

geophysics

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FALL 2021



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Fall 2021

Colorado School of Mines
Department of Geophysics
Newsletter

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MINES DEPARTMENT of GEOPHYSICS

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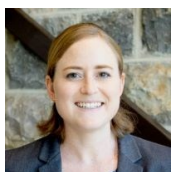
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Welcome from the Department Head

Welcome to the Fall 2021 edition of the Geophysics Newsletter!

I hope that this newsletter finds you well, in good health, and good spirits. I will use this opportunity to update you on the Department and, in particular, to highlight outstanding developments that will make a significant impact on our program.

As some may already know, Mines conducted faculty searches in clusters built around multiple themes during the preceding Academic Year. Geophysics played a central role in the Data Science cluster, and we were fortunate to receive significant interest from many excellent geophysicists. In fact, the quality of applicants in our field was so high that our colleagues on the search committee persuaded the Mines administration to hire not one but two outstanding colleagues to the Geophysics faculty. As noted below, both are excellent researchers and educators who have already made a significant impact in their fields and who will greatly enhance our program.

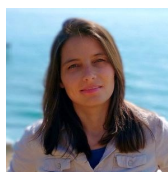


Dr. Eileen Martin will join the Mines faculty in January 2022 with a joint appointment in Geophysics and Applied Mathematics & Statistics. She obtained her Ph.D. (2018) in Computational and Mathematical Engineering from Stanford University and is currently an Assistant Professor in the Department of Mathematics at Virginia Tech.

Eileen's work centers on the theory and application of distributed fiber optic sensing through developing novel instrumentation, field deployments in multiple Earth environments, and petabyte-scale computational methods for data analysis. She applies her research to a diverse array of environmental, energy, and infrastructure questions, including subsurface imaging of geothermal sites, earthquake detection, permafrost thaw, near-surface geotechnical characterization, mine safety, and glacier motion. This broad spectrum of interests provides opportunities to collaborate broadly across disciplines at Mines.

Eileen has also successfully secured external funding and has been PI or Co-PI on ~\$2.5M in competitive NSF and DOE grants. She is a recent recipient of an NSF CAREER grant from the Office of Advanced Cyberinfrastructure focused on large-scale seismology algorithms.

Eileen is a committed educator who has devoted great energy to getting math undergrads started in theoretical and computational research over the past years. She is also a passionate advocate for women in science, launching a Women in Data Science event at Virginia Tech and promoting equity and inclusion across the geophysics profession.



Dr. Bia Villas Boas will join the Mines in May 2022 with an appointment in Geophysics. She received her Ph.D. (2020) in Physical Oceanography from the Scripps Institution of Oceanography at UC San Diego and is currently a postdoctoral scholar at Caltech, working closely with JPL researchers.

Bia's work focuses on studying the global oceans and their interaction with the atmosphere and includes theory, numerical modeling, and remote sensing. Her research lies at the forefront of quantifying how surface-wave physics influences global climate processes and has already made a significant impact on her scientific community, including by shaping upcoming NASA oceanographic satellite missions like the US-French SWOT (Surface Water Ocean Topography) mission to launch in 2022.

Bia has been recognized nationally and internationally for her research, being selected as a Fellow for the Planetary Boundary Layers program of the Kavli Institute for Theoretical Physics and as a French-American Doctoral Exchange Program laureate. Her research will strengthen collaborations with key external groups (NOAA, NCAR) working on climate physics, data science, and high-performance computing.

Bia is a dedicated educator, deeply involved in scientific computing education, and served as an instructor for The Carpentries - a global organization providing scientific computing training. She has a deep commitment to promoting diversity, equity, and inclusion and fostering a nurturing educational environment where students are supported to fulfill their potential.

We are thrilled to have Eileen and Bia on board and look forward to their arrival at Mines. They will make a tremendous impact on our program and drive the future scientific and professional leadership in our organization!

Welcome also our undergraduate and graduate students, who return to an almost normal Mines campus. With the whole Mines campus, we are rediscovering normal work patterns, including full in-person classes, and increasingly normal office and lab activities. We are also starting to travel again and host prospective students and visitors for lectures and research collaboration. I hope that we will see more of you — alumni, friends, and collaborators — on campus when your circumstances allow.

Finally, I would like to thank those of you who joined us for the Geophysics Reunion organized in September. It was an excellent opportunity to reconnect multiple generations of Mines geophysicists, and we look forward to the next opportunity to bring together our extended family. In just five years from now, we will cross into the second century of Mines Geophysics, and we hope to celebrate that milestone with a large gathering and many other activities of broad interest for our extended community. Please stay tuned and do not hesitate to reach out or visit when the opportunity arises.

I wish you only the best, with good health and professional success. Be safe! Stay in touch!

—Paul



Matthew Siegfried

MINES GLACIOLOGY LABORATORY: OBSERVING THE EARTH'S GLACIERS & ICE SHEETS FROM THE GROUND, AIR, AND SPACE

New research¹ out of the Mines Glaciology Laboratory uses laser altimetry measurements from NASA's newly launched, state-of-the-art ICESat-2 satellite, as well as European Space Agency radar altimetry, to track the filling and draining of subglacial lakes beneath the Antarctic ice sheets. The hydrological dynamics of these meltwater-fed lakes can impact ice velocity, ice mass loss, and ocean properties at the periphery of Antarctica. Therefore, constraining their physics is critical for improving ice sheet model projections and determining the transport of freshwater and carbon into the Southern Ocean. These isolated water features also serve as some of the most interesting Earth analogs for regions where we might find life elsewhere in the Solar System.

Led by **Dr. Matthew Siegfried**, the Mines Glaciology group uses satellite remote sensing techniques in combination with field-based and air-

borne geophysical methods to understand the physical processes of Earth's glaciers and ice sheets (continent-sized ice features). The team collects and synthesizes ground-, air-, and space-based data sets in an effort to span the spatial (centimeters to 100s of kilometers) and temporal (minutes to centuries) scales on which these processes occur. They apply creative geophysical approaches to overcome the inherent difficulty of observing continent-scale ice masses that drive and react to other components of the Earth's global climate system in order to develop new insight into ice-sheet evolution.

Some of Dr. Siegfried's recent work couples ground-based geophysical data with in situ data sets collected from a subglacial lake after melting a borehole through more than 3600 ft of ice, including fiber-optic-based temperature observations and sediment core analysis, to test hypothe-

ses developed using previous measurements from space. Dr. Siegfried is a science team member for NASA's ICESat-2 mission and is involved in seven active NASA and National Science Foundation grants, with the budgets totalling more than \$5,000,000.

Within the Glaciology Laboratory, Dr. Siegfried has cultivated a diverse and highly interdisciplinary team spanning glaciology, hydrology, geology, oceanography, and engineering. Two postdoctoral researchers within the lab broaden the team's foci. **Dr. Tasha Snow** couples a marine science background with glaciology to study the interactions occurring at the interface between the ice, ocean, and atmosphere around the Greenland and Antarctic ice sheets. She works with data scientists from the University of California Berkeley to build cloud-based, open-sourced machine learning and image processing techniques for developing new applications for satellite-derived sea surface temperatures (from thermal infrared imagery) and study ocean impacts on glacier change around Antarctica. **Dr. Roger Michaelides** brings planetary and engineering research to the group. He develops novel techniques for fully exploiting Interferometric Synthetic Aperture (InSAR) data to study dynamic processes in the Earth's hydrosphere and cryosphere, such as [permafrost dynamics](#). He is currently funded by the Colorado Geological Survey to map and investigate hazards across the state using InSAR. In

his free time, he also investigates pingos—important indicators of extant and extinct near-surface groundwater systems, hydrological properties, and local climate that have planetary analogs—in the Alaskan and Canadian Arctic with a *Previous page: Joint Mines/Georgia Tech field team, including Drs. Siegfried and Michaelides, collects multi-offset radar data for a pingo geophysical survey outside Deadhorse, AK in April 2021. Center this page: This summer, Cash Koning conducted field work on the Juneau Icefield and at the Mendenhall Glacier terminus.*



Cash Koning

variety of ground-based geophysical techniques. Dr. Michaelides will join the Department of Earth and Planetary Sciences at Washington University in St. Louis as an assistant professor in Fall 2022 and is looking for students interested in research opportunities.

