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Spring 2021

Colorado School of Mines
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Newsletter

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MINES DEPARTMENT of GEOPHYSICS

CONTENTS

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Welcome from The Department Head

Dear Friends and Colleagues,

Welcome to the Spring 2021 edition of the Geophysics Newsletter.

I hope this newsletter finds you well, in good health, and in good spirits. The last time I communicated with you in this form, we were preparing a new school year delivered under the uncertain and challenging circumstances caused by the ongoing COVID epidemic. The outlook is much brighter today, and we look forward with great optimism to the next academic year. Mines invested a lot of effort this past year into securing the campus through distancing measures, widespread sanitizing, face mask requirements, reduced class sizes, and more recently, a robust vaccination program for all student-facing faculty, staff, and students before the end of the current school year. We hope that the program will soon extend to the entire Mines population, thus allowing us to return in the fall to our Green Center offices and to reestablish the close-knit atmosphere characteristic for our Geophysics family.

Iga Pawelec

This has been a hard year for everyone and in particular for our students, yet I am pleased to report that we are approaching the end of the 2020-2021 academic year with a graduating class endowed with the same characteristics we are used to — competence, curiosity, integrity, ambition, industriousness and much more. We, the Geophysics faculty and staff, are grateful for the strength and resilience of our students, proud of their accomplishments, and confident in their ability to carry and boost the global recognition of our program. For all of us, our students' successes are our greatest rewards and we look forward to celebrating our graduates at the upcoming commencement ceremonies.

I am also pleased to acknowledge our researchers, primarily the postdoctoral scholars and graduate student groups, who maintained a vibrant intellectual space and continuity of our teaching and research program, despite the inevitable physical isolation. High-level scholarly work continued, with our researchers maintaining active roles in many relevant professional communities; for example, two of our colleagues will soon engage in high-profile lecture tours: Ali Tura as 2021 SEG Distinguished Lecturer, and John Bradford as 2021 SEG Global Near Surface Lecturer.

Although we are all keen to travel and engage more directly with colleagues and collaborators, we have learned a lot about remote interaction, and we intend to exploit such engagement in the future. As an example, we will maintain online delivery of the Heiland lecture even after we fully regain the ability to gather on campus, and I hope that many of you in our external community will tune in on a regular basis. We are also in the process of developing online courses supporting our first Geophysics Certificate primarily developed for our external community, in addition to retooling and expanding our existing courses that are the foundation of our established degree programs.

Despite the complexity of our remote operations, our effort to broaden the scope of the Geophysics program carries forward unabated. Our *Reimagine Geophysics* committee established several years ago continues its strategic work aimed at preparing our department to take advantage of growth opportunities in the context of the Mines environment, and in connection with societal needs and im-

peratives. We are advocating strongly for future faculty hires aligned with the Geophysics program and with the Mines goals of expanding our interdisciplinary culture that reaches across disciplinary boundaries. Included in this multi-pronged effort is our active engagement with new campus-wide CCUS initiatives, as well as with other Mines programs of societal relevance, including humanitarian applications, infrastructure and climate monitoring, natural hazards characterization, space exploration, and many others.

In the context of this broadening vision for our teaching and research, I am also pleased to note the promotion and tenure of two colleagues who are at the leading edge of our campus-wide outreach:

> **Brandon Dugan** has been promoted to Professor rank in recognition of his excellent teaching record, significant scholarly contributions, and great service to the Mines and global professional communities. As many of you know, Brandon is one of the recognized leaders and key contributors to the scientific success of the high-profile International Ocean Drilling Program. He also serves as Associate Department Head for Geophysics in which capacity he plays a crucial role in managing our operations through the current complex circumstances.
>
> **Jeff Shragge** has received tenure, acknowledging his growing stature and critical role in our Geophysics program, as well as in the international community. Jeff has recently been recognized by our students as Geophysics Outstanding Faculty for his excellent teaching delivered while also overseeing the development of our new Computational Geophysics track, developing multiple new courses, publishing on a continuously expanding set of research topics, and while serving as Editor-in-Chief for the journal Geophysics.

Congratulations Brandon and Jeff! We are proud of you and we look forward to your future successes.

I would also like to acknowledge the departure of our colleague Andrei Swidinsky, who at the end of the current academic year will pursue a new professional opportunity that will also bring him closer to his extended family roots. Andrei is an excellent teacher and scholar and has made great contributions to the Mines Geophysics program, including by his innovative research and by strengthening our well-recognized Geophysics Field Camp. Farewell Andrei! We wish you well and look forward to extending our friendship and collaboration into the future.

The Geophysics Program at Mines remains dynamic and my colleagues and I see great opportunities for growth and future strength. We hope to be able to share more of our ambitions in the near future, perhaps at the upcoming Geophysics Reunion organized in connection with the 2021 Annual Meeting of the SEG. Please stay tuned for further communication and do not hesitate to reach out or visit us at Mines when the opportunity arises.

I wish you only the best, with good health and professional success.

Be safe! Stay in touch!

Paul Sava

New Directions in Research

Photo by Iga Pawelec

Planetary Seismology: The Tool to Image Earth and Beyond

Modern day seismology is more than preparing for the next big earthquake. While understanding earthquake processes and seismic hazard assessment remains a vitally important active research topic, since the early 1900s, seismologists have successfully used seismic data to probe the interior of our planet. Now, seismology not only reaches farther depths within our own planet, but also explores the internal structures of other astronomical bodies.

"Earth"-quakes refer to our planet, but when referring to other planetary bodies, any event that sends energy throughout the planet is known as *~insert planet name here~*quakes. For example, Mars has Marsquakes and the moon has Moonquakes. While plate tectonics is the main cause of earthquakes on Earth, it is virtually absent on other planets in our solar system (however, Venus does have evidence for subduction as shown by Davaille et al., 2017). Therefore, the mechanisms that cause quakes on other planetary bodies are mainly meteoroid impacts, quakes of nontectonic origin, or even shifting ice sheets, known as ice tectonics (as seen on Europa, a moon of Jupiter).

