GEOLOGICAL SCIENCES
UNIVERSITY OF COLORADO BOULDER

Geology News

Pictured L-R: Tyler Wickland, Joe Smyth, Alisha Clark, Melia Kendall (in shadow), Lindsay Harrison (kneeling), Hannah Bausch, Steve Jacobsen.

Editors:
Robert Anderson
Dan Mitchell

2021 - 2022

Chair's Corner

Robert Anderson

I write as the summer of 2022 begins, and our faculty and students disperse into the world from our home base in the Benson Building. Our new graduates embark on their next steps in life. Faculty and graduate students dive into their labs or head off for field research, meetings and leisure. Lizzy Trower and her students are headed to the Turks and Caicos. Giff Miller is headed to Baffin Island (of course). Kevin Mahan is targeting the Four Corners area in a hunt for deep crustal xenoliths in the diatremes exposed in that area. I'll travel with Irina Overeem, Suzanne Anderson and grad student Josie Acuri to Alaska's north coast. The world is cautiously opening up a little bit from the cloistering imposed by COVID for the last several years.

We have just held graduation in person for the first time since 2020. It was a joy, on a perfect spring day, to see people in 3D, to shake hands, to meet parents, and to listen to the summaries of research that punctuate the graduation ceremony. This completed an academic year in which we had haltingly opened from the clamp-down of the prior year, reflecting an increasingly vaccinated population. It felt good to teach in person, to run field trips, and to have those serendipitous conversations from running into people in the hallway.

Staff. The Great Reshuffle has hit the department. For us, this year, it has meant the departure of office manager TJ Deaton, who masterfully demonstrated great competence for her many-faceted job, and endeared herself to us all. She left us, sadly, for a (much) higher paying position elsewhere in CU. Thankfully, she has remained in the wings to help us out while we search for a replacement, and has promised to help onboard the new office manager once we have found the right person. It turns out that finding someone with those skills, and especially the right demeanor, is hard to do.

This has meant that the rest of the staff has met with an incredible lift through the Spring semester. It has helped a lot that a replacement for Ingrid Simecek as an accountant shared with another department has been found. We are tickled to welcome Will Altizer to the department in that role. He has already demonstrated a great willingness to participate in departmental functions of all stripes.

Events. And speaking of functions. The grad students helped to organize and run a Spring picnic this year, our first in a while. This netted 80 people at the Martin Acres Park in south Boulder, where it was jazzy to see a lot of families enjoy the late afternoon.

Associate chairs. I have had the great pleasure to work with Tom Marchitto for 3 years as Associate Chair of the graduate program. Tom will be stepping aside this summer. Eric Small was Associate Chair of the undergraduate program until this last winter, when he took on the directorship of the most earthy of the Residential Academic Programs (RAPs) on campus, the Baker RAP. Happily for us, Lon has stepped into Eric's shoes, and is already making use of his extensive knowledge of the program to keep us organized and to help imagine how we can better position the department going forward.

Promotions. It is always a joy to announce promotions. Irina Overeem, who was hired as an Associate Professor, achieved tenure this year, reflecting her demonstrated engagement with the teaching endeavor atop her growing research stature. Julio Sepúlveda was promoted to Associate Professor with tenure, as he guides grads and undergrads alike into the worlds that employs bits and pieces of microbes to tell geologic stories. Kevin Mahan was promoted to Full Professor on the strength of his research on the planet's deep crust.

I'll spend a little more ink on Lizzy Trower. She sailed through the reappointment process, the step between being hired and going up for tenure, in which we assess whether one is on track. It did not hurt her case that she received one of eight Sloan Fellowships in Earth system science awarded in 2022. These early career fellowships are reserved for those with a distinguished research performance and with potential to "revolutionize" their field. Her toolkit to probe the geologic record is absolutely unique. Funding for work at the intersection of fields – in her case between microbiology and paleoclimate and sedimentology – is typically difficult within the funding structure of governmental agencies, and this Sloan Fellowship frees her to explore this interdisciplinary realm efficiently, and to make the splashes that we all anticipate.

Building. I suppose the biggest (and certainly the heaviest) news about the Benson Building is that we managed to shoe-horn in Alisha's monster press (see story on pg. 14) into her lab in the NE corner of the basement.