The lab also includes three graduate students and six undergraduates. **Elena Savidge** is using ocean measurements from seal-based instruments to find plumes of warm water along Antarctica's ice edge that indicate regions of substantial localized ice melting. She pairs seal tag field measurements with optical imagery to ground-truth ocean observations from space. In collaboration with glaciologists at the University of Washington Applied Physics Laboratory, **Wilson Sauthoff** investigates active subglacial lake activity using ice surface height variability during lake drain and fill cycles. [His work](#) provides a better understanding of the subglacial hydrological system,

its stability under variable ice thickness, and its influence on the broader, interconnected glacier and marine environments. **Hannah Verboncoeur** joined the lab this semester. She will study the floating Ross Ice Shelf (the largest Antarctic ice shelf, spanning 182,000 square miles), which provides stabilizing backstress (i.e., buttressing) for ice streams and outlet glaciers around its periphery. Her work will combine various field observational techniques, such as historical and modern airborne radar sounding, satellite imagery, and regional ice sheet modeling to determine the factors influencing the ice shelf buttressing potential.

The research group is also currently recruiting **a new graduate student** to join the team next semester to use Global Navigation Satellite System (GNSS) reflectometry to study snow accumulation and densification processes in Antarctica and validate atmospheric climate models and snow/ice compaction physics. Undergraduate researchers within the group include **Michael Field, Venezia Follingstad, Cash Koning, Matthew Oleszko, Becca Prentice, and Anna Valentine.**

Continued from page 5

Within his team and the broader earth science community, Dr. Siegfried also fosters the development of cutting-edge educational tools, outreach, and synergistic polar community-building programs. He has collaborated with institutions ranging from local elementary schools to the U.S. State Department in an effort to facilitate a conversation about the local, regional, and global impacts of changes at the Earth's poles. Current work within the lab aims to build K-12, community college, and undergraduate

lessons around virtual reality 360° video collected in Antarctica and Greenland. Furthermore, the team aims to build Python computer programming and remote sensing-based workshops to help students learn marketable skills and gain exposure to polar research. Dr. Siegfried also helps to organize the annual, NSF/NASA-funded West Antarctic Ice Sheet Workshop where the same interdisciplinary, collaborative, diversity and inclusion principles are fostered.

In early September this year, several members from the Mines Glaciology Laboratory joined 10 other glaciologists, Earth scientists, and artists from across Colorado to investigate the state of the Arapaho Glacier, approximately 45 miles northwest of Golden. Unlike most other Colorado glaciers that have transitioned into unmoving snow fields, like the St. Mary's Glacier, the Arapaho Glacier may still contain enough mass to flow un-



Mines students investigating the Arapaho Glacier.

Tasha Snow

der the force of gravity, though, based on its trajectory, that may change in the next decade. The Mines team took ground penetrating radar measurements across the glacier, while other members of the expedition drilled ice cores and recovered ice samples for isotope measurements, produced a digital elevation model of the glacier using drone-based Structure-from-Motion, and gathered rock samples for dating the glacial history of the area. The hot summer day meant melt water was pouring across and off of the glacier while the team conducted its work, but measurements were largely successful in building a comparison study between measurements from the last two decades. —Contributed by Tasha Snow

¹Siegfried, M. R., & Fricker, H. A. (2021). Illuminating active subglacial lake processes with ICESat-2 laser altimetry. *Geophysical Research Letters*, 48, e2020GL091089. <https://doi.org/10.1029/2020GL091089>



Iga Pawelec

FIELD CAMP 2021



Right: Hammering in electrodes for a DC resistivity survey at the Mines Survey Field site. Below top left: Students learning about the Matrice M600 Drone platform for airborne geophysical survey at Geophysical Discovery Lab (GDL). Below top right: Drone-based magnetic survey being performed above Mines GDL. Bottom left: Ground-penetrating Radar Survey on Mines campus. Bottom right: Students happy, even in the rain, while performing a gravity survey near Clear Creek in search of the infamous Golden Fault. Right page bottom: Deploying the Betsy gun energy source for seismic experiments at the Mines Survey Field. (Photos contributed by Richard Krahenbuhl, Iga Pawelec, and Matthew Siegfried)



After a year hiatus, Mines Geophysics Field Camp resumed in the summer of 2021. Rather than traveling to a remote location to conduct geophysical surveys, Field Camp remained local to the Golden area and the Mines campus. Due to the cancellation of last year's Field Camp, this year included both third-year students going into their final year as well as fourth-year students who were soon to graduate. In total, six graduate student teaching assistants led six teams of undergraduates totaling about 40 students. Overall, the camp

lasted four weeks - students traveled to campus for in-person field work for two weeks and then conducted virtual data processing for the final two weeks. Although socially distant, the hands-on application still highlighted the experience of undergraduates. Field camp provided great opportunities for students to apply geophysical methods that professors described in their courses. Above all, students were happy to safely be together doing science after being separated for such a long time. — Contributed by David Churchwell



2021 Field Camp: Seismic Acquisition Experiments

This year, the Geophysics Department once again partnered with Geophysical Technology, Inc. and Dawson Geophysical Company to conduct seismic acquisition experiments during the field camp.

Experiment 1

The seismic survey included two dense 2D lines: one with 2 m spacing for sources and receivers and another one with 5 m spacing. We acquired several experimental data sets for further research on land seismic acquisition and processing.

In addition we acquired several experimental data sets with the potential for further research.

In our first experiment, we deployed 38 gradient arrays with 10 m spacing using the array design shown in Figure 1a. The simple cross allows for spatial derivative estimation via finite differences. Our goal was to use this design to increase the spacing between sampling points and reconstruct dense data, going beyond the traditional Shannon-Nyquist sampling. While the data analysis is preliminary, comparing the inline and crossline gradients (Figure 2) reveals that there are significant differences in the wavefields depending on the observation direction. Our future investigation will focus on understanding these differences and finding ways to use spatial derivative data for data reconstruction and noise suppression.

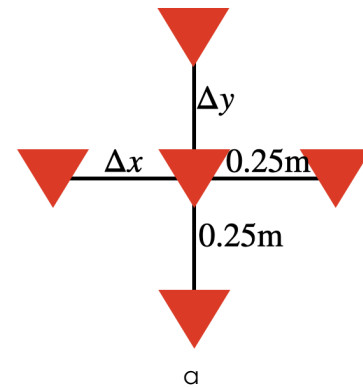


Figure 1: (a) Gradient array design ($\Delta x = \Delta y = 0.25$ m) and (b) image of the deployed array