With seismometers, what we learn on Earth can be applied to other planets. Propagating energy from a seismic source will ripple throughout the planet's interior and along its surface. From the wiggles (waves) on a seismogram that record moving ground motion, we can learn about the interior structure, active seismicity, and even how the planet formed in the solar system.

Planetary seismic experiments began with the Ranger missions in the late 1960s, but the seismometers sent as part of these missions were not operational upon landing. Later, however, the Apollo 11 mission included four seismometers which managed to transmit recordings for three weeks, initiating the first ever lunar seismic study followed by more seismic experiments on Apollos 12, 14, 15 and 16. These recordings of Moonquakes and meteoroid impacts helped map internal structure of the moon, which consists of a crust, a mantle and a core. The same seismometer network has also helped discover that a majority of Moonquakes originate at 800–1000 km depths. These Moonquakes have been shown to be caused by the gravitational pull of the sun and Earth.

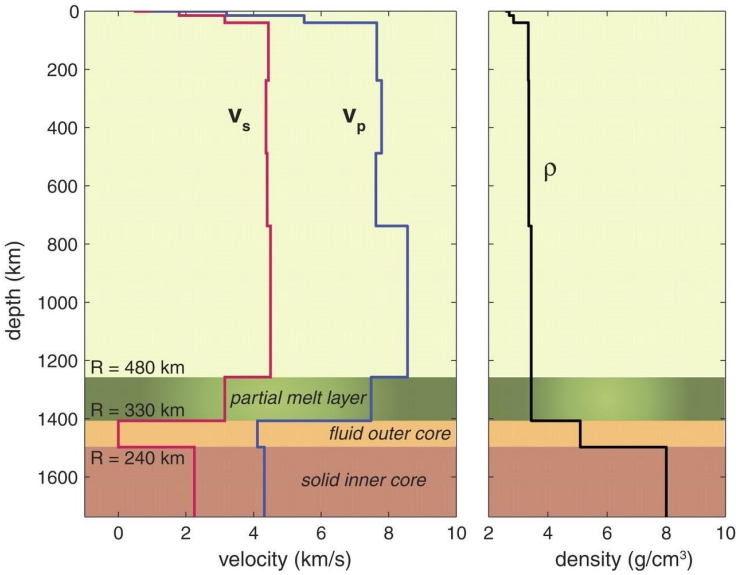

Figure 1 : Depth profiles of P– and S-wave velocities (Vs and Vp) and density (ρ) obtained by Apollo data studies for the top 1000 km, and elasticity of iron alloys for depths below that (Weber et al., 2011). The image shows the partially molten layer on top of the fluid outer core, which is above the solid iron-nickel inner core.

The array processing methods applied by Weber et al. (2011) predict the existence of a solid lunar inner core, a fluid outer core and a partially molten layer at the boundary of that outer core and mantle (Figure 1). In a recent Space Science Reviews article, Nunn et al. (2020) discuss plans to improve our understanding of the lunar subsurface structure with the aid of an international lunar network. On November 26, 2018, the second seismometer to ever land on Mars (as part of the Interior Exploration using Seismic Investigations, Geodesy and Heat Transport [InSight] mission) set a new precedent in planetary seismology. A previous seismic deployment occurred in 1976 with the Viking mis-

sion, but the seismometer never left the lander. The InSight seismometer was actually placed on the Mars surface with a robotic arm. A substantial amount of data has been collected from InSight since 2018, revealing many mysteries about the inner processes of Mars. A total of 485 Marsquakes have been detected up to October of 2020. Many of these events are likely due to volcanic and tectonic activity on Mars, but overall seismic activity is much lower on Mars as compared to Earth. The Mars data from InSight are free to download and visualize here: https://www.iris.edu/hq/sis/insight.

Due to the successful seismic missions on the Moon and Mars, there is limitless potential in exploring other planetary bodies. While solid land-based seismometers have been mainly deployed, other techniques such as infrasound (when seismic waves propagate acoustically in the atmosphere) could also be used for planets with harsh conditions like Venus. The only lander to successfully transmit color images from the surface of Venus was Venera 13, but it only could transmit data for two hours before succumbing to the intense atmospheric conditions. Therefore, it has been proposed to deploy balloons to hover in the upper atmosphere of Venus to detect Venusquakes that transmit infrasonic waves through the atmosphere.

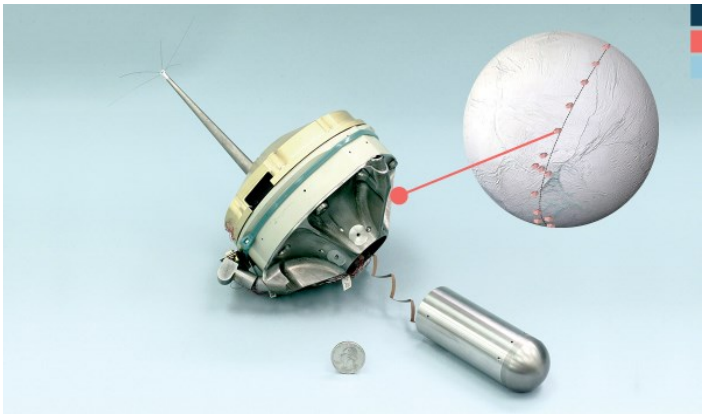

Figure 2. Concept for deployment of a network of seismic sensors on Enceladus, a moon of Saturn (NASA).

Future NASA missions are also being planned to investigate the ocean and ice moons of Jupiter and Saturn, which are quite diverse in their geology, appearance, potential for hosting life, volcanic activity, and composition. The challenges of going to other planets has pushed engineering of seismic equipment as well, by forcing scientists to be creative to collect seismic data in extreme environments, such as balloons floating in the atmosphere of Venus and creating super small seismometers (which can fit in the palm of your hand) that can withstand large amounts of radiation and magnetic fields. These tiny seismometers known as University MEMS Seismometers (Figure 2) will allow future missions to deploy a network of seismometers across another planet rather than relying on a single station.

