

MINES GEOPHYSICS

REVEALING THE DYNAMICS OF THE EARTH | FALL 2022



COLORADO SCHOOL OF MINES
EARTH • ENERGY • ENVIRONMENT

Fall 2022

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Richard Krahenbuhl

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SEARCHING FOR HERITAGE SITES IN PERU



Jared Low is working with UNSA student Merianth Verástegui Marín to gather frequency-domain electromagnetic data at the Huacas de Moche archaeological site in Trujillo, Peru. Specifically, data are being collected above an extensive Moche residential center between the temple Huaca de la Luna and the ancient palace known as Huaca del Sol, the two major pyramids at the site. In the background of the photo are Cerro Blanco (the mountain) and the temple Huaca de la Luna. (Photo: Richard Krahenbuhl)

Preserving cultural heritage sites is an important way for communities to stay in touch with, and understand, their history and culture. In Trujillo, Peru, Research Associate Professor Richard Krahenbuhl and student Jared Low, on behalf of a larger project team including Associate Professor Jeffrey Shragge and Jessica Smith, director of the Mines' Humanitarian Engineering & Science Graduate Program, performed surveys at Moche archeological sites as part of preservation efforts for irreplaceable Peruvian cultural heritage sites. The work is a collaboration with Mines, the Universidad Nacional de Trujillo (UNT), and the Denver Museum of Nature and Science (DMNS). The team is surveying a Moche archeological site at Huacas de Moche, Peru. This site has two temples that hold layers of history for different civilizations and which served as the urban center of the Moche people. The Moche civilization existed between 1 to 800 CE along the northern coast and valleys of Peru, and were known for their vibrant and naturalistic art in pottery and metalwork. Today, there is a dirt road and small canal in the area, which when built, destroyed, and now are eroding, the western half of one of the temples. Additionally, the local community is encroaching into the space as the site does not have an official heritage site designa-

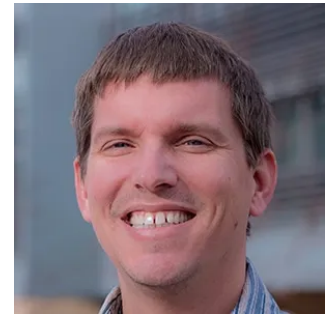
tion. The objective of these collaborative archaeo-geophysical investigations is to help preserve these cultural heritage sites, which are struggling in the face of urban and agricultural expansion, so people do not lose the ability to learn about this civilization.

There were several goals during the initial field campaign. The first was to build a long-term international collaboration between the three institutions (Mines, UNT, DMNS). The second was to share state-of-the-art technologies with UNT faculty and students for archaeological investigations through the use of presentations and hands-on experience with the instruments in the field. The final goal was for the Mines team and UNT students to evaluate and identify the best combination of geophysical instruments/frequencies for the work. The team implemented a combination of drone photogrammetry, magnetic, electromagnetic, and ground-penetrating-radar surveys over a subsection of the two sites to identify buried archaeological features. These geophysical instruments and technology can be used to provide images of the subsurface to locate key buildings and features. Knowing the locations of important features allows for potential recovery and understanding of the heritage site. Identifying the best combination of instruments and frequencies will guide expanded follow-up surveys in the future. — Cullen Young

From the Associate Department Head

Dear Mines Geophysics Community,

I am continually inspired and excited by all the amazing activities happening in our Department. I hope you enjoy the Fall 2022 newsletter where we highlight some of the science Mines Geophysics does and how we are reaching multiple audiences through different types of service. Just like our science, our service has breadth ranging from supporting the creativity of small student groups on campus to helping address some of society's grand challenges like finding reliable sources of freshwater.



While spanning a wide range of topics, our internal and external service activities have a few common threads. First, our student engagement in outreach and service is second-to-none, and in many cases, students are leading the initiatives, such as with projects in the GeoMaker space and with the Society of Student Geophysicists's trail cleaning along our wonderful Clear Creek. Second, we have growing interest in training members of the communities with whom we work, so they have the skills they need moving forward. This is most evident in the Department's activities in Peru, Benin, and Cameroon where we are working with local community members and universities to help provide the technology, skills, and knowledge needed to manage freshwater resources, mitigate landslide hazards, and characterize heritage sites. Third, we have a growing culture of continuous improvement where we are consciously reviewing our activities and assessing how we can improve our contributions to society through our technical expertise, our community support, and our desire to help others.

We also have two new members of the Department, who are already contributing to our success and growth. Lynn Lundebrek joined us as department manager in summer 2022 and has hit the ground full sprint. She helped us kick off the fall semester through organizing our presence at SEG/IMAGE, welcoming our new graduate students, and coordinating recruiting and welcome back events. Bia Villas Boas joins us as an assistant professor, bringing physical oceanography to our Department and expanding our growing data science activities. Bia's impact is already being noticed with novel field programs to assess the interactions between ocean currents, temperature, and the atmosphere. In the spring, Bia will bring her passion for data science and student engagement together when she begins teaching Geophysical Data Analysis.

I hope you enjoy reading the details of the fall newsletter and learning about our recent activities. Also, I'd like to remind you that Geophysics is turning 100 in 2026 and we are having monthly GP@100 events to celebrate this monumental birthday for the world's first Geophysics Department. I hope to see you at some of the events and at our big celebration in 2026!

-Brandon

Welcome to the Department

Lynn Lundebrek



The Department is happy to welcome Lynn Lundebrek, the new department manager. Lynn is from Minnesota and received her Bachelor's Degree in Communications from Concordia College. She is currently working on a Master's Degree in Organizational Leadership from Colorado State University. Lynn has previously worked for the United Way and spent over four years as a registrar advisor in the Mines' registrar office before joining the geophysics team. She is most excited to "help the Department achieve its strategic goals" and loves meeting and learning about each student, faculty, and staff member. Lynn is thankful for all of the warm welcomes from everyone in the geophysics community.