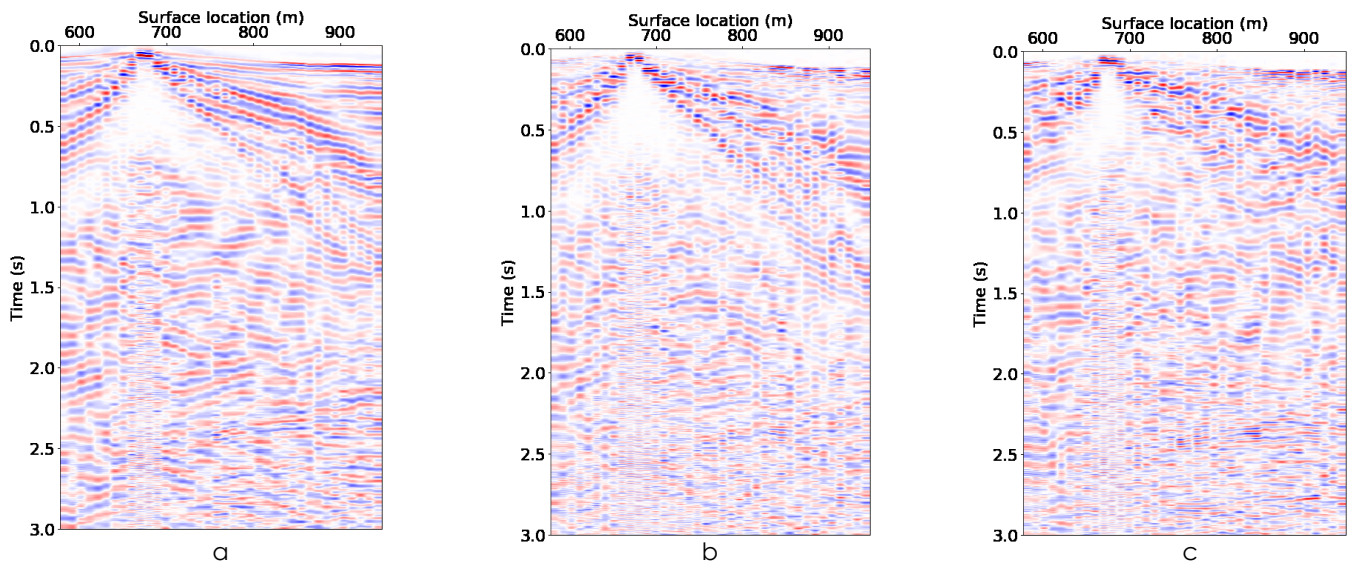


Figure 2: (a) Data from the central geophone of the gradient array, and (b) inline derivative and (c) crossline derivative.

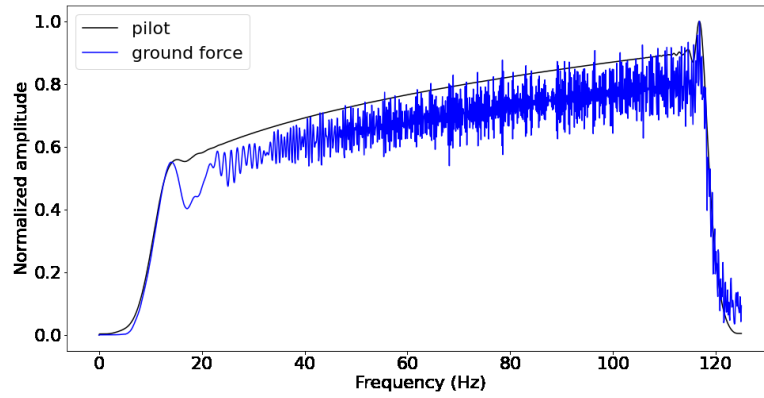


Figure 3: Amplitude spectrum of the reference sweep and the average ground force output.

Experiment 2

Our second experiment aimed to investigate the repeatability of Vibroseis sources and quantify the changes in subsurface properties resulting from ground compaction. We positioned the sources next to the denser line and repeated the same sweep 200 times. Rather than relying on the pilot sweep, we saved the ground force signal estimate computed from the accelerations measured on the baseplate and reaction mass. Figure 3 shows

the amplitude spectrum of the pilot sweep and the average ground force signal. The decreased force output for 12-22 Hz is particularly intriguing and has been confirmed by nearby geophones. In future work, we will analyze how that diminished output evolves as a function of sweep number and what changes occur in near surface properties over the course of 200 sweeps.

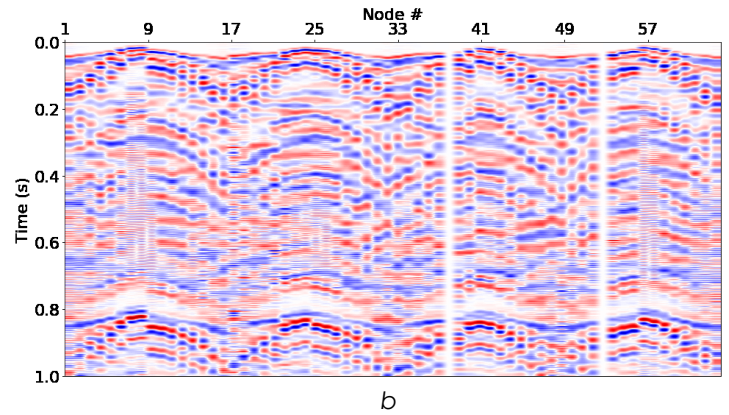
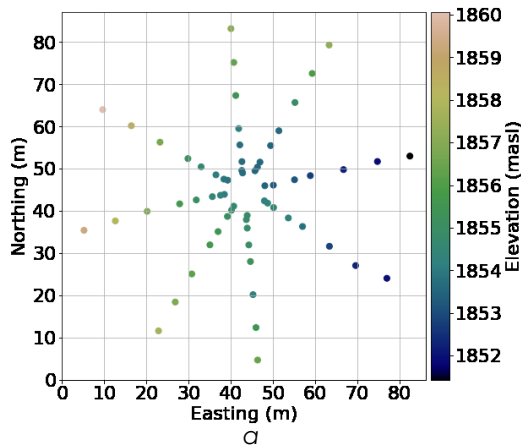


Figure 4 (a) Star array geometry for analyzing near-surface scattering. (b) Betsy gun shot data panels corresponding to the four lines forming the star array on plot (a).

Experiment 3

In our final experiment we deployed a star array whose aim was to assess and quantify directional near surface heterogeneity and scattering. Since much energy generated by the seismic source is trapped in the near surface, we sought to evaluate its directional transmission and characterize the subsurface volume in the vicinity of the source. Armed with 64 nodes, we designed the star array depicted in Figure 4(a), to quantify wave behavior at short wavelengths in the near source region. Given the limited number of sensors, we had variable sampling along the lines forming the star, with the densest sampling at the center and sparsest at the edges. Figure 4(b) shows example data recorded using

a Betsy gun impulsive source. The discontinuity in the first data panel indicates the presence of shallow heterogeneity in the middle of the array, while the irregular sampling and offset range limit the available analysis tools. We will repeat a similar experiment with higher sampling at future field sessions.

Experimental data acquisition is a growing component of each field session. While we continue to collect conventional line data, we also encourage thinking outside the box and challenging the assumptions about geophysical data acquisition and processing. This trend is likely to continue, and experiments will evolve as additional equipment is brought to the field. — Contributed by Iga Pawelec

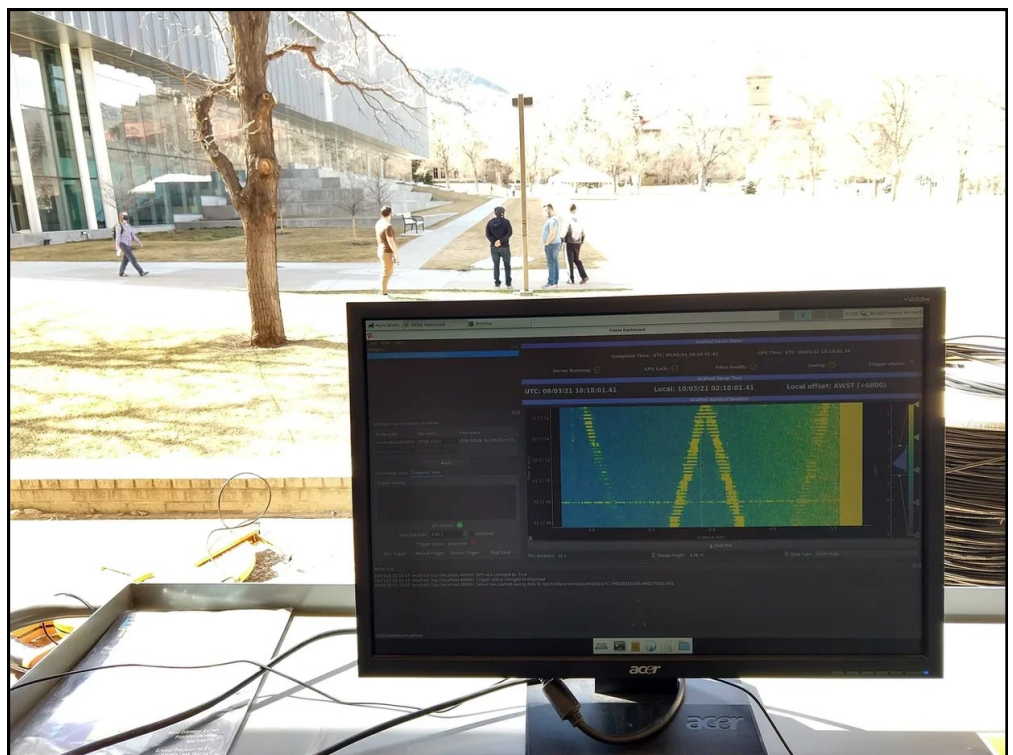
Explorations in Distributed Acoustic Sensing (DAS)

As any geophysicist knows, seismic waves are one of the primary proxies for studying processes in the Earth and its structure. They can be used to resolve large-scale structures in the core, mantle, and crust, as well as much smaller-scale structures such as fault zones or hydrocarbon reservoirs. Seismic waves are also the primary tool in understanding the mechanisms that govern earthquake generation and their link to the Earth's structure and dynamic processes. A seismic study can be either active, in which human-generated sources are used, or passive, in which the naturally occurring background seismic field is recorded.