Despite all the potential with future missions, there is still a lot to be learned regarding the structures of the Moon and Mars with current missions. For example, the depth to the Mars core-mantle boundary is still unknown. More future missions for these planetary bodies are continuing to be proposed and more enthusiastic young seismologists are contributing to these exciting planetary investigations that involve novel methodologies. Sterling Loza, who is actively involved with the Mars InSight Science Team that investigates the planet's structure with Martian seismic datasets commented, "Working with the Martian datasets is quite a privilege. To put it in a clear but simple way, the problems encountered in the Martian data are like those you'd come up with a bunch of friends when you're trying to push the limits of your capabilities. The InSight mission is truly pushing the limits of modern approaches and forcing creative thinking to solve new problems in an uncertain environment. The greatest difference between terrestrial and Martian data is the data quantity and certainty. But what this really leads to is the problem-solving approaches required." Sterling is a PhD student in the Global & Computational Seismology Group of the Geophysics Department & the Space Resources Program.

— Contributed by Neala Creasy and Susini de Silva

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CCUS Initiative Addresses Global Problem

With addressing climate change becoming a major global priority, carbon capture, utilization and storage (CCUS) is rapidly becoming a field of interest for many major universities. Mines will soon be leading the way through its new CCUS Initiative, led by Geophysics Professors Dr. Manika Prasad and Dr. John Bradford.

Carbon dioxide (CO_2) is a gas that has been linked to the warming of the planet. So much CO_2 has already been released into the atmosphere that simply not emitting more CO_2 is not sufficient to reduce the temperature of the Earth enough to meet national and international climate goals. This is where CCUS comes in. By investing in technologies to manage CO_2 differently, by capturing it, storing it, and finding positive ways to use it as a resource, the CCUS Initiative seeks to develop geologic and non-geologic solutions that can change how we derive energy and how that energy impacts the climate.

Multiple departments in the geosciences are involved in the initiative including Geophysics, Geology, Petroleum, and Mining. Other departments invested in this initiative include Civil Engineering, Chemistry (chemical and biological research), and Economics and Business, which are working on economic solutions for the carbon economy. In total, there are eight departments and 40 faculty actively conducting research on campus in CCUS. Additionally, the Payne Institute for Public Policy, which focuses on educating about the Earth and environment related to the public, is involved.

Some of the specific CCUS research areas at Mines include the process of capturing carbon from membrane separation technology, tailpipe emissions, and vacuums that pass CO_2 around. Additionally, people are working on what to do once the carbon has been captured, exploring how to convert CO_2 into different types of fuels and possibly extract hydrogen as a fuel. This could lead to research on how to create a fuel that doesn't have CO_2 emissions, as well as work on the production of biofuels using CO_2. Some solutions may still emit the gas, *Continued on next page*

> We are firmly gearing toward making this a global approach, not just a research topic.
>
> - Dr. Manika Prasad

Geophysics Faculty Pitch Ideas at CCUS Expo

Mines hosted a two day virtual expo on Carbon Capture, Utilization, and Storage (CCUS) research and transformative ideas ongoing at Mines. The expo was the culmination of the newly launched Mines Integrated CCUS Initiative, which is an interdisciplinary effort by the Payne Institute for Public Policy at Mines, industry leaders, and government officials to mitigate the effects of climate change through CCUS. "This CCUS expo is very timely and needed," said Mines President Paul Johnson, further saying how collaboration is one of the most important challenges of our time.

The Geophysics Department played an important role in several areas of research at the expo. PhD students and professors presented their research and provided analyses as to how geophysics can help in the CCUS effort. Dr. Ali Tura spoke on how various previous efforts and future technologies can make scientific progress in CCUS research, especially in geophysics, promising. There is much research that can be done in geophysics for CCUS.

Reservoir monitoring is a huge part of this problem. Dr. Yaoguo Li, Dr. Rich Krahenbuhl, and numerous PhD students (W. Anderson McAliley, Colton Kohnke, and Joseph Capriotti) use time-lapse gravity surveys to monitor the *Continued on next page*

CCUS Initiative continued

but if designed as a closed loop, they could release the carbon back into the same system, rather than into the environment. For example, one option is learning to trap CO_2 in concrete, which could become a major public works project. The CCUS Initiative has a major vision for the type of impact it would like to help make. According to Prasad, "We are firmly gearing toward making this a global approach, not just a research topic."

The CCUS Initiative is beginning with the development of a certificate program. There is a plan for four courses, with about 15 faculty involved. Courses will be fully online. The course structure is currently being created, with a goal of rolling it out by the fall semester of 2021. As an interdisciplinary program, it will first offer a graduate certificate and could grow into a full masters degree in a few years or become an undergrad degree later. The current direction of course curriculum will likely include concepts on geologic capture and storage, utilization of carbon storage, overview of processes with potential impacts, and the economic impacts. The certificate program will be open for anyone and is expected to take two semesters, comprising 12 credit hours.

Leading the way from the Geophysics Department are Bradford and Prasad. Bradford, the Vice President for Global Initiatives, Interim Vice President for Research and Technology Transfer, and Professor of Geophysics, has elaborated on the research possibilities of finding alternative utilization options for carbon once it is captured and stored. He has been aware of the challenges associated with climate change for several years, especially after working primarily within the Arctic. Then in 2015, while he was the president of SEG, he became especially interested in making an impact after hearing inspiring messages from major companies throughout the oil industry at an International Petroleum Technology Conference. Prasad, Geophysics Professor, Co-director of the Center for Rock & Fluid Multiphysics, CCUS Technical Lead, and the first professor at Mines to offer a course on climate change, says, "We believe this belongs at every university. Our goal is to have as much involvement as possible."

Mines also has an external advisory group including supportive partners from major companies and organizations such as Oxy, Inc. (Brian Owens, Sr. VP, Oxy, & Mines alumni, has been very instrumental in getting this started), ExxonMobil, Shell, ConocoPhillips, the DOE, Excel Energy, and more recent additions include Kiewit and GCC (Concrete Company).

In summary, the Geophysics Department is excited to help create a community and play a central role in this initiative because we have so many existing lasting industry connections. As a department, we have the opportunity to spread information and help others recognize the possibilities.