— Chloe Locke

Postcard from Michelle



Greetings from South Alabama!

We have made a successful (I think) transition to the coastal South. The food is outstanding, the people warm and welcoming, and the beaches unrivaled, at least in the contiguous US. Alabama is different from Colorado, but it does seem to be a special place.

As you can guess, I do not miss the bunches of email, but I miss my Geophysics family very much. I think of you every day and hope that you are well and happy—and staying warm, which is not a problem, here.

May our paths cross again soon,

Michelle

GEOPHYSICS: MAKING AN IMPACT ON THE WORLD

The Department is actively expanding and engaged in a wide range of research, education, and project-based activities to benefit our local and global communities. This issue we explore our role in the broader community and the impact that our Department has around the world. These stories focus on commitment to society and the positive impacts that we are working to achieve.

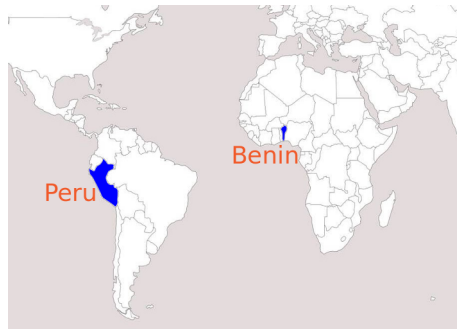
As the volume of geophysics-applicable challenges has increased in recent years, humanitarian outreach projects have become a larger focus for the Department. Two international projects that highlight these efforts include a Geoscientists Without Borders project in Cotonou, Benin, and a project in Majes, Peru. Associate Professor Jeffrey Shragge, Research Associate Professor Richard Krahenbuhl and students Bailey Mullett, Wyatt Lindsey, Brett Bernstein, and Cullen Young are involved in the Cotonou, Benin project, which uses low-cost geophysical equipment to perform surveys with local university students. In Majes, Peru, several Mines project teams have performed surveys with a local university to better understand the cause of ongoing landslides in the area.

For the Benin project, a team of researchers from the Department are working to design and construct low-cost, open-source geophysical equipment for use in hydrogeological studies. In the summer of 2019, Mines geophysics students and faculty worked with hydrology master's students at the University of Abomey-Calavi, and in December 2022, the team will return to Benin in order to expand collaborations with multiple stakeholders. The project team aims to build low-cost equipment that could be used in parallel with commercial-grade geo-

physical equipment during a field-camp-style campaign to characterize the subsurface. The project kicked off with students and faculty from the Department sharing low-cost equipment designs and best practices for acquiring the necessary components to construct the tools. Following the equipment fabrication

workshop, active-source seismic and resistivity lines were deployed in an area of Benin where potential future wells could be drilled for freshwater extraction. After data acquisition, team members introduced open-source programming packages and processing techniques that could be used to interpret the acquired data. The built instru-

ments will remain in Benin for future surveys. In Majes, Peru, a collaboration with the Universidad Nacional de San Agustín de Arequipa (UNSA) funded by UNSA through the Mines Center for Mining Sustainability, is part of a five-year partnership. Phase I focused on establishing relationships with the university and performing initial surveys. Phase II — now underway — focuses on using additional geophysical survey methods and improving existing surveys to provide a better understanding of the area. Since 2005, an ongoing landslide has impacted a farming region and vital highway systems that provide food and resources to the second largest city in Peru. A major goal



of the Phase II collaboration is to help UNSA build sustainable long-term research capacity through training using state-of-the-art geophysical instrumentation. This is done while actively applying these skills in the field to understand anthropogenically induced landslide hazards at the Majes agricultural community. During Phase I, the initial project visit in 2019, the Mines team worked with UNSA to perform seismic refraction, ground penetrating radar (GPR), time-domain electromagnetics (TDEM), and direct-current (DC) resistivity surveys. In coordination with local farmers, the group acquired data to update geologic models and constrain the local water table. This led to a better understanding of the landslides that were destroying local infrastructure. During Phase II, three Mines teams traveled to Majes from November 2021 through Summer 2022, with the common goal of training the UNSA faculty and students how to use the technology in the field and following up with data processing and interpretation. The first team of Research Associate Professor Richard Krahenbuhl and alumnus Hanna Flamme taught about

DC resistivity and Frequency-Domain Electromagnetics (FEM). Next to go was Professor Yaoguo Li, who taught how to use deep-sensing time-domain electromagnetics (TEM) instruments to gather data in areas with and without agricultural development. This kind of work can determine if irrigation may have contributed to the landslides. The third team of Associate Professor Jeffrey Shragge and alumnus Gavin Wilson trained the UNSA students to use new seismic acquisition instruments while acquiring a series of seismic profile data collected at two sites. The seismic surveys were conducted at the first team's DC resistivity survey location near the active landslide and the second location is near a potential landslide concern. Further processing must be done to make conclusions on the cause of the landslides. However, the collaboration between UNSA faculty and students and the Department's faculty and students on how to use geophysical instrumentation and perform field surveys is a mutual commitment to humanitarian projects that benefit communities around the world.

— Cullen Young

Dr. Shragge and UNSA seismic crew in Majes Peru. The controlled seismic source (accelerated weight drop) was taken by Peruvian customs, so the team improvised with a tractor and large boulder for the source. Inset: Looking over seismic data. (Photos: Richard Krahenbuhl)



LOCATING WATER IN CAMEROON



Image: MSClaudio

Water scarcity and security are top issues for many countries in the face of a changing climate. Dr. Manika Prasad, geophysics professor and director of the Mines Carbon Capture, Utilization and Storage (CCUS) Innovation Center and co-director of the Center for Rock and Fluid Multiphysics, has been tackling one aspect of these issues through her involvement in a water recovery mission in Cameroon.