The TRAiL lab in which Becky Flowers' research effort is based, and run by Jim Metcalf, now sports a working laser ablation device allowing them to drill teeny holes in the apatites and other minerals to explore their chemical composition and any zoning they display.

Departures. We lost a dear friend in Pete Birkeland, who died on a snowy day this winter at the age of 87. Please see pg. 30 in this newsletter for a more extensive summary of his life. A celebration of his life and career was held in Benson on June 17th. From me, I have lost someone to whom I looked for how to live a good life. Pete skied and biked as long as he possibly could, always with that twinkle in his eye.

Retirements and departures this year and next. While Steve Mojzsis and Chuck Stern retired from CU in the midst of COVID, the list of retirements is continuing to grow. Bruce Jakosky retired in December to turn his entire attention to his research at LASP. David Budd, Peter Molnar and Giff Miller are all phasing toward retirement, with full retirement to take effect at the end of this next academic year. Mike Willis is leaving CU for Virginia Tech, where he and his wife have finally solved the "two-body problem". I have also just learned that Jim White, who has served as interim dean of CU's College of Arts and Sciences since 2017, will be leaving to become the dean for the College of Arts and Sciences at the University of North Carolina. We wish all of these people well in their future endeavors!

Given these retirements, the department must and will take up the opportunity and the challenge of reimagining how we should look, what we should teach, and what topics we should dive into, going into the near future. COVID has changed what the department looks like. COVID has forced us to explore other modes of teaching.

The world is indeed a different place. We are all experiencing things for which we didn't even have words a couple years ago. What was zooming, other than going really fast? Supply chains… As we have begun to emerge from the pandemic, the workforce has shifted as it experiences the Great Retirement, the Great Reshuffle, the Great Resignation. Many have begun to rethink what it is they wish to do with the remainder of their lives. The "new normal" is not normal in any way, but instead continues to shift, and I suspect will continue to do so for quite some time. But we have a faculty who are collectively nimble-minded. I anticipate that we will thrive on the challenge of this new time.

I watched the lunar eclipse last night, that of the Super (we are closer to the Moon than average, so it is bigger) Flower (it happened in May) Blood (turns red in the Earth's shadow) Moon. I watched as the Moon went into eclipse and as it came out. I hope that we can all come out of the COVID eclipse as brightly and as full of promise as did our Moon. I wish you all well, and trust that you are staying safe.

With cheer, Bob

Contents

@cu_boulder_geology
Check us out on Instagram
instagram.com/cu_boulder_geology/

Greetings from the Alumni Advisory Board - Dean Miller

It has been another interesting year in which the Advisory Board continues pretty much in a holding pattern given ups and downs of the COVID pandemic. We have not met in person since the beginning of the pandemic, but have held biannual Zoom calls with Bob Anderson to discuss issues in the Department. We miss seeing each other in person and hearing from the new faculty members about their research. However, we continue to meet with students, albeit remotely.

The Department has done a remarkable job keeping things on track during these challenging times, which is reflected in the feedback we receive from the students. They are still having a very good academic experience.

As Bob Anderson mentions in his column, we lost Pete Birkeland earlier this year. He was an amazing person both professionally and personally. Several of the Advisory Board members attended Pete's memorial and subsequent Happy Hour. Many of Pete's former students were there and it was great to see a lot of folks from over the past few decades in the Department. We have a very strong community in the Department, which has served it well, and will continue to do so into the future.

Hopefully, we'll be able to report next year on our first in-person meetings for quite some time. Until then, take care and stay safe.

Thank you Advisory Board for your investment in the Department of Geological Sciences, our students, our staff, our faculty and our researchers.

March 17, 2022 in front of the Benson Earth Sciences building. One last hint of Winter.

May 17, 2022 in front of the Benson Earth Sciences building. Looking Southwest toward the Flatirons.