One problem with using seismic waves is that seismic sensors can be expensive, challenging and time consuming to deploy. This is why Distributed Acoustic Sensing (DAS) has been gaining popularity for both industry and academic purposes for studies including surface and borehole applications. DAS offers an exciting type of seismic measurement that provides both high spatial and temporal resolutions and can record dense seismic data over tens of kilometers, as well as record high-fidelity seismic signals with wavelengths as short as a few meters. All of this is done with a single fiber and an interrogator. Moreover, DAS is sensitive not only to seismic signals, but to a wide frequency range of strain-change signals across more than 17 octaves from submillihertz to more than 100 kilohertz. Thus, depending on application and frequency range of interest, DAS can be treated as tensometer, broadband seismometer, geophone,

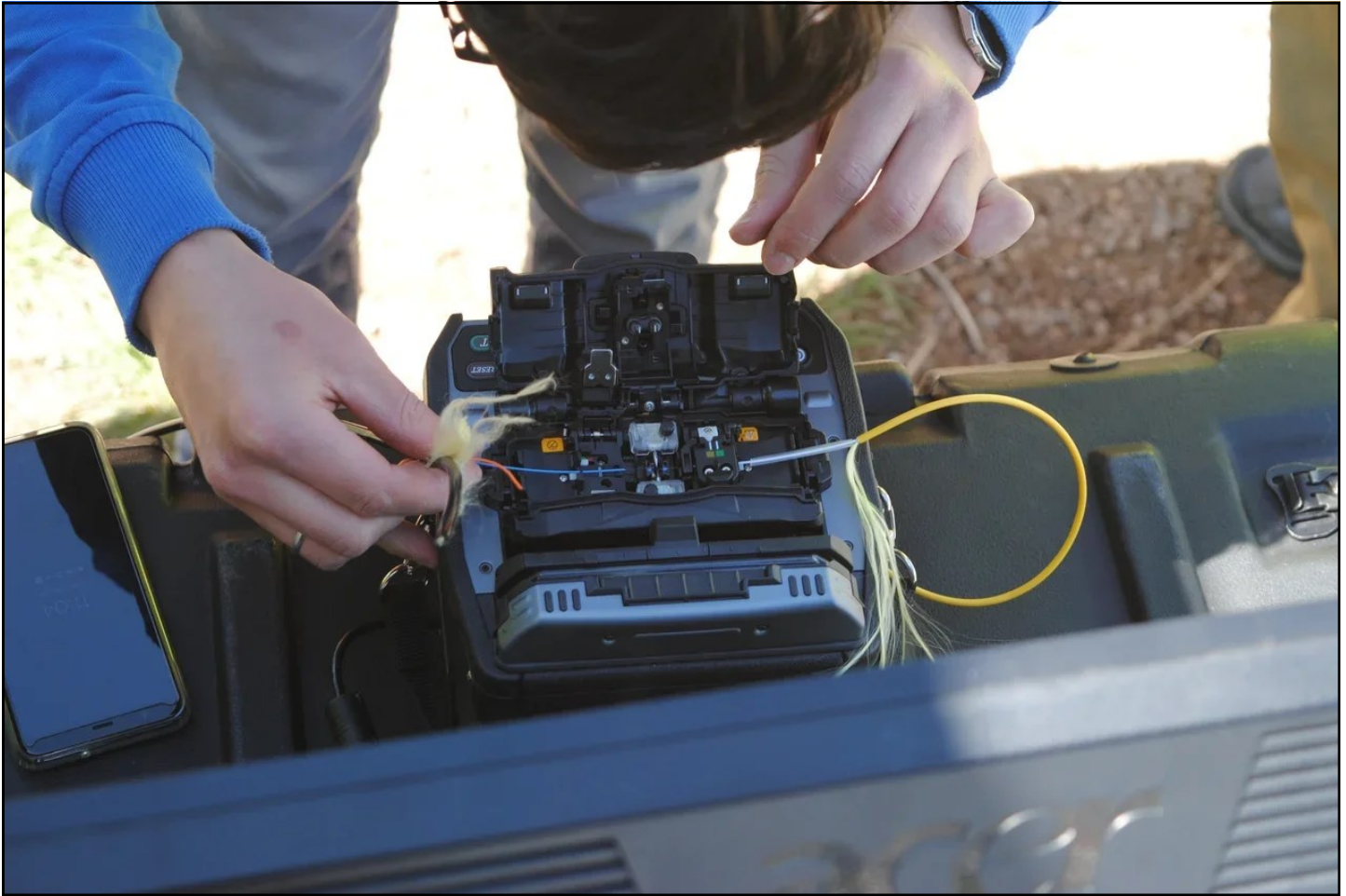
hydrophone, or even microphone. Yes, we have even listened to DAS-recorded music!

A DAS interrogator converts a standard telecommunications single mode glass fiber into thousands of extremely sensitive acoustic and vibration sensors. The interrogator connected to one end of the fiber uses a laser generator to send thousands of short pulses of light into the fiber every second. As the light travels in the fiber, it is reflected back from fiber imperfections in a process known as Rayleigh Backscattering. Vibrations from the surrounding environment will disturb the fiber and cause differences in the reflections that will then be observed by the DAS interrogator. The actual measurement that is recorded is the amount of strain change on the fiber at any particular location, which can then be converted to a particle velocity similar to that measured by traditional geophones. However, unlike geophones measuring at predetermined



Aleksei Titov

Real-time footstep tracking with temporary fiber cable installation on Kafadar Commons during "Introduction to distributed fiber optic sensing class".



Anna Titova

Connecting two silica glass optical fibers using electrical arc (fusion splicing) during Geophysics Field Camp 2021.

discrete points, DAS utilizes the entire fiber to take distributed measurements. The optical fiber IS the sensing element!

The Geophysics department is fortunate to have faculty and students who are experts in the DAS technology as well as two interrogators for use in seismic and other experiments. They have been and are continually working on applying this exciting technology to the problems we see in the field, as well as to what new opportunities come with the new technologies.

Projects in the Geophysics Department implementing DAS data range from vertical seismic profiling (VSP) data from the North Slope of Alaska and the Gulf of Mexico to surface recorded data in Colorado (including one professor's back yard), to other short-term surface arrays for both active and passive exploration. One can even transform telecommunications fiber-optic cables that already exist into dense seismic arrays. One project is even proposing to use the fiber infrastructure in

the City of Arvada for a passive monitoring exercise.

The RCP group is dedicated to understanding the value of the fiber for other applications including Distributed Temperature Sensing (DTS) and Distributed Strain Sensing (DSS), which collectively with DAS are called Distributed Fiber-Optic Sensing (DFOS). The applications of these technologies include time-lapse VSP, tube-wave analyses, micro-seismic analyses, and even flow monitoring.

In the spring semester of 2022 the department will welcome Assistant Professor Eileen Martin, who will bring her expertise to the department, as she has worked with several DFOS systems in the past and continues to work with DAS projects.