— Contributed by Carolyn Pohl

CCUS Expo continued

nature of density in the subsurface. Dr. Ilya Tsvankin and Graduate Student Yanhua Liu apply full-waveform inversion to get a time-varying seismic image for monitoring carbon sequestration. Both efforts are important in reliably determining how the subsurface changes as carbon is sequestered. This is critical because one crucial aspect of CCUS is confidently knowing where the carbon is located so that seepage can be mitigated. Another key research area is the determination of seal stability and storage capacity for individual reservoirs. Dr. Manika Prasad, Dr. Mathias Pohl, and Dr. Jyoti Behura of the Center for Rock and Fluid Multiphysics study this problem, among others. Laboratory experiments and models are being developed to determine the reliability of reservoir seals and whether the sequestration of carbon goes beyond those thresholds.

The expo introduced new ideas and research opportunities to potential partners. There is much to be done in combating climate change, and CCUS is no silver bullet. However, it is recognized that CCUS will play an important part in the solution that helps global emissions be net-zero at some point in the near future. This expo was an excellent first collaborative step in ensuring we get there.

— Contributed by David Churchwell

Humanitarian Geophysics—

Intersections creating progress

Mines' Geophysics Department is a global leader in taking a more societal and humanitarian approach to the problems faced by geophysicists. The Humanitarian Engineering and Science Masters program (HES) is an interdisciplinary program at Mines that brings together the Geophysics; Engineering, Design, and Society (EDS); Geological Engineering, and Environmental Engineering departments. This interdisciplinary program combines the complex sociotechnical aspects of geoscience with the cultural, political, and economic layers woven within many scientific problems around the world. The HES program is led by Director Dr. Jessica Smith while the Humanitarian Geophysics track is led by Director Dr. Jeffrey Shragge and Co-director Dr. Richard Krahenbuhl. Krahenbuhl is also the Associate Director of the HES program.

This discipline is one part of a larger initiative at Mines to tailor the technical curriculum around a previously overlooked societal and political problem. While initially small, it has expanded into the three tracks that make up HES: Humanitarian Environmental Engineering, Humanitarian Geological Engineering, and Humanitarian Geophysics. Through all three tracks, Mines is fulfilling its desire to conduct more of its research alongside community partners on problems of mutual interest, while also promoting sustainable solutions that are equitable and inclusive.

Moreover, Humanitarian Geophysics is concerned with the crucial intersection between technical solutions and sustainable community development. It is not uncommon to walk away from projects if the technical goals are misaligned with the cultural, political, or economic realities of an area. Therefore, the discipline is not simply concerned with understanding new complex social science problems in geophysics. It is also deals with promoting scientific growth in an equitable, inclusive, and sustainable way by working *with communities, not for them*.

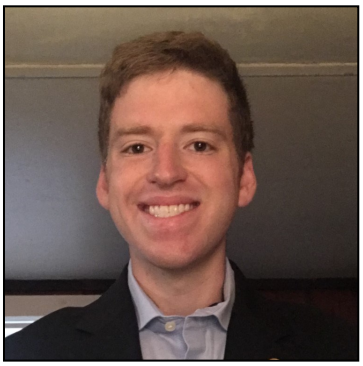
Mines entered this discipline through its unique blend of social science and technical aptitude. Mines has long been known for its prowess in STEM while also becoming more involved with social science elements as years have progressed. Specifically, the Humanitarian Geophysics' curriculum is taken from parts of the Geophysics graduate program and parts of EDS. Therefore, the university is uniquely positioned to thrive in this discipline.

Students have also shown great interest in humanitarian projects for several years and this has continued to grow since the establishment of the discipline. There have been several senior design and master's projects on low-cost geophysical instrumentation, environmental justice concerns (at home and abroad), and archeological surveys that include a humanitarian element to them. Therefore, Shragge and Krahenbuhl expect the program will continue to spark the interest of more students over time and become more established.

The next step for Shragge and Krahenbuhl is clear: get more students. To obtain more funding and resources for Humanitarian Geophysics projects, more Geophysics students need to enroll in HES with a geophysical project. Therefore, if you have a student, are a student, or know of a prospective student who is interested in taking Geophysics to new realms, go to the Humanitarian Geophysics website for more information! (https://geophysics.mines.edu/humanitarian_geophysics/)

Photo left: One of the organizations the Mines' Humanitarian Geophysics program works with is Geophysicists without Borders (GWB). Here, GWB project students acquire a test seismic line on the Université d'Abomey-Calavi campus.

Students Pursue Humanitarian Goals



Geophysics senior David Churchwell is working on a senior design project that involves the low-cost seismometer. This device aims to reliably find groundwater in communities that may not be able to afford traditional geophysical surveys. Moreover, the research fosters scientific growth in communities while promoting equitable, inclusive, and sustainable growth. "I have been grateful to work with this device and have a part in Mines' growing initiative to work with Humanitarian-centric problems. Blending together social sciences and geophysics excites me and I look forward to continuing work with this device."

Humanitarian Geophysics senior Sigourney Burch focuses on using various geophysical techniques to investigate mass grave sites in Pueblo, Colorado. She has several goals. First, she hopes to illuminate new historical facts for the purposes of closure for local families. Second, she aids in providing social justice for minority communities that may have been subjected to mass grave plots more often than other groups. "I have always had a passion for the social sciences, so finding an interdisciplinary field that allows me to pursue this passion using the knowledge I have gained as a geophysical engineering major at Mines is a dream come true," she said.

DIA Team Unlearns Racism

[geophysics.mines.edu/dia/]

Members of the Diversity, Inclusion and Access Committee (DIA) have been learning how to better serve as anti-racist advocates by participating in Unlearning Racism in Geoscience (URGE), an NSF-funded initiative led by a PI at the Woods Hole Oceanographic Institute.