Geological Sciences Advisory Board Members

Eric Anderson
USGS

Lisa Campbell
Anschutz Exploration Company

Patricia Corbetta

Tim Farnham
Shell

Dawn S. Kaback
Retired

Houston Kempton
Environmental Consultant

Dean Miller - Chair
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Shannon Cheree Stover
BP

Sean Sundermann
Kilduff Underground Engineering

Charlie Wilson
Thornburg Investment Management

Joe Zamudio
Mineral exploration and remote sensing consultant

Bob Anderson inducted into the National Academy of Sciences

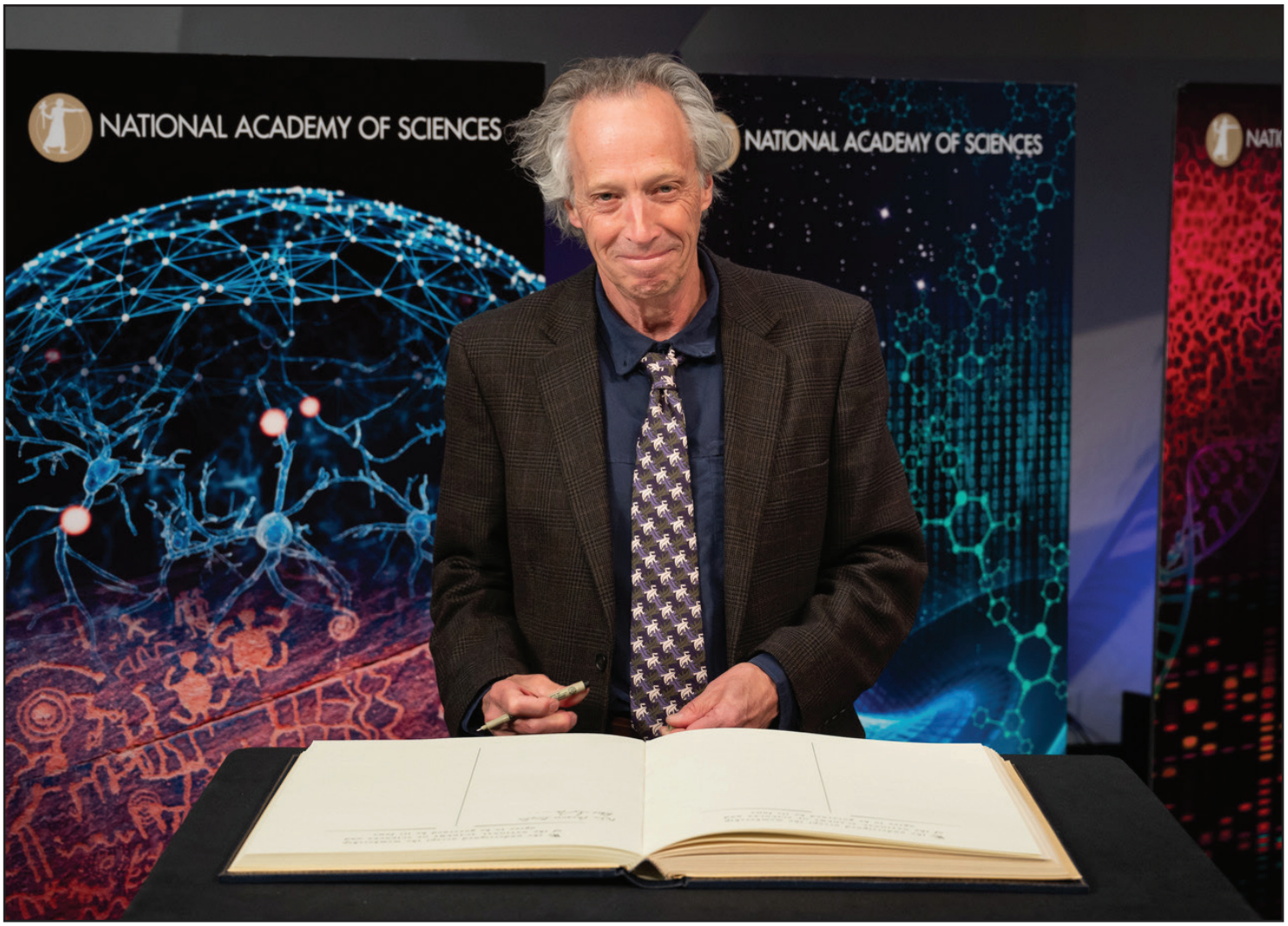
- Suzanne Anderson

In April, Dr. Robert Anderson was inducted into the National Academy of Sciences as a member of the historic class of 2021. The 120 new American members inducted that day included a record number of women (59), among them CU's Fran Bagenal (Emeritus, astrophysical and planetary sciences). Election to the National Academy of Sciences reflects each scientist's "distinguished and continuing achievements in original research". Current NAS membership totals approximately 2,400 members and 500 international members. Bob is the first member of the department to receive this honor.