Mines Geophysics is proud to be a leader in this exciting technology and on the cutting edge of new research. —Contributed by Aaron Girard

Reconnecting in 2021

Geophysics Alumni Reunion

Alumni, faculty, students and staff reconnected this fall at the first Geophysics Department Reunion. Meeting over the September 25th-26th weekend, the event offered a chance for both a friendly reunion and an opportunity to strengthen the bonds between past and present as the department prepares for a future of growth and change.

According to Department Head Paul Sava, the "Department's connections to the world is through its graduates and alumni which fuel the continuum of the department." Thus, Sava said, the reunion was important for building the intergenerational community of Mines geophysicists, especially after such a long period of isolation.

Happy Hours

The reunion weekend kicked off with alumni happy hours. There were three different locations - The Eddy Hotel and Taproom, Golden City Brewery, and Mountain Toad - that hosted happy hours for three different alumni groups - pre-1990, 1990-2010, and 2011-2021.

People were thrilled to be together once again. Smiles and laughs were spreading around the tables, and the usual questions were asked in order to catch up with one another: Where are you working? What are you researching? What are you up to now? However, it was not these questions that defined the mood for the happy hours. It became clear that one common thread was lining its way throughout the evening for everybody: the strength of community.

The COVID-19 pandemic shook the globe and caused in-person social gatherings to cease in its



Iga Pawelec

wake. Some, however, have discovered a previously unrecognized sense to grow together as a community - one that has experienced the similar wonders, difficulties, and growth of Mines Geophysics in some way. It was this that came out to all, in some sort of manner, at these events. Every story - whether it was a memory from an old class, or a tale describing the fun students would have after work-days of field session - brought to the fore how each and every graduate had recognized the community they had, and still have, after graduating from Mines Geophysics. Conversing over drinks simply provided the atmosphere in which it was manifest. Mines Geophysics provided the link.

As the happy hours closed and people headed towards the dinner, what stuck in the air was a sense of thankfulness for people being together again. It seemed like a long lost sense, especially after a pandemic that has changed the course of in-person gathering. However, it was showcased in full-force for all Mines Geophysics alumni at the happy hours.

Dinner

The reunion dinner was the main event to bring the intergenerational group together to celebrate Mines Geophysics. The dinner did not just highlight where Mines Geophysics had been, but pointed the department towards the future.

This was a theme brought up by Department Head, Dr. Paul Sava, during his remarks. Sava walked through critical crossroads facing the department and how it was during these trying times that they realized change was not only necessary but paramount. Such change would not only keep Mines Geophysics up-to-date with recent technological innovations and research but would also allow the department to fully realize itself as a community for all potential students, regardless of background or interest. Sava highlighted changes such as a new department-wide curriculum, more interdisciplinary collaboration, and increased diversity within faculty, staff, and students. Sava stressed the change is ongoing, but it is necessary to maximize Mines Geophysics' full potential.

Similar themes were emphasized by the evening's keynote speaker, Katerina Gonzales. Gonzales, a 2015 Geophysics alum, put together a vision for geophysics and its ability to illuminate the complex, deep rooted problems that are present in today's society. She said it is critical for all to recognize the usefulness in, "seeing below," which could mean seeing below the earth, seeing below the surface of a simple problem to truly understand the complex nature of things, or seeing beneath the surface of a friend to check in on their emotional wellness. This lets people establish a broader viewpoint that might open more minds and establish more empathy in the beholder. Gonzales told the audience that people must also have the courage to act on these newfound broader perspectives. In order to implement the

change that must happen after "seeing below", people must be willing to recognize what elements of work/research are unhelpful and act accordingly. Not only that, but people should have inner strength and bravery to face the daunting challenges of today while maintaining humility and responsibility for promoting equality and healthy relationships (with other people and one's own work). As Mines Geophysics forges ahead into the future, Gonzales' vision is that the department should be a haven for growth and innovation in the midst of the grand challenges that plague the world.

After Gonzales' speech, Society of Student Geophysicists (SSG) President Michael Field and Socie-



Iga Pawelec

Alumni standup during an interactive portion of the evening.

ty of Graduate Geophysics Students (SGGS) Vice President Brett Bernstein took the podium to get the audience moving, asking the audience to stand up and sit down in response to a series of questions. SGGS pint glasses were handed out to the oldest alum present and the alum who traveled the furthest distance to attend the dinner that evening.

Overall, the reunion dinner was successful in bringing together Mines Geophysics alumni and current faculty, staff, and students and promoting a vision for Mines Geophysics that is pioneering and inspiring.

Hike/Kafadar/Tours

Sunday was a beautiful morning for alumni activities. At 9 am a group of about 10 alumni set out on a hike up South Table Mountain. Along with the hike, small groups participated in campus tours to reminisce and reflect on how much the campus has changed over the years. Many alumni agreed that despite the recent frenzy of building and remodeling on campus, two things have remained the same: the lack of air conditioning in the Trads, and the Green Center basement. During the walk through the Green Center basement several alumni recognized their common experiences. It was difficult to make it past two rooms without having someone share a memory of doing research in at least one of them. In the radiation room, 2018 graduate Mandy Schindler reflected on her senior project saying, "I practically used to live in this room my senior year." She even took a couple selfies with the machines as if they were old friends.

On Kafadar commons, alums put their geophysical knowledge to the test. Using three different

geophysical methods, they had to find the location of certain objects buried in the Kafadar Geophysics underground laboratory. The methods used were hammer seismic, GPR, and a magnetometer. People of all ages and even outside of the reunion stopped by to test some of the equipment. One of the student volunteers explained how "The scavenger hunt is a great way for the alumni to use what they learned during their time here at Mines while also being able to test out some of today's new technologies." Overall, Sunday's attendance was smaller than Saturday's but the enthusiasm and love for geophysics was equally great.

The weekend's events were amazing for many participants including 1992 graduate Rob Elliott who said, "It is so great to be able to see everyone again." Having everyone together for the first time was a sweet light at the end of a dark two-year tunnel and the beginning of a beautiful new Mines geophysics tradition. — *Contributed by David Churchwell and Chloe Locke*



Iga Pawelec

Alumni/Students' Favorite Memories

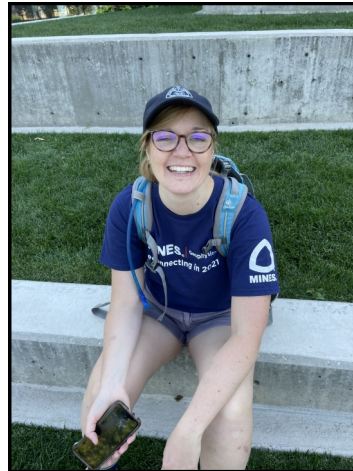
Peter Papazian '79

Favorite Memory:
Field camp in
Sawatch and the
lovely basement of
the Green Center



Mandy Schindler '18

Favorite Memory: Going
for after work beers with
her research group



*Favorite
Memory:*
Mines being
such a
great place
to be, mak-
ing a lot of
international
friends, and
learning a
ton



Gerardo Garcia '91

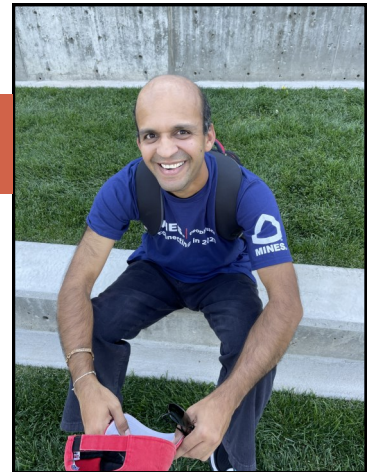
Kurang Mehta '08

Favorite Memory: Hanging
out in Higher Grounds and
talking about geophysics
with classmates



Terrill Ray '90

Favorite Memory: The great
group of people in the ge-
ophysics department, field-
camp in Fairplay, and the
theory of fields class



Hannah Flamme
'17, '21

Favorite Memory:
The sense of com-
munity and how all
the grad students
want to help each
other and know
what other stu-
dents are doing



Favorite Memory: The
sense of community and
how the professors al-
ways make time for their
students and are always
willing to chat

Andréa Darrh '23



—Contributed by Chloe Locke

Workshop Series: "Teaching with a Heart"

Over the summer, Dr. Roel Snieder taught a four-part workshop series called "Teaching with a Heart". The workshops were aimed at helping instructors in higher education to create a compassionate and nurturing classroom environment. Dr. Snieder taught the series with Cynthia James and Dr. Qin Zhu. Ms. James is a world-renowned speaker, author, minister, and transformational coach who focuses on emotional integration. Dr. Zhu is an assistant professor in ethics and engineering education at Mines. The series consisted of the following workshops:

1. How do you show up in the classroom and why does it matter?
2. Bringing authenticity and compassion into the classroom,
3. Supporting your student emotionally, and
4. Developing intention and attention.