Cameroon is facing an increasingly worrisome water supply issue. Western Africa is heavily dependent on seasonal precipitation for its water and there is less falling each year. According to a report published in the American Journal of Climate Change¹, the mean monthly rainfall in Cameroon has been de-

creasing at a rate of 2.2% per decade since 1960. During the drier months, shallow aquifers are the primary water source for Cameroonians. As these aquifers receive less runoff and their water levels decrease, the wells approach a layer of brackish water that is not safe for consumption.

We formed a team with the students as well as the hydrologists from the local area and anyone who wanted to help, so we had a lot of people helping.

—Dr. Manika Prasad

Dr. Prasad collaborated with her colleague from Fort Hays State University Dr. Hendretta Ali on a grant funded by the Society of Exploration Geophysicists' Geoscientists without Borders to locate an alternative, deep aquifer water sources that could provide potable water for the surrounding towns. Their research group involved officials from the town government, local hydrologists, university students and staff from Cameroon, an American graduate student, and anyone else interested in helping with field work.

"We formed a team with the students as well as the hydrologists from the local area and anyone who wanted to help, so we had a lot of people helping," Dr. Prasad explained. "It was actually a lot of fun because people would volunteer for field work and say, 'Okay tell me what we're doing.'"

To carry out this research, the team utilized an electrical resistivity survey with the Syscal Pro multielectrode system. Electrical resistivity measurements are particularly useful for water location and allow for comparatively inexpensive data acquisition and processing. Such a project design is affordable and attainable for many communities throughout the world. The results, handed over to the local government in 2022, identified numerous potential new drilling sites.

Left: Running a line to conduct electrical resistivity measurements which are particularly useful for water location and allow for comparatively inexpensive data acquisition and processing.





Yaounde university students and volunteers planning survey design at a site. (Photo: Manika Prasad)



Clear water from a source near the survey that dries up after the rainy season. We had to climb down a slippery slope of ca. 10 m. (Photo: Manika Prasad)

Aside from locating water sources, an important part of the work involved collaborating with a group of enthusiastic researchers. Dr. Prasad was inspired by the unique, diverse backgrounds within the research group and capitalized on the opportunity to encourage the team members to lessen the perceived gap between geoscientists across the world.

"Part of the project goals were to make sure that students are talking to each other and that there is no myth about being in one place ver-

sus another," Dr. Prasad said. "Our role (as faculty) was to also provide the impetus to facilitate everyone communicating, and that I think, was a major accomplishment."

She added on the importance of how low-cost projects can have big impacts, "Often-times we think science has to be together with big money, but it doesn't have to be. There are so many things we can do with small money, small resources. It's amazing how much you can do, we want to continue."

— Nicholas Dorogy

¹Mbog, S., B. Bot, O. Sosso, L. Nsobih, and D. Bitondo, 2020, Assessment of Rainfall Variations in South Region, Cameroon: *American Journal of Climate Change*, **9**, 410-422. doi:[10.4236/ajcc.2020.94026](https://doi.org/10.4236/ajcc.2020.94026).

INSTALLING SENSORS IN MINES

Improved catalogs of mine seismicity may expand our understanding of mine geology and provide information to help engineers reduce risk in their planning.



Last spring, a team of researchers led by Dr. Eileen Martin (Mines) and John Hole (Virginia Tech) deployed a massive, high-resolution vibration sensing network throughout a longwall coal mine in Virginia.

The longwall mining process is designed to include small, controlled rock collapse events as coal is removed. This new seismic sensing network ran for over six weeks and has already given researchers an unprecedented glimpse into small seismic events inherent to the mining process. These insights have been learned by acquiring dense seismic array information about events very close to where they occur. Improved catalogs of mine seismicity may expand our understanding of mine geology and provide information to help engineers reduce risk in their planning.

This new sensing network uses a technology known as distributed acoustic sensing (DAS) to repurpose fiber optic cables as seismometers. Previous attempts to adopt seismic monitoring underground have often encountered challenges with maintaining high accuracy timing synchronization between the sensors. Moreover, issues with the permissibility of electronic components in many areas of the mine hamper research. DAS overcomes these difficulties by immediately collecting seismic

data from many virtual sensors along the fiber simultaneously and by using electronic components only at a single above-ground location that can be safely used to monitor activity throughout the mine.

The network was able to detect numerous small seismic events which the team is now using to understand the added value of the underground monitoring system. Researchers collected 33 terabytes of data while mining operations were occurring. Thus, this team is also creating a new software suite to help interpret this massive amount of data.

In addition to collaborators at Virginia Tech and Oak Ridge National Laboratory, Mines graduate students Derrick Chambers (Geophysics (GP) and Gabe Walton (GGE). This research was carried out through the Center for Advanced Subsurface Earth Resource Models (CASERM) with additional funding provided by the National Institute for Occupational Safety & Health and additional materials provided by collaborators at Oak Ridge National Laboratory. For more information about CASERM, please visit <https://caserm.mines.edu>

—Eileen Martin

RESEARCHERS DEVELOP OPEN-SOURCE SOFTWARE

Dr. Eileen Martin and Dr. Ge Jin, in conjunction with several outside collaborators, are developing open-source software for fiber-optic sensing. This project, known as the Distributed Acoustic Sensing Data Analysis Ecosystem (DASDAE), will facilitate interoperability between various data formats, provide reference implementations of process-

ing and visualization routines, and eventually, provide domain-specific applications for areas such as urban geophysics. To find out more, visit DASDAE's GitHub page: <https://github.com/dasdae> or DASCore's (the foundational library of DASDAE) documentation page: <https://dascore.org>.