During the induction ceremony, held in the National Academy's building on the National Mall in Washington, D.C., each new member signs "the book", a registry that dates to the beginning of the NAS. Bob's wife, Suzanne Anderson, mother, Florence Anderson, and brother, David Anderson attended the induction ceremony.

The NAS was established by an act of Congress in 1863 to provide scientific advice to the nation. The enacting legislation passed through both the senate and the house and was signed by President Lincoln in a single day, a feat that is hard to imagine from a modern vantage. Since its Civil War beginnings, the NAS has grown. The Academy established the National Research Council in 1916 at the request of President Woodrow Wilson to expand the community of scientists engaged in its advisory work. Membership in the NAS affords opportunities to work on topics ranging from education to diversity to science frontiers. Bob is looking forward to engaging in this work in years ahead.

Dr. Robert Anderson signing the book at the National Academy of Sciences.



Faculty News

Leilani Arthurs

In August 2021, Dr. Leilani Arthurs was promoted from Assistant Professor to Associate Professor with tenure.

In October 2021, Arthurs and two of her graduate students presented results of their research at the annual meeting for the Geological Society of America. William Bennett shared preliminary findings about the use of eye-tracking methods in geoscience education research. Collette Wilfong presented her findings about the gap between the knowledge of evidence-based active learning methods and the extent of their implementation in geoscience courses. Arthurs presented a study that investigated students' preconceptions about groundwater and the use of that prior knowledge to facilitate their learning about aquifers.

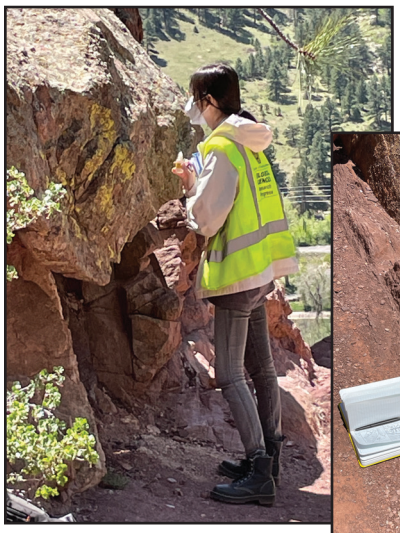
Pictured L-R, Collette Wilfon, Leilani Arthurs and William Bennett. Celebrating Will Bennett's graduation and Collette Wilfong's defense.

In December 2021, Carlton Mueller accepted his "dream job" working as a coordinator for the GeoFORCE K-12 outreach program of the Jackson School at the University of Texas at Austin. With the offer in hand, he switched from pursuing a PhD to a Master's. His Master's specializes in geoscience education research, specifically bridge programs.

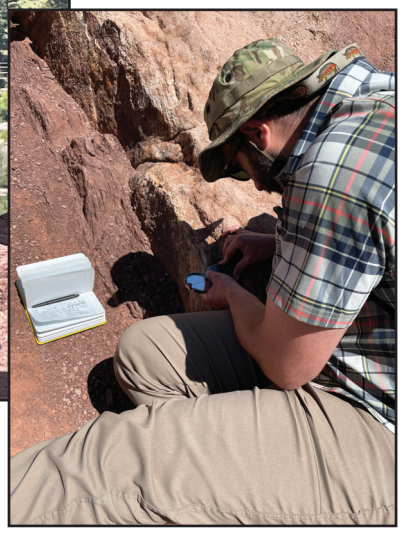
In April 2022, William Bennett successfully defended his Master's degree in Geoscience Education.

In May 2022, Collette Wilfong successfully passed her comprehensive exam towards PhD candidacy and William Bennett graduated with his Master's.

During Maymester 2022, Leilani taught GEOL 2700:



Judice Gao performing an acid test during Maymester Field Geology.



Randall Duncan using Brunton compass during Maymester Field Geology.