The workshop series was attended by 16 teachers from Mines, Red Rocks Community College, the University of Illinois, and the University of Tennessee. The series was evaluated very positively, with one participant saying:

"Through the course of our two weeks together I had more ideas for how to adjust and reorganize and rethink my classroom than I have had in the past two years. The focus on mental, spiritual, and academic health was truly inspiring and unique. Too often, professors do their job in isolation and this can lead to stagnation on the part of the educator and the student; this course helps to rethink and reform our approaches to teaching by creating healthy relationships to work, to each other, and to our students."

As part of his role of Professor in Professional Development Education, Dr. Snieder and his co-workers will continue developing material for the Teaching with a Heart workshops, and expand the audience to which this type of training is offered.



Roel Snieder



Cynthia James



Qin Zhu

SGGS Kicks Off Fall Running

The Society of Geophysics Graduate Students (SGGS) started Fall 2021 running! Although this past year brought significant challenges to graduate student events, SGGS stuck to its core mission of bringing grad students together and building camaraderie between research groups. The academic year started with officer elections and every grad student's true passion, food! The 2021-2022 SGGS officers are made up of both first-year and current students from various research groups. SGGS has resumed bi-weekly student happy hours

and has several autumn-themed celebrations planned, including celebrating National Dessert Day with pizza and a surprise dessert treat and Halloween with a pumpkin carving and lunch event!

For fans of the Geophysics pint glass, SGGS will be releasing Geophysics merchandise for both the office and the chilly autumn! SGGS is looking forward to hosting many more events this semester. We hope to see you there!

2021-2022 Officers:

- President: Gavin Wilson
- Vice President: Brett Bernstein
- Treasurer: Iga Pawelec
- Social Media Chair: Rosie Zhu
- Social Chairs: Mari Held, Tomas Snyder, David Churchwell

Student Organizations

SSG Sets Big Plans for Fall Semester

SSG has big plans for the Fall semester. According to president Michael Field, the group is "hoping to take part in a classroom takeover program to conduct labs remotely in K-12 classrooms to promote geophysics at Mines and diversity in STEM." In addition the group is hosting some department volleyball games, as well as a great lineup of speakers including new Assistant Professor Eileen Martin, Planetary Institute Senior Scientist and Mines Geophysical Engineering alum Nathaniel Putzig, and The Ohio State University Associate Professor Ann Cook. SSG is also excited to announce their new officers.

2021-2022 Officers:

- President - Michael Field
- Vice President - Cash Koning
- Treasurer - Seunghoo Kim
- Secretary - Danielle vonLembke

Research Roundup

Department research projects funded through grants and contracts reflect a breadth of research interests and collaborations. Below is a list of such projects currently underway in the department.

Research Begun in 2021

Project: Creating CO2 storage capacity maps for the Colorado State Land Board surface estate

PI: Manika Prasad

Funding agency: Colorado State Land Board

Amount: \$51,238

Project description: This project will assess the suitability of Colorado public lands for carbon sequestration.

Project: Collaborative Research: Frameworks: Seismic COmputational Platform for Empowering Discovery (**SCOPED**)

PIs: Ebru Bozdog and non-Mines collaborators listed below

Funding agency: National Science Foundation

Amount: \$613,000

Project description: The goal of SCOPED is to establish a novel hybrid cloud+HPC computational platform for use by the broader scientific community that combines large-scale processing and modeling of seismic data with a suite of open-source seismic codes. Education and training of the new generation of seismologists with desired computational skills to operate big data and HPC/Cloud computing are also one of the main goals of SCOPED to facilitate the continuation of research and scientific discoveries. The SCOPED team includes Carl Tape (the University of Alaska Fairbanks), Marine Denolle (the University of Washington Seattle), Felix Waldhauser (Columbia University Lamont), Ian Wang (the Texas Advanced Computing Center & the University of Texas Austin), and Dr. Bozdog. SCOPED officially started in September 2021 and will be active for four years.

Project: Collaborative Research: Investigating four decades of Ross Ice Shelf subsurface change with historical and modern radar sounding data

PI: Matthew Siegfried

Funding agency: National Science Foundation

Amount: \$317,470

Project description: This project, led by Georgia Institute of Technology and in collaboration with Stanford University, exploits nearly half a century of historic film and modern digital radar observations over Ross Ice Shelf, Antarctica. Ross Ice Shelf provides resistance to the outflow of numerous large outlet glaciers and ice streams that drain both the East and West Antarctic ice sheets, and these comprehensive radar surveys collected since the 1970s provide insight into the structural integrity of Ross Ice Shelf as well as ongoing ice-shelf processes that drive large-scale ice sheet evolution like basal melting and refreezing.

Project: Drone detection and mapping of flowlines

PI: Yaoguo Li

Funding agency: Leidos

Amount: \$43,758

Project description: Feasibility of flow line detection and characterization using drone-based magnetic data: The project investigates the feasibility of and methodology for detecting and characterizing flow lines in the oil field using magnetic data measured from drone platform and machine-learning methods.

Project: Seismic and hydrostratigraphic characterization of the onshore-offshore freshwater systems of Martha's Vineyard and Nantucket, Massachusetts, USA
PIs: Brandon Dugan, Jeffrey

Shragge

Funding agency: National Science Foundation

Amount: \$49,417

Project description: This project will use geophysical surveys to increase our understanding of coastal freshwater resources by characterizing the sedimentary layering in the coastal environment.

Project: Investigating groundwater flow, submarine groundwater discharge, and slope stability on the Atlantic continental slope offshore Massachusetts, New England, USA

PI: Brandon Dugan

Funding agency: International Ocean Discovery Program (IODP)

Project description: This project will use scientific drilling, in situ measurements, laboratory experiments, and numerical modeling to enhance our understanding of the relations between fluid flow and seafloor seepage, which has implications for slope stability, ocean chemistry, biological diversity, and ecosystems services.

Project: Managing frac hits to reduce environmental impacts and improve resource stewardship

PI: Dr. Ge Jin

Funding agency: Department of Energy: National Energy Technology Laboratory

Amount: \$42,519

Project description: The project uses computer vision to identify frac-hit precursors in the low-frequency DAS data in real time, so we can protect parent wells from being damaged by child well completion in unconventional reservoirs.

Project: Decarbonizing the Intermountain West

PI: Manika Prasad

Funding agency: National Energy

Technology Laboratory (NETL)

Amount: \$250,000

Project description: This project is part of NETL's CarbonSAFE project and will address energy challenges by developing a regional technology roadmap to transition the Intermountain West to a carbon neutral and economically sustainable energy system within the next 15 years.

Project: The enigmatic surface of Bennu: Using OSIRIS-REx data to calibrate ground-based radar observations of near-Earth asteroids (NEAs)

PI: Dylan Hickson

Funding agency: National Aeronautics and Space Administration (NASA)

Amount: \$461,599

Project description: High-resolution radar scattering simulations are being performed using data of NEA 101955 that Bennu obtained by NASA's OSIRIS-REx sample return mission. The purpose is to better understand the processes on the unique surfaces NEAs possess. This research is a collaboration between University of Arizona, University of Helsinki, University of Florida and Mines. Mines Geophysics undergraduate Amanda Camarata is also working on this project.