—Derrick Chambers

SPOTLIGHT ON UNDERGRADUATE RESEARCHERS



SEUNGHOO KIM

Seunghoo Kim is a senior majoring in Geophysical Engineering. Under the mentorship of Dr. Eileen Martin, she is working on a project to develop a compression method for distributed acoustic sensing (DAS) data that can minimize information loss and avoid aliasing. Kim says that the DAS data collection is particularly large and can easily require a terabyte of storage space every day. Thus, making DAS data accessible to researchers is very challenging. She intends to develop a compression method that overcomes these storage challenges. An advance in this area of research has the potential to open the door for many researchers to study DAS data and to explore novel ways to use this technology.

Ray Lowenstein is an undergraduate researcher who completed his Bachelor's Degree in Natural Resources from the University of Florida in 2016. He is currently taking a few courses at Mines before enrolling in graduate school in January. He works under the mentorship of Dr. Yaoguo Li and Dr. Mengli Zhang. Together, they are working on using ergodic sampling as a method of inverting gravity gradiometry data. Ergodic sampling has the potential to acquire more information using the same number of samples while also being extremely cost and time efficient. They are exploring this method by examining the qualities of density contrast models which they obtain from inverting synthetic gravity gradient data and sample on various grids such as ergodic processes with different numbers of samples.

—Chloe Locke



RAY LOWENSTEIN

Dr. Bia Villas Bôas



Dr. Bia Villas Bôas is a new faculty member in the Department. She is a physical oceanographer who focuses her studies on the interaction between the oceans and the atmosphere. Before coming to Mines, Dr. Villas Bôas received a BS in Physics from the Federal University of Rio Grande do

Norte, her MS in Oceanography from the University of São Paulo, and a PhD in Oceanography from the University of California-San Diego. She was a post-doctoral scholar at Caltech.

Q: What is your new position here at Mines and what does it entail?

A: I am an assistant professor of Geophysics. Being a professor on the tenure track line entails three main components which are teaching, research, and service. This year I am going to be teaching Geophysical Data Analysis and then next year I will be teaching a new class, Physical Oceanography. Within the research component I am also going to be advising students on both the undergraduate and graduate level, as well as picking up my research program here. Service entails both university service (e.g., serving on committees) and community service like serving on panels.

Q: What are you most excited about, coming to the Golden area?

A: I grew up by the beach, and I never lived far from the ocean, so this is a bit of a change. I really like how close to nature we are here. It's really easy to go out on a hike or go for a bike ride. This is also my first time living somewhere where there are proper seasons. I am fascinated by the change of the landscape as we go through fall/winter. and that side of nature. I also like the size of Golden — I am not a big city person.

Q: What is your favorite thing about the Mines geophysics community? How does it differ from other schools you have attended or

worked at in the past?

A: What I really love about geophysics at Mines is the current diversity of people with different research backgrounds. This diversity is somewhat new; it was not really like that a couple years ago so I am excited about joining the Department in a time of big changes. I come from an institution that was primarily focused on oceanography, so everyone around me was sort of doing similar things, but coming to Mines geophysics is exposing me to topics and research areas that I never really thought about before.

Q: How did you go from a physics major to discovering a passion for oceanography?

A: I always liked math and physics and what I knew since I was a kid is that I wanted to be a scientist. I decided to major in physics because that would give me a lot of options on what to do as a scientist, but I was originally going to focus on astrophysics. It wasn't until my senior year that I found out that you could actually use math and physics to study the oceans. That was an instant hit for me because I grew up by the ocean and had always loved being in the water, but everything I knew about ocean sciences was always related to biology (which I wasn't a big fan of). When I discovered that I could use physics to study the ocean and the atmosphere it really fascinated me, and I decided to go to grad school in physical oceanography.

Q: What are your specific interests in the fields of geophysics and oceanography?

A: I don't really have a background in geophysics, but as far as oceanography goes, I am mostly interested in how the ocean interacts with the atmosphere. The ocean is constantly exchanging information with the atmosphere in the form of fluxes of heat and momentum. I am interested in how small-scale processes at the air-sea interface can impact climate and weather — even in places far away from the ocean, such as Colorado. A lot of the work that I do involves observations from remote sensing platforms and analysis of large datasets, which overlaps with the interests of some of the other faculty here in the Department and at Mines in general.

Q: After studying and living in multiple countries, how do the applications of these sciences differ in other parts of the world?

A: I think we are fortunate to live in a time where the Internet allows us to collaborate with people all over the world and use observations from instruments that are all over. I believe the potential for us to do work that goes beyond local in terms of impact has really grown. That said, I've always tried to have at least one project focusing on understanding what is going on with weather and climate at a local level. During my masters, in Brazil, I did work focusing on the South Atlantic. When I moved to San Diego, my focus shifted to processes in the California current region. Now that I live in a landlocked state, I haven't really decided what I am going to focus on, but I am really looking forward to contributing to education and awareness around the role of the ocean in climate, which most people in Colorado are removed from.

Q: What are some research projects you have worked? What made them important to you?

A: The thing I like the most about science is how individuals can work on something very teeny tiny that does not seem like it will make a difference, but when it is all put together, you can actually do something with a big impact. A lot of my career has been related to projects that happen at NASA, which are largely mission driven. One of the most rewarding projects that I've worked on (and still do) is related to the Surface Water and Ocean Topography (SWOT) satellite mission. SWOT will transform our knowledge of the ocean, rivers, and lakes, and it will bring together the oceanography and hydrology communities. I have been a part of the SWOT science team since my first year of grad school, together with a large group of scientists and engineers all working on very specific problems. Next month SWOT will be launched into space, and I'm excited to see the discoveries that will come from so many years of work.

Q: What research projects are you working on?

A: One of the two main projects that I am working on is NASA's Sub Mesoscale Ocean Dynamics and Vertical Transport Experiment (S-MODE). S-MODE is collecting an unprecedented number of observations to better understand the role of small-scale ocean processes in climate. My research group will use observation from S-MODE to explore how

ocean surface waves interact with small-scale currents. I'm also part of a small group of scientists who are developing a mission concept for a satellite that is going to measure ocean currents and winds simultaneously, called ODYSEA. Our proposal will compete with many other satellite ideas, but if funded, I expect to be working on this project for several years.