Introduction to Field Geology in person, after two years of teaching it remotely due to COVID-19. The photos above are of students in the field May, 2022!

Shemin Ge

The hydrogeology group continues research in water-induced seismicity and climate change impact on groundwater resources. The group welcomed MS student Cameron Chambers in the fall, while MS students Kelleen Lanagan and Lauren Salberg (co-supervised with Suzanne Anderson) graduated in winter 2021 and Scott Stokes in spring 2022. Kellen, Lauren, and Scott all smoothly landed their new careers in government and private agencies.

Scott's thesis deals with how injection of wastewater causes earthquakes in the Raton Basin in central southern Colorado and central northern New Mexico

Pictured L-R, Claudia Corona, Scott Stokes, Fabiana Fuentes (in coming grad student), and Shemin Ge

where production of coal-bed methane generated wastewater has been injected to deep underground since 1994 with a sharp increase in earthquakes in the meantime. Scott asked how the earthquakes were triggered initially. He dug into the basin geology and then constructed a 3D hydrogeologic computer model to predict how much pore pressure the injected water creates. He found that injected water caused pore pressure in rocks to increase and that acted as the trigger at places where the rock is already weak and broken, for example, in preexisting fault zones. He found that the time when the pore pressure reaches a certain threshold is consistent with the timing of the earthquakes occurred on these faults. Scott has submitted his thesis work to a journal for publication.

PhD student Claudia Corona (now co-supervised by Suzanne Anderson) remains a steady anchor of the group and published the first part of her dissertation research in spring (Corona and Ge, 2022, Examining subsurface response to an extreme precipitation event using HYDRUS-1D. Vadose Zone Journal). Claudia's paper examines how extreme precipitation events impact groundwater storage dynamics. She conducted numerical modeling to simulate the nonlinear water flow processes in the vadose zone between land surface and the water table, using the precipitation data that caused the 2013 Front Range flood and the subsurface data in the Boulder Creek Watershed, Colorado. A major finding of Claudia's work is that the water table responded rapidly, on the order of days, to the extreme precipitation event, but the recovery of the water table to its normal position can take much longer, 1-2 years in the Boulder Creek Watershed case. This suggested that the subsurface acts as a water storage and buffer during and after extreme precipitation events.

Finally, Shemin finished and published a review paper that she started to write during her sabbatical almost two years ago (Ge and Saar, 2022, Review: Induced seismicity during geoenergy development—A hydromechanical perspective. Journal of Geophysical Research) that summarized the advances and future research challenges in understanding the mechanisms of induced seismicity.

Brian Hynek

Professor Brian Hynek, along with graduate students Amanda Steckel and Adam Solon (EBIO) attempted a first: a microbiology study on top of the world's highest active volcano. Funded by the National Geographic Society, the team spent three weeks in Argentina climbing and conducting science up the side of Ojos del Salado (6,893 m; 22,615'). This volcano boasts extreme UV exposure, a huge

Graduate students Amanda Steckel and Adam Solon conducting solar irradiance measurements in a penitente field 18,500 feet above sea level. The non-sun-facing aspects provide protection from harmful UV rays and when combined with liquid in the melting snow spires, provide a rare habitat for life in the harsh setting. Microbiology analyses are currently underway.

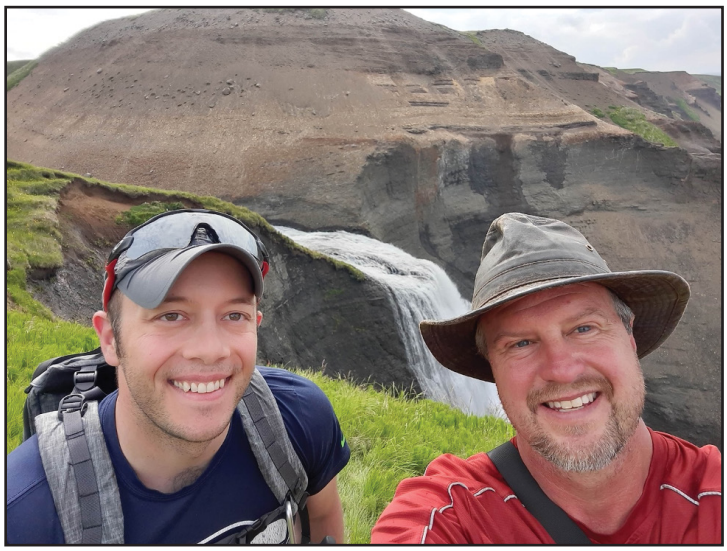
diurnal temperature flux, carbon-poor soils and extreme aridity high above the Atacama Desert. Thus, it is a great analog environment to study the potential habitability of early Mars, where similar conditions are thought to have existed. Targets included fields of snow spires known as penitentes, aquatic environments, volcanic tephra and soils, and hydrothermal settings. Analysis of the samples are currently underway and will greatly contribute to our knowledge of how microbes can adapt and survive in one of the most extreme environments on our planet. Read more here: https://www.colorado.edu/today/2022/03/07/expedition-highest-active-volcano-unearths-clues-about-life-other-worlds