Project: Leveraging ICESat-2 altimetry for Antarctic subglacial lake identification, evolution, and basal properties

PI: Matthew Siegfried

Funding agency: NASA

Amount: \$334,837

Project description: This project funds Dr. Siegfried's work which is part of NASA's ICESat-2 Mission Science Team to use ICESat-2 laser altimetry to generate high precision maps of surface-height change across the Antarctic ice sheet that provide windows into subglacial water systems.

Project: Easy Deployed Distributed Acoustic Sensing System for Remotely Assessing Potential and

Existing Risks to Pipeline Integrity

PIs: Ge Jin, Yilin Fan, Ali Tura, and Jennifer Miskimins

Funding agency: Department of Transportation

Amount: \$665,370

Project description: The project is expected to provide economical solutions that use distributed acoustic sensing (DAS) for pipeline long-term, real-time monitoring.

Project: Collaborative Research: Characterizing controls on post-fire steep-land ravel - when does bioturbation go too far for diffusive models?

PI: Danica Roth

Funding agency: National Science Foundation

Amount: \$349,920

Project description: This project will use a novel combination of short-lived radionuclide analysis, high-resolution topographic data and physical measurements to calibrate and conduct the first field test of a convolutional sediment flux model on long-distance sediment transport after wildfire in California.

Ongoing Projects

Project: Mines multidisciplinary academic-industry consortium - redefining academic-industry-agency consortia for the coming decade

PI: Brandon Dugan

Funding agency: Colorado School of Mines

Amount: \$15,000

Project description: This project has a primary goal to develop a revitalized consortium model that feeds into a new multidisciplinary consortium between energy companies, geoscientists, and petroleum engineers at Mines. The research team is gathering input from companies and federal and state agencies to discuss all options for a 21st century consortium model. The team will integrate the response to put forth the "best" option based on our

external needs and internal capabilities. The learnings and outcomes will be conveyed to on-campus colleagues across all campus disciplines.

Project: #22: Geophysical imaging at Majes I and Majes II for geology, water, cemented subsoils, and landslide risk

PIs: Richard Krahenbuhl, Yaoguo Li, Jeffrey Shragge, Brandon Dugan

Funding agency: Universidad Nacional de San Agustín de Arequipa - UNSA

Amount: \$780,001

Project description: This project is the second phase of our initial successful geophysical investigations at the major agricultural development of Majes I in southern Peru to better understand the broader 3D distribution of geology and subsurface water movement as they relate to increased landslide hazards. This study will help develop decision-support tools for water use, land use and landslide risk assessment. The second component of the project is to perform a focused, near-surface geophysical survey over a test-bed at the future Majes II agricultural development to understand the general distribution and properties of the shallow cemented subsoils (caliche) that must be identified and broken up prior to development, irrigation and cultivation.

Project: Observationally constrained simulations of the evolution of polar snow using a multi-sensor approach

PI: Matthew Siegfried

Funding agency: NASA Goddard Space Flight Center

Amount: \$157,520

Project description: This project, led by the NASA Goddard Space Flight Center and in collaboration with University of Colorado-Boulder, University of Maryland-College Park, University of Oregon, and University of Washington, aims to fill in an urgent gap in our understanding of Earth's atmosphere

-ice-ocean interactions by producing observationally constrained models of all stages of the life cycle of snow over ice sheets. To develop these models, the team is leveraging several unique satellite measurements, complementary existing airborne and in situ measurements, global atmospheric modeling, mass and energy balance modeling, and process modeling.

Project: Constraining West Antarctic snow accumulation and firn densification processes with GNSS reflectometry

PI: Matthew Siegfried

Funding agency: NASA

Amount: \$315,899

Project description: This project, led by Mines and in collaboration with NASA Goddard Space Flight Center, uses GPS signals emitted from orbit as signals of opportunity to produce time series of net snow accumulation across Antarctica in order to validate atmospheric climate models and firn compaction physics. We will also push the development of this GPS interferometric reflectometry method to test the limits of its space and time resolution.

Project: Pingo SubTerranean Aquifer Reconnaissance and Reconstruction (Pingo STARR)

PIs: Matthew Siegfried, John Bradford, Andrei Swidinsky (Mines affiliated faculty)

Funding agency: Georgia Institute of Technology

Amount: \$445,961

Project description: This project, led by Cornell University and in collaboration with University of Alaska Anchorage and Planetary Science Institute, uses poorly investigated ice-cored hills in the Arctic called "pingos" as an analog to understand potentially similar geomorphic features on Mars and Ceres. Pingos on Earth are important indicators of extant and extinct near-surface groundwater systems, hydrological properties, and local climate, and therefore

pingo-like features on other planetary bodies may provide a history of water elsewhere in the solar system and represent potential resource deposits for future explorers. We are investigating pingo systems in the Alaskan and Canadian Arctic with a variety of ground-based geophysical techniques, including ground penetrating radar, time domain electromagnetic, and capacitively coupled resistivity, as well as space borne radar imaging.

Project: WAIS Workshops 2020 and 2021: A transdisciplinary forum to accelerate NASA-funded research of marine-based ice sheet systems AND 2019-2021 WAIS Workshops: A transdisciplinary forum for studies of the West Antarctic Ice Sheet and the next generation of polar scientists (Two separate grants)

PI: Matthew Siegfried

Funding agency: NASA and NSF

Amount: \$77,245, \$123,524

Project description: The West Antarctic Ice Sheet (WAIS) Workshops, held over the past quarter century, have been a key venue for transdisciplinary scientific exchange on the state and behavior of WAIS, processes that influence its change, and projections of its future mass balance and sea-level contribution. The community-based structure of the workshops brings together students, early-career, and senior scientists who are investigating WAIS using ground-based and shipborne methods, airborne geophysics, satellite remote-sensing, and numerical modeling all under the same roof to answer difficult, but essential questions regarding the fate of WAIS and other marine-based ice sheets.

Project: Towards improved imaging of the outermost core through determination of the effects of lowermost mantle heterogeneity and anisotropy

PI: Ebru Bozdog

Funding agency: National Sci-

ence Foundation

Amount: \$269,000

Project description: Earth's outer core is molten iron, plus roughly 10% of a lighter alloying material. With a radius that is slightly larger than the planet Mars, the core sits ~2900 km below Earth's surface. The fluid outer core holds high importance for a number of reasons, including the generation of Earth's magnetic field, and being an important mechanism to transfer heat to the mantle, which helps to drive the convective engine responsible for plate tectonics. This project tests commonly used methods, corrections, and approximations to investigate the region and ultimately move towards full-waveform modeling to improve the models and our understanding of the outermost part of the outer core. PhD student Reynaldo Vite Sanchez and Post-doctoral fellow Dr. Neala Creasy also work on this project.

Project: Collaborative Research: Calibrating quartz fabric intensity as a function of strain magnitude: a field-based investigation in the Snake Range core complex, Nevada

PI: Jeffrey Lee

Funding agency: NSF

Amount: \$82,641

Project description: This project quantifies the relationship between finite strain and kinematics by generating a calibration equation that expresses fabric intensity of quartz crystallographic fabric data as a function of finite strain magnitude. This calibration centers on the Prospect Mountain quartzite, which is well-exposed within the well-characterized, Cenozoic extensional shear zone in the Northern Snake Range metamorphic core complex, Nevada. The project provides an important opportunity to quantify strain localization within the deeply exhumed portions of any orogen, which is essential for characterizing the dynamics and rheological evolution of deforming litho-

sphere. The project is in collaboration with Prof Sean Long, Washington State University, and his PhD student Nolan Blackford.

Project: Planetary orbital radar processing and simulation system

PIs: Paul Sava, Nathaniel Putzig (Planetary Science Institute)

Research associate: Dylan Hickson

Funding agency: NASA

Amount: \$178,680

Project description: With the number of radar instruments flown on space missions increasing, developing open-source software to process and simulate acquired data is essential. This project aims to develop a general orbital radar simulator and processor integrated with a geographic information system to enable improved analysis of orbital radar datasets and increase collaboration within the planetary science community.