Q: How do you think geophysical and oceanography research benefit the world community?

A: There are several steps to go from basic science to applications, and my work focuses mostly on basic research. That said, one of the biggest challenges that humans are facing is climate change, so any effort that we can muster to fight that will benefit society. The research that I and other colleagues at Mines are doing focuses on better understanding the past, present, and future of the Earth's climate. Geophysical research as a whole can help us find solutions to mitigate and adapt to such challenges.

Q: What world issues do you think geophysical research can be used to help solve in the future?

A: Hands down climate change, in my opinion. That encompasses a lot of topics in Earth sciences, such as oceanography, glaciology, and hydrology, for example. There is a need for us, as a society, to shift away from using fossil fuels as our main source of energy. I believe that Mines is in a unique position to contribute to this challenge given its focus on entrepreneurship and interdisciplinarity.

— Chloe Locke



GRAD STUDENTS LEARN AND SERVE THROUGH SUMMER EXPERIENCES

Over the summer, graduate students typically participate in a variety of experiences. Here, students share their adventures in internships, work, and travel.

DAVID HERMAN



David was a teaching assistant for the undergraduate Field Camp held in Steamboat Springs. After

Field Camp, he enjoyed a cruise to Alaska with his family to see beautiful wildlife and fantastic glaciers. At the end of the summer, David donated peripheral blood stem cells for a leukemia patient following a long process of testing and screening.

DERRICK CHAMBERS

Derrick spent the summer collecting Distributed Acoustic Sensing (DAS) data in a coal mine in the Western United States. Derrick recorded several rockbursts with a new type of DAS-based seismoacoustic array. He hopes to develop the monitoring concept into a viable strategy for un-



derground mines and learn more about rockburst source physics from the recordings.

AHMAD TOUREI

Ahmad worked with Dr. Eileen Martin in the northern slope of Alaska doing fieldwork on DAS permafrost monitoring. They worked in the northernmost part of the United



States, Utqiagvik, Alaska to study geophysical and geomechanical properties of degrading permafrost in the Arctic. The duo had initially deployed 2 km of fiber optic cable and started collecting DAS and DTS data in the Summer of 2021. In 2022, they spliced the cable (because it had been chewed by a lemming) and ran a multichannel analysis of surface waves survey in eight different locations in disturbed and undisturbed permafrost regions. Their research is critical to help us understand and forecast per-

mafrost changes in the Arctic.

YANHUA LIU

Yanhua interned with Shell where she worked on addressing source non-repeatability problems in 4D, time-lapse full-waveform inversion (FWI). She and her colleagues proposed a novel method to mitigate the source non-repeatability problem in double-difference 4D FWI. The tests on both 2D and 3D models demonstrate the potential of the proposed method for reducing the influence of the error in the source wavelets in 4D FWI.

HANNAH VERBONCOEUR

Hannah started the summer by receiving her Wilderness First Responder Certification to prepare her for research in remote, icy locations. She



then traveled to McCarthy, Alaska for the International Graduate Summer School in Glaciology where she took classes on quantitative glaciology, completed a short research project studying the nearby Kennicott Glacier, and explored the area with 27

other graduate students. Hannah also traveled to Tromsø, Norway to participate in the Scientific Committee on Antarctic Research's RINGS Workshop tackling the issue of large gaps in Antarctic datasets. She then traveled to Juneau, Alaska where she taught undergraduate level students about glaciology, sea level rise, participating with local communities, and communicating science to the public.

JAMES CARMICHAEL

James interned as a subsurface engineer with Enstor, Inc. in Houston, where he modeled subsurface storage facilities (previously depleted conven-



tional sandstone fields) within the Black Warrior Basin. His models relied on daily sampling of injection/withdrawal rate, hydrocarbon production and downhole pressure information. Additionally, James assessed an internal study on induced seismicity at an underground storage facility. To wrap up his summer, James took a quick hop to Paris, France, then on to Brussels, Belgium, and finally Amsterdam, Netherlands. Once back in Colorado, he moved from Boulder to Denver!

IGA PAWELEC

Iga interned with Chevron in the Computational Reservoir Geophysics Department working on a project in multiphysics anomaly detection using fiber optic data. Her work took advantage of continuously recorded



strain, strain rate, and temperature information to uncover any unusual happenings in a production well. A fun part of her summer was the regular ping pong games with fellow interns and coworkers that culminated in a ping-pong tournament (Alum Ivan Lim Chen Ning and Iga represented Mines!). Interns also participated in volunteer and outreach opportunities. Iga assisted in a baseball-themed return to school event where she was also able to meet the Houston Astros' mascot, Orbit.

MAUREEN JAMES

Maureen had a fellowship with the Colorado State Senate in which she developed policies to advance Carbon Capture, Utilization and Sequestration (CCUS) and environmental justice. She had interactions



with the major stakeholders to discuss the impact of shutting down mines in the area and how it would affect the community residents. She interacted with Governor Jared Polis, Senator Chris Hansen, Senator Bob Rankin, Department of Natural Resources official Dan Gibbs and other top government personnel. Her work has been used by the Colorado CCUS taskforce. She also continues to work, in conjunction with her advisor Dr. Manika Prasad, to modify existing CCUS policies and design new procedures for the state. Maureen was also a teaching assistant for the climate change and sustainability course and created step-by-step instructions on how to create models from climate data.

MARIEHELEN HELD

Marihelen worked with Oxy in Woodlands, TX. For her summer project, she used Red, Green, and Blue (RGBs) spectral decomposition, envelope methods and machine learning for fault identification in the Garden Banks protraction area located in the Gulf of Mexico.