How do we sample that volcanic lake? There is no possible way down. The volcanic gases will rust out our drone before it could reach the surface; plus there are constant eruptions happening. So, let's go fishing with our super high-tech sampling system! (We were able to retrieve 400 mL of invaluable sample for geochemistry and microbial analysis.)

Professor Hynek and his graduate student Justin Wang (MS, Aerospace Engineering, 2022) returned to Costa Rica to continue their studies on one of the most acidic and dynamic lakes on the planet. A key target was Laguna Caliente, a roiling sulfurous crater lake in the active Poás volcano. The lake is 100 × more acidic than battery acid, yet Hynek's team has detected Bacteria living in this environment since he first explored it in 2013. What is even more phenomenal is that microbial analyses revealed that there is likely a single species living here- an absolute rarity on Earth given that different species in an ecosystem work together to provide energy and nutrients for others in a typically complex food web. Justin led a high-profile paper this spring in Frontiers in Astronomy and Space Science (https://www.frontiersin.org/articles/10.3389/fspas.2022.817900/full) detailing how this single species of bacterium can survive and even thrive in this caustic setting. These results were based on lake samples from 2017, collected five days before the volcano went into a major eruptive phase that drained the lake and magmatically sterilized the crater.

In 2019, the volcanic activity waned some and a new lake reformed. The studies of the team then shifted to colonization and succession: What microbes will come in and colonize Earth's youngest lake? Will it be the same bacterium that was there before? How quickly can a newly formed acidic lake be colonized? This unique incipient aquatic environment may hold clues to how life on early Earth (and Mars) dealt with high volcanic and impact flux that led to frequent sterilization events. In May 2022, they returned to Poás to again sample the lake and analyses are underway. They were also able to sample two other active volcanoes, including a crater lake 300' below the volcano's rim. They successfully collected the first sample of this constantly erupting lake in well over a decade. Geology undergraduate and UROP researcher Stephanie Schubert has been assisting in the analysis of the Costa Rican microbes and recently presented her results at the 2022 NASA Astrobiology Science Conference (AbSciCon). This exciting study was on how microbially-produced bioplastics might be a biosignature that could help them detect past life on other planets. Geology undergraduate researcher and UROP recipient Sydney Ciechanowicz has recently joined to the team to help with their microbial studies from across the globe.

Graduate student Justin Wang displaying the required dress code for work in active volcanoes.



GEOL alum Michael Lotto and Professor Brian Hynek on a reconnaissance trip to Iceland to identify the field site for the NASA rover tests and collect precursor data. In the background is the thick stratigraphic section that the Mars rover team investigated.

NASA has been sending robotic geologists to Mars since the 1990s. Yet these rovers operate in a very different mode than a field geologist does on Earth. For example, they can only see where their cameras are pointing and miss a lot of the context; and scientific measurements of rocks are inherently limited due to time and power constraints. A NASA team including Professor Brian Hynek has worked for a decade to determine what modes of robotic exploration on Mars will result in the best science in the shortest amount of time.

In July and August 2022, Professor Hynek, along with graduate students Justin Wang and Richard Archer, and CU alum Mike Lotto (GEOL MS, 2020), joined the NASA team for their latest field exercise in the Tjörnes Peninsula, northeastern Iceland. Here, there is a thick stratigraphic sequence of a variety of depositional facies spanning marine, fluvio-deltaic, lava flow, volcanic airfall, hyaloclastites, and glacial. The rover team and its instruments were put to the test to unravel the complexities. In the end, the results

of the study will feed directly in to traverse planning for the Perseverance rover currently exploring Jezero crater, Mars. The team also learned that puffins do not like drones flying around their nests. The scientific results are currently in review in the Journal of Astrobiology.