This program was developed to help geoscience programs currently developing programs to improve issues of diversity, inclusion, access, equity, and justice at their local institution. Multiple papers have been published in the last few years highlighting the lack of diversity in the geosciences which are seen as one of the least diverse disciplines in STEM (e.g., Bernard and Cooperdock, 2018; Dutt, 2020). URGE developed a community-wide journal-reading and policy-design curriculum that includes biweekly interviews with experts and leaders at the intersection of geoscience and anti-racism to help departments set and achieve actionable, meaningful goals supported by data. URGE's primary objectives are to "(1) deepen the community's knowledge of the effects of racism on the participation and retention of Black, Brown, and Indigenous people in Geoscience, (2) draw on existing literature, expert opinions, and personal experiences to develop anti-racist policies and strategies, and (3) share, discuss, and modify anti-racist policies and strategies within a dynamic community network and on a national stage." Each week, discussion groups (called 'pods' by the program) talk about readings and interviews focused on learning about and implementing anti-racist strategies. At the end of the curriculum, each pod will submit a document that summarizes their action plans. The Geophysics Department's DIA Committee started an URGE pod that includes faculty, staff, and students from Geophysics, Geology & Geological Engineering, and Hydrologic Science & Engineering.

Each week, discussion groups (called 'pods' by the program) talk about readings and interviews focused on learning about and implementing anti-racist strategies.

URGE runs from January 18 to May 07, 2021, so our process is still ongoing. But one thing is clear: there is a need and a desire on campus to be able to talk about issues both on our campus and society more broadly and move beyond talk to determine what concrete, actionable steps we can make to move forward. We will not see racial justice until we all realize that we have a voice and figure out when and how we can use it. Everyone has an opportunity to be that ally, even if it is just talking to a friend or family member who does not see the importance of this struggle about why you are committed to racial justice. We all need to use the power we have to make change, and members of the Geophysics Department hope to develop some concrete plans for the department and more broadly at Mines. *— Contributed by Kamini Singhe and Matthew Siegfried*

Learn more about URGE and the Geophysics Pod deliverables:

https://urgeoscience.org/pods/mines-geoscience/

Home Sweet Home

News from the Green Center Basement

It has been a while but we have finally moved back to the Green Center. We used the in-between time wisely by giving our labs a desperately needed facelift. By moving most of our laboratory equipment to the GRL-A, it enabled us to remodel and upgrade all of our existing lab space. Also, with Dr. Prasad's move from the Petroleum Engineering Department to the Geophysics Department, we combined her laboratory equipment with the existing ones. Some necessary changes were made to accommodate for the additional devices. One of the biggest transformations was the remodel of our old rock cutting room; it became the new poroelastic lab. That room received a full makeover with new flooring and a desperately needed fresh coat of paint.

Left: Old rock cutting lab Above: New poroelastic lab

With the remodel of our old laboratory space, also came a new name for our research group. We are now the 'Center for Rock and Fluid Multiphysics'. In our hearts we will still be 'Rock Abusers' and we will continue to squeeze rocks until they tell us all of their secrets. Feel free to stop by if you have the desire to crush a rock and study how the rock properties change as we do it.

— Contributed by Mathias Pohl

Field Camp Update

The 2021 Geophysics Field Camp will take place in Golden, Colorado. While staying close to home was a difficult decision, the department decided that a local field camp would be the best balance between risk and educational reward given the still-evolving COVID-19 situation. A major focus of field camp this year will be to expose our students to cutting edge technology including drone-based geophysics (carrying systems such as magnetics, EM, GPR, radiometrics and multispectral sensors), wireless seismic surveys and distributed acoustic sensing (DAS) acquisition. Being close to the Mines campus gives us the opportunity to work closely with these new and exciting techniques in a safe and educational environment.

— Contributed by Andrei Swidinsky

Postdoc News

Although there have been many changes in the department throughout the last year and a half, one of the most positive changes is we have more postdoctoral fellows than ever! They come from a wide range of backgrounds and are working on an excitingly diverse set of research projects. In this issue, we are highlighting a few researchers and their work within the department. More highlights will come in the next issue! You can see a complete list of the postdoctoral fellows at https://geophysics.mines.edu/faculty-and-staff/#POST-DOC.

Susini De Silva

Susini grew up on the west coast of Sri Lanka and completed an undergraduate degree in Physics at the University of Colombo, Sri Lanka. During her PhD work at the University of Connecticut Department of Physics, she studied the topography and attenuation at the surface of Earth's inner core, which is actively solidifying within the liquid iron outer core. Susini also started studying earthquake seismic recordings to resolve Earth's interior to better understand the geodynamic evolution of our planet. After completing her PhD, she was interested in branching out to explore more shallow structures of the Earth in high resolution, and the Mines Geophysics Department provided a perfect opportunity. As a postdoctoral fellow, Susini conducts tomographic imaging of the crust and upper mantle beneath the Middle East using full waveforms.

Shaked Stein

Shaked is from Israel. He completed his BSc, MSc, and PhD at Ben Gurion University of the Negev in Israel where he was working on desalination of saline groundwater from the coastal aquifer from both the operational and hydrological perspectives. He came to Mines for its reputation, the Rocky Mountains, and the great opportunity to work with Dr. Brandon Dugan.

Shaked is working on the applicability of pumping water from an onshore-offshore aquifer at Nantucket Island using field and modeling approaches. He is also investigating the option to inject the desalination brine waste into the saline coastal aquifer since it may be an environmentally friendly solution for brine disposal. Shaked hopes to stay in the research field and at a university or a research institute to investigate his research interests and promote science.

Neala Creasy

Neala is from Kansas City, Missouri and completed a BS at Michigan Tech which was followed by a PhD at Yale. She chose Mines' Geophysics Department because she wanted to work with Ebru Bozdag, and of course she has always wanted to live in Colorado!

Neala is working on global earthquake simulations to study seismic anisotropy, which she hopes to convert to a job either at a National Lab, the USGS, or a university.