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SOCIETY OF GEOPHYSICS GRADUATE STUDENTS

The Society of Geophysics Graduate Students (SGGS) is a group of students that represent the geophysics graduate student body. We organize social events to help students get out of the office and interact with one another in a stress-free environment in which work does not have to be the first thing on one's mind.

Our organization also represents the Department in the Graduate Student Government (GSG). A representative from SGGS attends the bi-weekly GSG meetings and serves as the main interface between the Department and the student government organization. This ensures that the

students from the Department can voice their opinions and influence the vote on topics important to them, their fellow graduate students, and the school.

We organize social events to help students get out of the office and interact with one another in a stress-free environment in which work does not have to be the first

Grad students should be on the lookout for announcements regarding future activities. In November, we hope to hold an evening bowling

night, where students can get together in an off-campus setting, socialize, and release some stress. We are also planning a game night where we will gather on campus and enjoy dinner with various board and video games; the perfect time to prove to your colleagues that you actually are better than them at Mario Kart! There are also a few recurring events in the works such as weekly trivia teams at Woody's and Golden City Brewery social hours. Further exciting events are in the works for the remainder of this semester and beyond. We hope to see students involved and joining us in some fun!

— Brett Bernstein

GEOMAKER CLUB SEEKS NEW MEMBERS

The Ken Lerner GeoMaker Space located in the Green Center is going to be home to a brand new geoscience-oriented club in late 2022. Dr. Jeffrey Shragge is starting the GeoMaker club to primarily focus on developing open-source geoscience software and instrumentation for a broad spectrum of applications. The club will be open to students at all levels interested in observing the Earth. All Earth science groups and projects will benefit from this unique space and the accompanying resources specifically dedicated to designing and

testing technology for environmental and geophysical characterization and monitoring. The club will have access to several types of geophysical equipment including soldering stations, a circuit board printer and mill, a 3D printing station, subsurface water testing area, a microcomputer and sensor breakout board library, a collection of basic electrical components, and full sets of tools and hardware.

Although the makerspace is less than a year old, several student-led projects have already been developed. Larger

projects include a low-cost frequency domain electromagnetics conductivity meter, a low-cost direct-current resistivity system, a low-cost three-channel seismometer nodes, a remote-controlled magnetometer vehicle, and a microcomputer-controlled hydraulic testing system.

If you are interested in finding out more about the GeoMaker club, and working closely with geoscience instrumentation, contact Dr. Shragge at jshragge@mines.edu.

— Cullen Young

SOCIETY OF STUDENT GEOPHYSICISTS

A goal that the Society of Student Geophysicists (SSG) undergraduate club has defined this year is to strengthen the community within the club and Department. Strengthening the internal community is important since the 100-year anniversary of the Department will be happening in 2026. Communication is an important factor in building a community, and we have strengthened our communication to include email, the Daily Blast, school calendar, and an SSG group chat. We have strengthened the internal community by hosting meetings for the undergrads in the club to get to know the geophysics professors and the graduate students. Along with our bi-weekly meetings on Fridays, we have hosted a hike for SSG members to get to know each



**Clear
Creek
Cleanup**

other outside of school. During this hike we strengthened our internal community, but we also helped the community of Golden by picking up trash. We hiked along Clear Creek because it is a trail loved by many in the Golden community, and we wanted to make sure trash was not accumulating along the trail or in

the water. Next time, we plan to hike along the Geology trail to continue helping the community, but can also make stops along the way to learn about the geology of the area and how it relates to geophysics.

—Danielle Vonlembke

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DOROTHY KANINI MWANZIA

Dorothy was a teaching assistant for Field Camp. She guided students in collecting, processing, and interpreting geoelectrical resistivity and gravity data. Dorothy rode in a seismic vibrator truck and learned how deep seismic surveys are conducted. This position refreshed her technical and geophysical data pro-

cessing and interpretation skills. Dorothy also won a Clinton Global Initiative University fellowship. This fellowship equipped her with the knowledge to approach and implement projects successfully. She employed linear and logistic regression algorithms to predict the climate patterns of the Lamu area in Kenya 100 years into the future.

—Maureen James, Aaron Girard



NEW IUGS GEOLOGICAL SITE



Aerial view to the north of the Northern Snake Range. Cliffs of ductilely stretched lower plate Neoproterozoic and Cambrian quartzite and schist units are visible in Hendrys Creek. Brittely stretched Paleozoic carbonates of the upper plate are visible along the ridge southwest of Hendrys Creek. Photo Credit: Michael McWilliams

The Northern Snake Range metamorphic core complex in Nevada has been recognized for its unique and impressive structure, geomorphology, and extensional tectonic history. Chosen as one of the first 100 International Union of Geological Sciences (IUGS) Geological Heritage Sites, it is among the seven geological sites globally that expose spectacular tectonic structure and allow for the investigation of tectonic processes. A total of seven sites in the United States were selected as part of the first 100 IUGS Geological Heritage Sites. Among the other sites are the well-known Grand Canyon, Yellowstone, and the La Brea Tar Pits. Our own Dr. Jeffrey Lee's PhD research centered on the

structural and tectonic history of the Northern Snake Range, and he currently has an NSF grant to specifically research its unique ductile deformation history. This site exposes an aerially extensive low-angle detachment fault where rocks above are deformed by brittle normal faulting and rocks below are deformed by ductile deformation processes. According to Dr. Lee, "The Northern Snake Range is an extraordinary geologic site to read about and visit." As geophysics is concerned, the site hosts a plethora of opportunities to understand complex extensional tectonic geometries and processes which can actually be seen by the human eye.