Project: CAREER: (An) elastic mantle structure based on 3D wave simulations & full waveform inversion: From GLObal ADjoint models to visualization of Slabs, Plumes And Convection in MANTle (SPAC-MAN)

PI: Ebru Bozdog

Funding agency: National Science Foundation

Amount: \$620,000

Project description: Advances in supercomputers and numerical methods, together with the increase in the quality and amount of seismic data in recent years, have provided new opportunities to improve the resolution of tomographic images based on 3D numerical wave simulations. This project images the attenuation structure of the mantle through simultaneous elastic and anelastic full-waveform inversions. Furthermore, to improve the global data coverage, specifically underneath oceans, we explore assimilating emerging data sets in full-waveform inversions, such as those from acoustic floating robots MERMAIDS. To facilitate effective exploration of Earth's mantle for re-

search and educational activities, constructed models together with data from other disciplines are being used to design an interactive, collaborative Earth model, SPAC-MAN (Slabs, Plumes And Convection in MANTle), for visualization in virtual and augmented reality environments and planetariums. The collaboration with the Denver Museum of Nature & Science will reach a range of age groups from children to adults, educating them on the interior of our planet and its dynamics while promoting STEM fields. PhD student Rachel Willis works on this project.

Project: Imaging rock properties and CO₂ density using gravity, EM, and seismic data AND quantitative imaging of 4D pressure changes using seismic data (Two grants)

PIs: Manika Prasad, Jyoti Behura

Funding agency: Department of Energy

Amount: \$400,914, \$466,953

Project description: The SMART initiative is a ten-year, multi-organizational effort with the goal of transforming interactions within the subsurface and significantly improving efficiency and effectiveness of field-scale carbon storage and unconventional oil and gas operations. Prasad and Behura along with Mathias Pohl, Hua Wang (Dept. of Mathematics and Computing), and Yaoguo Li are researching the development and application of machine learning algorithms to overcome the challenges posed by the lack of massive amounts of data in geophysical applications. More information about the project can be found at <https://edx.netl.doe.gov/smart/>.

Project Title: Feasibility simulations of EM monitoring of CO₂ storage

PI: Yaoguo Li

Funding Agency: Department of Energy

Amount: \$76,740

Project description: Numerical feasibility study of CO₂ storage moni-

toring using electromagnetic geophysical methods: The project investigates the feasibility of monitoring CO₂ storage in saline formations by carrying out numerical simulations of responses in such scenarios when using active- and passive-source electromagnetic methods.

Project: MARSIS 3D imaging

PIs: Paul Sava, Frederick Foss (Freestyle Analytical & Quantitative Services (FREAS), LLC)

Research associate: Dylan Hickson

Funding agency: NASA

Amount: \$262,734

Project description: The Mars Advanced Radar for Subsurface and Ionosphere Sounding (MARSIS) instrument onboard the European Space Agency's Mars Express Orbiter has collected dense coverage of radar sounding data over the polar regions of Mars since launching in 2003. This project uses 3D wavefield imaging techniques to produce the first properly imaged 3D volumes of the north and south polar ice caps on Mars from MARSIS data.

Project: Carbon Utilization and Storage Partnership (CUSP) for the Western USA

PI: Ali Tura

Funding agency: Department of Energy

Amount: \$350,000

Project description: This multi-year project involves collaboration with 13 states. The overall project objective is to implement a regional initiative in order to accelerate onshore CCUS technology deployment in the Western Region of the United States.

Project: Ambient seismic imaging and model building

PI: Jeffrey Shragge

Post-doctoral fellow: Aaron Girard

Funding agency: ExxonMobil Upstream Research Company

Amount: \$164,468

Project description: Long-time seismic recordings are becoming more common with the increased

use of ocean bottom nodes (OBNs), which allow for the use of ambient seismic wavefields at sub 1.5 Hz frequencies lower than the typical minimum values in active-source surveys. This project involves an ambient waveform interferometry study involving 2014 OBNs deployed on the Gulf of Mexico seafloor that recovers usable coherent surface waves as low as 0.3 Hz that exhibit strong sensitivity to large-scale features including salt bodies. This study suggests that low-frequency ambient OBN data could be very useful for building long-wavelength starting models for elastic full waveform inversion.

Project: Full-waveform inversion of the Iranian plateau and its surrounding region incorporating ISC arrival-time data

PI: Ebru Bozdog

Post-doctoral fellow: Ridvan Orsvuran

Funding agency: Air Force Research Laboratory

Amount: \$346,000

Project description: High-resolution present-day snapshots of Earth's interior are essential for understanding the past and present dynamics of the mantle, which shape the surface of our planet through tectonic processes such as earthquakes and volcanic activities. Higher-resolution models are also crucial for better understanding the source of earthquakes, accurately locating them, and from an engineering point of view, assessing seismic hazards and detecting nuclear explosions. This project's goal is to construct a detailed P- and S-wave structure of the Middle East and its surrounding area, including Anatolia and Caucasus, based on full-waveform inversion for improving source parameters and location of seismic events in the region. The team has performed a P-wave arrival-time tomography and set up a methodology to combine multiple datasets of seismic waveforms and ISC (International Seismological Center, <http://www.isc.ac.uk/iscbulletin/search/catalogue/>) arrival-time data in joint seismic inversions. The final stage of the project is dedicated to performing full-waveform inversion to iteratively construct the elastic model of the target area with constraints from the ISC catalog.

Project: High resolution 3D imaging of SHARAD data

PI: Paul Sava

Research associate: Dylan Hickson

Funding agency: NASA

Amount: \$522,288

Project description: Expanding on recent development of 3D models of the north and south polar ice caps on Mars derived from data obtained by the Shallow Radar (SHARAD) onboard NASA's Mars Reconnaissance Orbiter, this project aims to enhance the resolution of these models by incorporating state-of-the-art 3D wavefield imaging technology and newer data.

Project: Investigation of Mars' interior based on 3D simulations of seismic wave propagation

PI: Ebru Bozdog

Funding agency: NASA-JPL

Amount: \$424,000

Project description: Before the NASA's InSight Mars mission, most knowledge on Mars' interior came from gravity and geochemical analyses of a suite of basaltic achondrite meteorites that are believed to have come from Mars. As part of the InSight project, a geophysical lander, including a very broadband seismometer, deployed to the Mars surface. This has allowed seismologists and planetary scientists to investigate the interior of another planetary body by seismic data other than the Earth and the Moon in our solar system. As part of the InSight project, we investigate seismic data from InSight to characterize seismic signals and constrain Mars' interior using marsquakes to improve our understanding of the structure and

geodynamics of the planet. In addition to classical seismological methods and tools, we also get help from 2D/3D numerical seismic wave simulations.

Project Title: Exploring submarine slope failures with seismic data and physical laboratory experiments

PIs: Brandon Dugan, Paul Sava

Funding agency: National Science Foundation

Amount: \$291,949

Project Description: This project integrates laboratory and numerical models to develop a process-based understanding of submarine slope failures as a function of initial conditions and driving mechanisms.

Heiland Lecture Series

Lectures are open to the public and available via Zoom:

<https://mines.zoom.us/j/97650641229>

October 20

Dr. Earle Wilson
Post-doctoral fellow, Caltech

October 27

Dr. Roelof Snieder
Professor and Director of the Center for Wave Phenomena
Colorado School of Mines

November 3

Dr. Frederik J. Simons
Geoscience Professor and Associate Chair
of the Department of Geoscience
Princeton University

November 10

Dr. Mark Haynes
Jet Propulsion Laboratory, Caltech

November 17

Dr. John Bradford
Professor and Vice President for Global Initiatives
Colorado School of Mines

December 1

Benjamin Drenth, Research Scientist
U.S. Geological Survey (USGS)

THANK YOU FOR YOUR CONTINUED SUPPORT!

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 Department of Geophysics or sponsoring one of its programs, please contact us, (303-273-3935) or Sara Pond, Assistant VP and Director of Annual Giving (303-273-3153)