Ezgi Karasözen

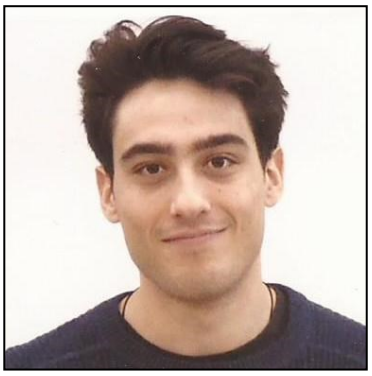
Ezgi is from Ankara, Turkey, where she completed her undergrad at the Middle East Technical University in Geological Engineering. She came to Mines to work on Mars! After working on the tectonic structure of Mars and completing her MSc, she "came back to Earth" to complete a PhD. She aims to understand where earthquakes are happening and how we can identify active faults and assess the seismic hazards. To investigate these problems, Ezgi uses a wide range of techniques from seismology and geodesy.

Her PhD research focused on establishing source characteristics of earthquakes; with a particular focus on achieving high-precision, absolute earthquake locations; specifically for earthquakes in Iran and Turkey, since those countries have suffered from devastating earthquakes throughout history and are in need of accurate earthquake locations to find faults that are likely to rupture in future earthquakes.

Ezgi works on seismic array analysis across Alaska, which has four small-aperture seismic arrays, originally established to detect nuclear test explosions; however, she uses the arrays for earthquake monitoring. Her aim is to answer the question of whether we can use these data for earthquake monitoring — more specifically in real-time — which is vital for rapid response purposes and earthquake early warning systems.

Roger Michaelides

Roger grew up in Libertyville, Illinois and studied Physics and Science of Earth Systems at Cornell University. He received a PhD from Stanford University in 2020 where he worked with Howard Zebker using interferometric synthetic aperture radar (InSAR) to study the interactions between permafrost physical processes, wildfires, and soil moisture within the context of a warming Arctic. He came to Mines to work with Dr. Matt Siegfried and the Geophysics Department, and (of course), to enjoy the mountains and outdoors. As a postdoctoral researcher working in Siegfried's Glaciology Lab and with the Colorado Geological Society, Roger is working to develop a dedicated processing and data visualization environment for InSAR data with an emphasis on natural hazards in Colorado. He also is actively exploring the potential of the ICESat-2 mission for dedicated investigations in tundra and periglacial environments, as well as being involved with Pingo STARR, a project to characterize the internal structure, hydrology, and formation mechanisms of pingos using various field geophysical methods. Roger's ultimate goal is to better understand and detect ground-ice formations on both Mars and the icy satellites of the outer solar system.



Dylan Hickson

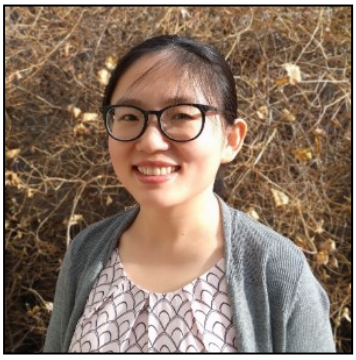
Dylan hails from Toronto, Canada where he obtained a PhD in Earth & Space Science at York University in 2019. Following a two-year postdoctoral fellowship at Arecibo Observatory in Puerto Rico, he joined the Geophysics Department in April 2021. Dylan is excited to be part of the Mines community and hopes that the vast knowledge, experience, and support in the department will help to advance his research in radar remote sensing of Mars and asteroids.

— Contributed by Aaron Girard

Aaron Girard

Aaron is originally from Colorado and completed his undergraduate degree right here in the Geophysics Department. From there, he started a world-wide journey: completing an MSc in the IDEA-League joint master program at TU Delft, ETH Zürich and RWTH Aachen in Europe, where he focused on full-waveform inversion using extended images, and then moved to the University of Western Australia to work with Dr. Jeffrey Shragge for a PhD exploring imaging with ambient seismic wavefields. Just over halfway through his degree, Shragge moved to the Mines' Geophysics Department and Aaron took the opportunity to come back to Colorado and continue his research. Aaron is focusing on reservoir scale exploration using background ambient seismic wavefields. The results have shown that it is possible to use ambient and passive seismic methods to characterize the subsurface better than previously expected. Aaron plans to continue this research and is looking to apply these findings in industry as well as in research institutes and universities.

Yanrui (Daisy) Ning



Daisy is an RCP alum and rejoined RCP as a postdoctoral fellow in January 2021. With a PhD degree in Petroleum Engineering and a minor in Geophysics, she worked in the oil industry as a reservoir engineer and a data scientist for two years. Daisy's current research interests include reservoir simulation and machine learning, focusing on hydraulic fracturing optimization, enhanced oil recovery (EOR) in unconventional reservoirs, as well as carbon capture, utilization, and storage (CCUS). After completing her postdoc fellowship, she expects to obtain a faculty position in academia, continuing academic research and mentoring talented students.

Frantisek Stanek

Frantisek is from Pilsen, Czech Republic, and studied Geophysics at Charles University in Prague at the Czech Academy of Sciences. During his time there, he met people from Mines at conferences and followed the publications from the Geophysics Department with great interest, quickly realizing that the department has a great reputation. He is now part of the Reservoir Characterization Project (RCP) where he spends most of his time analyzing data acquired by fiber optic cables (DAS). It is still quite a new technology, but it is quickly evolving and already capable of monitoring changes of different physical fields. A high density of sensors distributed along the fiber provides a huge amount of data with a high potential to help better understand, for example, a reservoir's response to its stimulation. Frantisek is mainly interested in microseismicity induced by hydraulic fracturing, data integration and complex reservoir characterization, though he enjoys collaborating with colleagues and learning something new from them every day.

Geophysics Faculty Accolades

Professor Ali Tura has been honored as 2021 Distinguished Lecturer for the Society of Exploration Geophysicists (SEG). This respected SEG program will feature Tura's "recent advances in seismic reservoir characterization and monitoring." Tura leads the Reservoir Characterization Project (RCP), one of the Department's largest and most enduring industry consortia. For more information about the lecture and to register attendance, visit https://seg.org/Education/Lectures/Distinguished-Lectures/2021-DL-Ali-Tura.

Professor John Bradford has been honored as 2021 Global Near Surface Lecturer for the SEG. The tour will feature Bradford's "Taking the Power of Exploration Geophysics from the Oil Patch to Help Solve the World's Grand Challenges."
In addition to his geophysics research, Bradford serves the Mines campus as Vice President for Global Initiatives and Business Development. Visit the SEG Near Surface Global Lecturers website for the tour schedule and registration information.

