracy (and inaccuracy) of dinosaur depictions in movies ranging from Fantasia (1940) to Jurassic World: Fallen Kingdom (2018). For example, the Spinosaurus that battles with T. Rex in Jurassic Park 3 actually lived in aquatic environments, so they never would have encountered each other! Join Loewen as he moves through the history of dinosaurs in cinema, shaped by scientific discoveries over the last century — and by what audiences think look cool — in the video, which has over 3 million views! *-Jake Luman*

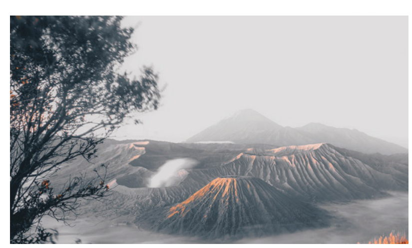
Find Video Here


Photo credit: Vanity Fair

A Surprisingly Soft Mineral May Control How Earth Recycles Rocks







The geological events we see on the surface of the Earth as mountains, volcanoes, and earthquakes are expressions of processes that are happening deep in our planet. Here on the Earth's crust, we're part of a conveyor belt system called plate tectonics where old crust at the margins of oceans is shoved back underground beneath continents, into the mantle.

As that crust goes deeper into the Earth, some of the minerals in the rocks change under the high temperatures and pressures of the mantle. New research from adjunct associate professor of geology Lowell Miyagi and colleagues finds that one of these mantle minerals is among the weakest in the Earth's interior.

Seismic waves travel through different materials at different speeds, so when seismic waves show something unusual, geoscientists pay attention and naturally wonder — what's that made of? One of these notable unknowns is a feature at the boundary between the mantle and the core known as a Large Low Shear Velocity Province (LLSVP). Geoscientists previously thought that these provinces were hotter than the surrounding rock and might be the source of some volcanic features like the Hawaiian Islands or the East African Rift Zone. "However, more recently, people think that these are a different kind of rock than the mantle," Miyagi says. "So the question is: What kind of rock is it, and how does it pile up there?"

One candidate is the mineral davemaoite, with the chemical formula CaSiO3. It's part of a class of minerals called perovskites. Sinking slabs of rock are rich in davemaoite (up to 30%), and the rest of the mantle doesn't have much of it.

"It is very difficult to study because it cannot survive to room pressure," Miyagi says. "It has to be made at high temperature and pressure. If you take the pressure and temperature away it becomes a glass."

To study the elusive material, the team squeezed powdered CaSiO3 under 30 gigapascals of pressure (19 times the pressure of the deepest point of the ocean) between two diamond anvils and heated it to 1600 °F.

After analyzing the structure of davemaoite, the researchers modeled its strength and behavior when being stretched or pulled. Davemaoite, they found, is about 1,000 times softer than the rest of the mantle.

At a depth of around 340 mi (550 km), the temperature and pressure forms davemaoite in much of a sinking rock slab, suddenly making it very weak. If this dense slab, rich in soft davemaoite, separates and sinks, it's plausible that it could form an LLSVP, Miyagi says. "This would occur over long time periods of piling up this material by dripping these upside-down plumes to the base of the mantle." *-Paul Gabrielsen*

Thank you to all our Donors!

We'd like to express our sincere gratitude to the many CMES alumni and friends who continue to show their dedicated support of our students and faculty through generous philanthropic contributions. Here are a few highlights:

This past March, 274 donors gave $128,777 to support student scholarships and other initiatives in the College as part of the University of Utah's fourth annual UGiving Day. Thanks to UGiving Day contributions, as well as other donations, we were able to award over $840,000 in scholarship funding to 159 students. These scholarships make a world of difference to our students as they pursue their degrees. Thank you to all our wonderful donors and friends!

For the second year, the Rocky Mountain Power Foundation funded generous scholarships to support students in the College. This year the Foundation contributed $6,000 to support one student in each of our four departments. We appreciate Rocky Mountain Power assisting us in our efforts to recruit, retain, and train excellent students who will make a profound impact in the earth sciences.

Rocky Mountain Power Foundation

Geology alumnus Bill Tafuri (Ph.D. 1987) and his wife Karen recently committed to a wonderful legacy gift to create the Bill and Karen Tafuri Endowed Scholarship in Geology & Geophysics. This scholarship will be created through their estate and will provide critical support to students for generations to come. Thank you, Bill and Karen!

Alumni, friends, and family of Professor Raj K. Rajamani recently established the Professor Raj K. Rajamani Legacy Scholarship in Metallurgical Engineering. This scholarship represents an opportunity for the next generation of bright students to learn and develop themselves into creative, intelligent researchers and scientists who can continue Dr. Rajamani's legacy of innovating and inventing to help leave the world in a better place than the way we found it, for the benefit of all beings. Thank you to all who have contributed to this fund so far!