— Rachel Willis

Faculty Honors

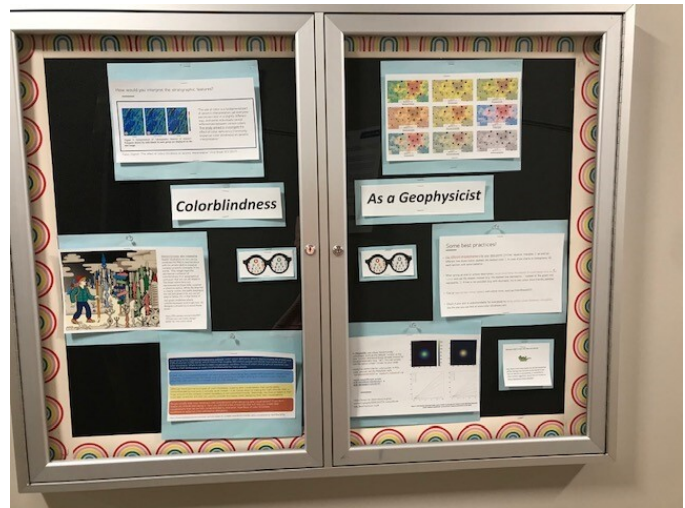
The American Geophysical Union (AGU) has honored **Dr. Kamini Singha** by selecting her to present the 2022 Paul A. Witherspoon lecture. Lectureships are presented annually to mid-career scientists who have made significant contributions to hydrologic science through research aimed at socially important problems and through mentoring of young scientists. The lecture will be presented at AGU's annual meeting December 12-16 in Chicago.

Dr. Roel Snieder delivered the 2022 Society of Exploration Geophysicists-American Association of Petroleum Geologists (SEG-AAPG) Distinguished Lecture: "Measuring Variations in the Seismic Velocity as a Diagnostic of R." The lecture was delivered twice during the fall.

Last spring, just a little past the deadline of this newsletter **Drs. Kamini Singha** and **Ilya Tsvankin** were named as Mines' University Distinguished Professors.

DIVERSITY, INCLUSION & ACCESS UPDATES

A new display in the geophysics hallway next to the workroom aims to represent the broad diversity of identities and interests among the students, faculty, and staff with its monthly-rotating content. The board, which is maintained by the Diversity, Inclusion & Access Committee, is still a work in progress, so keep your eyes out for new changes!



Our Department strives to foster a welcoming and accessible environment for those in the geophysics community by encouraging respect and support for people of all backgrounds. Therefore, the Diversity, Inclusion & Access (DI&A) committee is a vital component of the Department. Cultivating and sustaining a diverse and inclusive department is critical to our education and innovation missions, as well as to our future success as one of the top geophysics departments in the nation. Students and faculty come from many different countries. The DI&A committee's primary objectives are to build a more inclusive and accessible environment, align departmental policies and procedures with DI&A, and inspire shared responsibility, participation, and accountability for DI&A efforts across the Department and the Mines community. There have been numerous educational and social efforts and activities to ensure that the Department is diverse, inclusive, and accessible.

The DI&A committee conducted a self-assessment of the Department's culture to understand improvements needed to boost the department's DI&A outcomes and successfully integrate DI&A as a more significant component in faculty searches. The DI&A committee also awards the Pakiser Fellowship. This fellowship is used to recruit students who hold

outstanding promise for future success in geophysical research and/or education and ensures that diligent efforts are made to recruit women and members of minority groups who are under-represented in the Earth sciences.

To foster social interaction and create a sense of community among geophysics students, the DI&A committee began hosting coffee hours starting in 2021. The gathering grew from an average of 10 students to meetings with more than 20 people present. Due to the success rate and interest from students, the Department handed over the management of the coffee hour to the Society of Graduate Geophysics Students. The meeting has since been rebranded as the 'Geophysics Social Hour'. This coffee hour is held every Wednesday and encourages participation from undergraduates, graduates, and members of the faculty. Conversation topics range from research discussions among peers fostering collaboration between students and faculty, to navigating life at Mines and any topic in-between. Join the fun on Wednesday mornings for coffee and snacks to give your day a boost while helping us foster a welcoming community within the Department.

—Maureen James



Field Camp 2022, Steamboat Springs

The Mines Geophysical Field Camp needs no introduction – considered a signature geophysics student experience by many of our alumni, it's an opportunity for undergraduate students to put the theoretical knowledge acquired in classes in practice. This year marked multiple milestones: Assistant Professor Matthew Siegfried took over as Field Camp Director, and we set off to a new location (Steamboat Springs) with new external collaborations.

I had the opportunity to be the lead Field-camp teaching assistant, participating in session planning and overseeing deep seismic acquisition. It has been a joy to observe students make connections between what they learned

in classes and how to plan a geophysical survey to answer specific geoscience questions, use the available geophysical instrumentation effectively, and then process and interpret the acquired data.

However, scholarly pursuits were not the only takeaways from Field Camp. Kassidy Page remarked, "Teamwork is going to make-or-break the day. Your team is going to help you get through each day because everyone comes from a different background with different ideas and strengths". When asked about his favorite aspects of the Field Camp, MJ Alghamdi said that it's "getting to know my classmates since I don't interact with them a lot in class."

Students also appreciated the beauty of our

surroundings – particularly the hot springs. “Soaking in them or doing field work next to them is great,” said Cash Koning.

Students are united regarding the importance of Field Camp in the curriculum. “It’s essential – being out in the field is probably a chance that not everybody will get to enjoy when they start their careers,” said Zahra Al Mualem. “Being in the classroom is only one side of the coin,” explains Venezia Follingstad, “being able to connect that theory to using instruments and interpreting data in real-world situations was very helpful to my learning.”