Promoted

Both of our department leaders have received promotions this year. Dr. Paul Sava has been named Geophysics Department Head, a position he steps into after having been Interim Department Head since the summer of 2019. Sava is a Professor and Green Chair of Exploration Geophysics as well as a Co-PI of the Center for Wave Phenomena. Geophysics Associate Department Head Dr. Brandon Dugan has been promoted to Professor. Dr. Dugan has been at Mines since 2016 and has served in his departmental leadership role since 2018.

On the Move

Change is in the air this spring as faculty either take on new roles or literally move. Dr. Manika Prasad has been named the technical lead in the CCUS Initiative, giving her a higher profile on the Mines campus.

Dr. Jeffrey Shragge has been granted tenure at the associate professor rank, marking a move up another rung of the university ladder.

Dr. Andrei Swidinsky is moving on by returning to his hometown of Toronto, Canada, where he has accepted a position as Tech Chair in Exploration Geophysics in the Department of Earth Sciences at the University of Toronto.

Student Awards

Cecil H. Green Medalist: Sigourney Burch. Named for pioneer geophysicist and philanthropist Cecil H. Green, the award is bestowed on a student who, in the view of the Geophysics faculty, has attained the highest level of scholastic achievement, personality, and integrity. After completing her B.S in Geophysical Engineering, Sigourney will continue as a Mines graduate student in the Humanitarian Engineering and Science Master's Program. She will pursue the Humanitarian Geophysics track of this program with a thesis focusing on archaeological geophysics. Of this new opportunity, she says, "I am so excited for the opportunity to explore my passions for the social sciences, while further pursuing my geophysics education."

Hannah Haugen received two awards. The **John C. Hollister Award**, which goes to a student who demonstrates leadership, maturity and scholarship beyond academics and the **TK Young Geophysics Leadership Award**, given to recognize excellence and leadership through service and collaboration. Hannah's all-around performance earned her many favorable remarks from the faculty. Of her time here at Mines, Hannah says, "I came to Mines looking for an education, but found a family. Part of that family has definitely become the students, faculty, and staff of the Geophysics department. I have loved working with my fellow Geophysics students, and am so grateful to have been able to learn and work together with them these last four years. All of the professors in the department have also been wonderful, sharing their expertise and love for the subject, as well as endless patience, especially in this last year with remote learning" Hannah will pursue a Master's degree in Hydrology at the University of Arizona. She is excited to continue to dig in to research questions regarding critical water resources on the interface between everyday management decisions and cutting-edge scientific knowledge.

Mendenhall Prize for Outstanding Graduating Masters' Students—**Dana Sirota and Maitham Alabbad** were awarded this prize for their academic performance, cutting-edge research and having the highest standards of integrity and professional conduct. Dana, whose research carried her overseas, said of her experience, "My time at Mines went far beyond the campus! The department gave me the opportunity to do geophysics around the world, and both to learn and to teach!" Maitham added, "I was very happy when I got admitted into CSM. It has been a roller coaster ride with the Covid-19 pandemic and everything, a lot of changes and surprises along the way, and here we are now. It feels unreal. Alhamdulillah.

Outstanding Graduating Seniors: David Churchwell and Ahmed Alharbi. Both David and Ahmed have carried top-notch GPAs throughout their time in the department. David has been active in Society of Student Geophysicists, serving as secretary. He plans to continue in the Geophysics Non-Thesis Masters program at Mines next year and will then go to law school. He said, "I am incredibly thankful to have been a part of, and will continue to be in, the GP department. This is not solely due to the amazing science I have learned and will continue to learn from fantastic instructors. The Geophysics department instilled that all Geophysics graduates have the perseverance and integrity to equitably improve many livelihoods through science and engineering. My experience has been one that I will never forget and will continue to look back upon in favor and nostalgia." David was also nominated by his peers to be the 2021 E-Days Engineer for Geophysics. Ahmed successfully graduated in the fall and returned to his home country of Saudi Arabia where he is working in Aramco's exportation team. He said of his time at Mines, "My time at Mines was challenging, transformative, and rewarding. It was really worthwhile to be a student of remarkable professors who are very supportive and committed to providing an excellent education with a collaborative environment."

George R. Pickett Memorial Award: Senior Ana Garcia-Ceballos, for demonstrated accomplishment and interest in the field of borehole geophysics. Ana, who will continue in the department this fall says, "I chose to go into the Master of Science program because the courses offered by the CSM Geophysics Department provide an in-depth understanding of theoretical background, data processing as well as how to implement them in practice. The courses provide excellent opportunities to apply my knowledge in various areas of research. Upon completing geophysics field camp this summer I will carry out an internship before starting in Fall 2021 and continue to explore my areas of interest.

George T. Merideth Award for Early Leadership in Geophysical Engineering: Joseph Stitt. Joe's leadership qualities have been demonstrated in his role as president of the Society of Student Geophysicists and in his research activities. Of his time in the department, he said, "Everyone I have interacted with in the geophysics department has been amazing to me both in supporting and pushing me to be the best student I can be. I have had amazing experiences with conducting research on AVO inversion analysis with RCP and leading SSG as president over the past year" After graduation, Joe will attend Stanford University to pursue a Ph.D. in geophysics in the Stanford Exploration Project group under Dr. Biondo Biondi.

Student Clubs

SSG & SGGS: Persistent and Promising during Covid

The Society of Student Geophysicists (SSG) is an undergraduate student club for anyone interested in geophysics at Mines. It is a student organization within the Society of Exploration Geophysicists (SEG) and the faculty advisor is Dr. Jeffery Shragge.

In a normal year, SSG would interact with the Golden community by showcasing the importance of geophysics, attending conferences that allow its members to network, and engaging the greater Mines community in how geophysics influences their future scientific careers. The goal of the club is to improve outreach to non-geophysics students and promote interaction between different undergraduate students within the Geophysics Department.