For more information on how you can further your legacy and impact in the College of Mines and Earth Sciences, please contact our Development Director, TJ McMullin, at 801-581-4414 or travis.mcmullin@utah.edu. If you are ready to contribute to the college, you can also follow the adjacent QR code or visit https://cmes.utah.edu/development/giving.php. Checks can be mailed to the University of Utah Advancement Office at P.O. Box 58006, Salt Lake City, UT 84158. Please indicate how you would like your gift to be used on the check or online special instructions. Thank you so much for supporting our efforts! *-TJ McMullin*

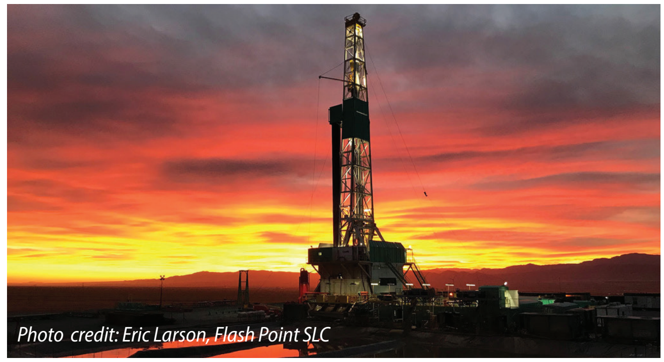


Photo credit: Eric Larson, Flash Point SLC

Update From the Utah FORGE Project

A University of Utah project is progressing toward developing new geothermal technology that could make the renewable energy of the Earth's interior more accessible. That's according to scientists with the Utah FORGE project, a geothermal laboratory northeast of Milford, Utah recently featured in Science. Utah FORGE scientists briefed U President Taylor Randall on the project during the second leg of the president's Utah Across Utah tour.

Led by Joseph Moore, a research professor of civil and environmental engineering and adjunct professor of geology & geophysics, the $218M project was awarded to the U's Energy & Geosciences Institute after a three-year, five-way competition, and is the university's largest-ever research grant.

"This is a unique facility," said Clay Jones, a geologist with Utah FORGE and the Energy & Geosciences Institute, who provided the overview of the project. "There's nothing else like this in the world."

The heat beneath our feet is an enormous, inexhaustible resource. According to Cornell professor Jefferson Tester and colleagues, tapping just 2% of the heat available at a depth of two to four miles would provide more than 2,000 times the U.S.'s annual energy needs. Currently, the only way to access that heat and produce electricity is through conventional geothermal power plants built near naturally occurring hot springs, where heated water rises to the surface. But hot springs are too rare for geothermal energy to be widely used for electricity production. Only a few dozen geothermal plants are in operation in the United States, producing less than 0.5% of U.S. power production.

An engineered geothermal system, though, could create geothermal energy in many more places. By drilling deep wells and opening up fractures in subsurface granite, the FORGE project aims to circulate water through an artificial geothermal system and expand the capacity of this renewable, carbon-free energy source.

An extension of funding through at least 2030 has been submitted, and Moore recently traveled to Washington, D.C. to educate Utah's Congressional delegation about the project and the need for continued funding. *-Paul Gabrielsen*

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Roman Noblewoman's Tomb Reveals Secrets of Ancient Concrete Resilience

Over time, concrete cracks and crumbles. Well, most concrete cracks and crumbles. Structures built in ancient Rome are still standing, exhibiting remarkable durability despite conditions that would devastate modern concrete.

One of these structures is the large cylindrical tomb of first-century noblewoman Caecilia Metella. New research shows that the quality of the concrete of her tomb may exceed that of her male contemporaries' monuments because of the volcanic aggregate the builders chose and the unusual chemical interactions with rain and groundwater with that aggregate over two millennia.

To understand the mineral structure of the concrete, Marie Jackson, research associate professor of geology and geophysics, teamed up with researchers Linda Seymour and Admir Masic from the Massachusetts Institute of Technology and Nobumichi Tamura at the Lawrence Berkeley National Laboratory. They delved into the microstructure of the concrete with an array of powerful scientific tools.

The volcanic tephra the Romans used for the Caecilia Metella mortar was abundant in potassium-rich leucite. Centuries of rainwater and groundwater percolating through the tomb's walls dissolved the leucite and released the potassium into the mortar. In modern concrete, such a flood of potassium would create expansive gels that would cause microcracking and eventual spalling and deterioration of the structure.

In the tomb, however, the potassium dissolved and reconfigured the concrete's binding. X-ray microdiffraction and Raman spectroscopy techniques allowed the team to explore how the mortar had changed. The remodeled domains "evidently create robust components of cohesion in the concrete," says Jackson.

"It turns out that the interfacial zones in the ancient Roman concrete of the tomb of Caecilia Metella are constantly evolving through long-term remodeling," says Masic. "These remodeling processes reinforce interfacial zones and potentially contribute to improved mechanical performance and resistance to failure of the ancient material." *-Paul Gabrielsen*

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