I do not doubt that Field Camp will keep evolving and using novel acquisition technology. I will always remember it fondly: as someone who particularly enjoys seismic methods, I loved working with modern wireless nodes,

pushing vibroseis to its limits, and watching fiber optic technology being added to the core acquisition. I can only hope that, as we march toward the Department’s big 100th anniversary, we can make the Field-camp experience more accessible to everyone who wishes to participate. —
Iga Pawelec



Above: Field-camp students explaining to Provost Rick Holz and Dr. Paul Sava the gravity and electromagnetic survey design and data collection process. Below: Students set up a gravity survey grid at the sulphur cave study area. The sulfur cave was one of the main study areas during Field Camp.



Above: Bob Reynolds, research associate at the Denver Museum of Nature & Science, and the main geology instructor during Field Camp, is teaching the students about the geology of different hot springs along the Yampa River in Steamboat Springs. He is feeling the temperature of the hot spring.



Above: Field-camp participants checking in at Colorado Mountain College residence hall in Steamboat Springs.



Norman Bleistein (1939-2022)

The geophysical community has lost one of its brightest lights with the passing of Dr. Norman Bleistein, University Emeritus Professor at Mines. He was 83. Dr. Bleistein was recognized as one of the world's leading applied mathematicians in the field of exploration geophysics.

Dr. Bleistein received a PhD in mathematics from the Courant Institute for Mathematical Sciences at New York University in 1965. After a year of post-doctoral study there, and three years as an assistant professor of applied mathematics at MIT, he moved to the University of Denver (DU), where in 1969, he advanced to the rank of full professor.

In 1979, at DU, Dr. Bleistein, with colleagues Jack Cohen, John DeSanto, and Frank Hagin, founded a research group that would become the Center for Wave Phenomena (CWP). In 1983, the "DU Four" moved their research group to Mines where a year later it officially became CWP. Norm also founded the Consortium Project on Seismic Inverse Methods for Complex Structures as part of CWP. Norm served as CWP director until 1996.

Dr. Bleistein and his colleague Jack K. Cohen were pioneers in use of large wavenumber asymptotics to develop some of the earliest true-amplitude seismic migration methods. The earliest application produced true-amplitude Kirchhoff-style migrations. Bleistein and others would later extend these techniques to develop amplitude-preserving Gaussian beam and reverse time finite-difference migration algorithms. The latter work was conducted after his retirement from Mines.

The Consortium project at CWP has been

a highly successful program that has educated many students to this day. Norm's enthusiasm and brilliance served to inspire generations of students, many of whom have become leaders in exploration geophysics.

Bleistein's efforts were not confined to Mines or the US; his reach was international. While teaching short courses in Europe, China, and Brazil, he actively recruited students and developed new collaborations. He helped a number of mathematicians improve their careers. Norm had a way of pulling students into the topics he taught. "Do the easy problem first," he would say.

Dr. Bleistein's impact in publications is manifold, with 135 peer-reviewed articles and more than 2,000 citations. Bleistein was also the author of three landmark texts on the subject of the mathematics of seismic imaging, mathematics of wave phenomena, and the general topic of asymptotic methods.

In recognition of his impact on the field of seismic imaging, Dr. Bleistein was awarded Honorary Membership in the Society of Exploration Geophysicists (SEG) in 2005. For his lifetime of achievements, in 2014 he was awarded the SEG's highest honor, the Maurice Ewing Medal.

Bleistein had passions for foreign travel, bicycling, and photography. He would immerse himself in local cultures, capturing scenes and moments from his trips in his photography. He is survived by his children Steven (wife Kayu and son Alexandre) and Abby (husband Rich, and sons Max and Jack), his wife Judy Armstrong and her children Clare and Kevin (wife Rachel and daughter Mia).

— John W. Stockwell, Jr.



Mines Geophysics will turn 100 in 2026!

Our program was established in 1926 as the world's first Department of Geophysics and continues strong today as one of the top global applied geophysics programs worldwide. We have initiated a wide range of activities celebrating and engaging our entire Geophysics family. We hope that you will continue to join us! Calendar updates can be found at <https://geophysics.mines.edu/100th-anniversary/> or contact us a geophysics@mines.edu

First GP@100 Workshop

Thank you to our alumni and friends who attended our first GP@100 GP Gives Workshop!

Dr. Eileen Martin and Dr. Jeffrey Shragge hosted the Department's first GP@100 GP Gives Workshop focused on Distributed Fiber Optic Sensing (DFOS), on Friday, November 11th. This workshop included an introduction to DFOS technology, varied applications, related research programs in the Department of Geophysics, and live demonstrations of fiber optic sensing.



December 12, 2022 - Chicago, IL	AGU Mines GP Alumni Reception
2023	
January	Remote Sensing Challenge Cup - Prize Awarded! Challenge will post in early January 2023
February	Colorado School of Mines #digmines - Field Closet Initiative
March	Distinguished Alumni Heiland Lecture and Reception in Person and Remote Zoom
April	GP Day Around the Word - Hoist one for GP! Regional Ambassador Hosts Needed
May 20-21 - Steamboat Springs, CO	Field Camp Alumni Weekend - Visit us in Steamboat!
June - Vienna, Austria	EAGE Mines GP Alumni Reception
July	GP Virtual 5K - Race details to come
August 28 - Houston, TX	SEG IMAGE Mines GP Alumni Reception
September - Golden	Welcome Back BBQ
October	Distinguished Alumni Heiland Lecture and Reception In-Person and Remote Zoom
November	GP Gives Workshop, topic and date TBD - Free to Alumni
December 11 - San Francisco, CA	AGU Mines GP Alumni Reception



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SUPPORT GEOPHYSICS

The Department of Geophysics is grateful for gifts and support from alumni, friends of the Department, and corporate partners. Your support helps us deliver many of the programs from which our students benefit, including graduate and undergraduate fellowships and scholarships, opportunities for students to engage in professional development activities, computing upgrades, department initiatives, and Field Camp.

If you are interested in making a gift to the Geophysics Department or sponsoring one of its programs, please contact the Mines Foundation (303-273-3275) or <https://weare.mines.edu/supportgeophysics>