This year, however, has been anything but ordinary. COVID-19 placed several burdens on SSG. The officers worked diligently to make SSG meetings COVID-safe so the club could continue to bring people together. However, with students being wary of being on campus and certain activities prohibited under Mines COVID guidelines, SSG meetings looked very different in the fall and spring.

SSG has yet to let the pandemic push the club into obscurity, though. The time-old tradition of guest speakers continues, for the most part, virtually. SSG students were still given opportunities to network with the promotion of all major conferences throughout the year. The club also still brought the wonder of geophysics to elementary students by presenting for Golden's Mitchell Elementary 5th graders via Zoom. Finally, SSG is collaborating with the department to plan the GP BBQ and GP Days to bring the community together one last time before the semester ends. — *Contributed by David Churchwell*

SSG OFFICERS

2020-2021
President: Joseph Stitt
Vice President: Michael Field
Treasurer: Cash Koning
Secretary: David Churchwell

2021-2022
President: Michael Field
Vice President: Cash Koning
Treasurer: Seunghoo Kim
Secretary: Dani vonLembke

The Society of Graduate Geophysics Students (SGGS) lives up to its mission of bringing graduate students together by organizing events aimed at lifting students' spirits and, whenever safe, providing opportunities for live interaction. And what better way to bring people together than organizing food? This academic year has seen the continuation of the beloved breakfast (or lunch) burritos, with several events taking place in the designated outdoors space on campus. We ran a pick-up and delivery service when the weather made outdoors meetings infeasible, got together on-line to play games and organized a very successful combined Pi Day and St Patrick's Day celebration that helped to alleviate some of the pre-Spring Break anxiety. But we are not just about food! We selected a new logo for our organization and are planning to use it on our very own pint glasses in anticipation of the good times to come when we will be able to get together and enjoy one of Golden's most iconic beverages. In the meantime, the glass will be a reminder that we are not alone and a part of a greater community.

— *Contributed by Iga Pawelec*

Geophysics Alumni News

Ready to Meet Up Again: Reunion Update

With vaccinations going well and plans to return to in-person events on campus in the fall, the Geophysics Reunion Committee is pleased to announce there will be an in-person reunion September 25-26.

Though details are still being finalized, look for a happy hour and dinner the evening of the 25th and some hiking and campus tour opportunities on the 26th. We are also planning at least one virtual option for those still facing travel restrictions.

Invitations for the event will be sent out in May along with a request for your photos to be included in a reunion slideshow. If you plan to attend and need accommodations, consider booking those early as the reunion will take place the weekend that begins the combined conference for the Society of Exploration Geophysicists and American Association of Petroleum Geologists, September 26 to October 1.

Women at Mines Interest Group

The Women of Mines Interest group is led by Mines alumni with members from Women in Science, Engineering & Mathematics (WISEM) and other areas on campus. The group works to strengthen diversity in Geophysics and across all areas of Mines with the goal to achieve 40% women at Mines by 2024 when Mines turns 150 years! The Women of Mines Interest Group also offers an array of opportunities for Mines Alumni to continue a culture that promotes Mines' rich tradition of excellence.

Development → Enabling lifelong learning

Collaboration → Fostering and strengthening relationships

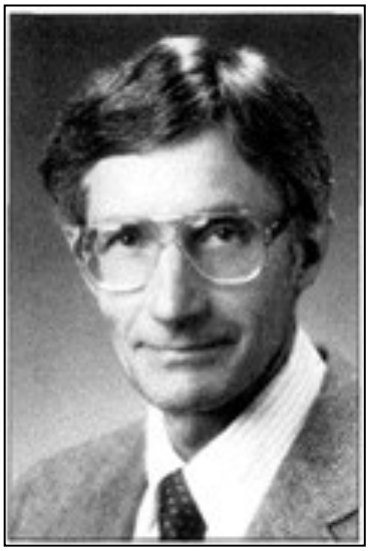
Networking → Supporting and promoting Women of Mines Alumnae

There are currently 26 Mines Alumni involved with degrees in Geophysics from 1977 to 2018. We would love to have you join us!

Ways to Get Involved

Want to get involved? We have a few great opportunities for you. **Learn more at our website:** https://weare.mines.edu/s/840/19/interior.aspx?sid=840&gid=1&pgid=4163&cid=6134. Or connect with us on Linkedin.

In Memoriam: Bill Schneider



In 1977, following graduate study at MIT and a leadership role at Geophysical Services, Inc., Dr. Bill Schneider came to Mines to help lead the revolution in seismic data processing. He immediately began teaching the core course in Exploration Seismology, and over the next few years, he created and shared a marvelous note set that focused on many of the fundamental elements of seismic data processing. In the early 1980s, Bill and Dr. Tom Davis became a well-known and respected team, with Bill focused on data processing and Tom focused on interpretation.

Shortly after Bill's arrival on campus, he led planning for, and implementation of, a large Keck Foundation grant which included a supercomputer, a seismic acquisition system and a mobile data processing computer. Students during the early 1980s will remember his enthusiasm for helping them learn to use the equipment at field camp and in research projects. He also was instrumental in recruiting the faculty who founded the Center for Wave Phenomena (CWP), and he supported the development of the Reservoir Characterization Project (RCP). They became models for industrial consortia at Mines, and twenty-five years later they still are leading the profession.

Near the end of the decade, Bill founded Golden Geophysical (which eventually merged with Fairfield Industries) and resigned from Mines. However, that was not the end of his contributions. He continued to work closely with the RCP: processing seismic data acquired through the Project, advising students working with the data, serving as a member of the RCP Board, and being Chairman of the Board for a number of years.

For all of his scientific accomplishments, many will remember Bill most for his gentle demeanor and generous spirit. Whether it was a student struggling with a physical concept, a graduate research assistant finishing a thesis, or a green department head learning the ropes, Bill always was ready to offer encouragement and advice but never willing to compromise his integrity. He truly was one of the "greats" in the profession, and he had a profound and lasting impact on Mines and its Geophysics Department.

— Contributed by Phillip Romig Jr., Tom Davis and Ken Larner

2020-21 Publications

2021

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