Professor Hynek and Richard Archer conducted a separate NASA-funded project after the rover tests on the Reykjanes Peninsula- the other side of Iceland. In this work, they are trying to determine the effects of salinity on microbial communities in hydrothermal systems with Mars-like basaltic substrates. Relict hydrothermal systems on Mars appear to have been quite briny, and terrestrial subaerial ocean-influenced hydrothermal systems have received little attention from scientists. By characterizing salty hydrothermal systems a stone's throw from the Atlantic Ocean and meteoric-sourced hydrothermal systems inland, they hope to characterize the microbial inhabitants and apply this knowledge to early Mars.

National Geographic funded a second field expedition for Professor Hynek, but this time to the highest desert on our planet- the Puna within the Catamarca region of northern Argentina. This remote area has received very little scientific study, yet the vast expanses and salars (salt flats) host unworldly ecosystems. In the UAV image to the upper right, Professor Hynek is standing on a mushy halite salt flat next to a saline lagoon. The meter-scale bulbous features in the lagoon are stromatolites, similar to features in the rock record that are the earliest recognized macrofossils on our planet. But at this locale, they are different than the typical carbonate variety- these have microbially-precipitated interbedded layers of gypsum and carbonate deposited seasonally during changing geochemical

GEOL graduate student Richard Archer sampling the Gunnuhvir geothermal field for mineralogy, geochemistry, and microbiology to help assess similar settings on early Mars.

"Laguna Brian" (notional name), a newly discovered series of lagoons that host gypsum-carbonate stromatolites; only the second documented ecosystem of this variety on Earth. Note the two persons for scale.

conditions and microbial communities in the lagoon. In part, they believe these microbes use anoxygenic photosynthesis for energy, which is the predecessor to oxygenic photosynthesis on early Earth; perhaps making these feature a Rosetta Stone for scientific inquiry. Until now, only one occurrence of gypsum-carbonate stromatolites like these are known on Earth (also in Argentina) and the first scientific results are forthcoming. In April, 2022, Professor Brian Hynek discovered this second locale, based on satellite imagery analysis and field reconnaissance. Unfortunately, this salar is about to undergo exploration drilling in support of lithium mining that could greatly perturb the entire system. The team is hurriedly writing an NSF rapid response proposal to try to protect this extremely rare environment on our planet Earth.

Kevin Mahan

Kevin Mahan's group continues to work on tectonics and deformation processes in deep continental crust, with ongoing projects in the Colorado Plateau, the Colorado and Montana Rockies, the southern Appalachian Mountains, and the European Alps. Michael Frothingham, a 4th year PhD student co-advised by Kevin and Vera Schulte-Pelkum, continues his work on integrating crustal seismic anisotropy studies across a range of spatial scales. His first paper on an application to basement rocks in Colorado was published earlier this year in the journal Tectonics, and his second paper which is focused on the anisotropy of a mid-crustal decollement in the southern Appalachians was recently submitted for review to the journal Geology. Michael was also selected for an Outstanding Student Presentation Award at the 2021

American Geophysical Union annual meeting. Two collaborating visitors from France will join the group in late spring. Benoit Gasnier is a Master's student from the University of Bourgogne Franche-Comté who is studying Colorado Plateau crustal xenoliths. He will be at CU during May and June 2022 and his advisor, Dr. Philippe Goncalves, will join the group for two weeks in late May.

Giff Miller

After being shut out of fieldwork on Nunavut for all 2020 and 2021, a brief opening appeared in Kuujjuaq, Nunavik in late summer 2021, so Giff Miller and PhD student Jon Raberg raised the flag and headed north, recovering sediment cores from Lake 3LN, sampling vegetation with their Alaskan colleagues, lake waters with U. Buffalo colleagues, and re-collecting temperature loggers installed in soils and lake waters back in summer 2019.

Graduate student Jon Raberg and Martha Raynolds from U Alaska raise the flag on their raft.

Graduate student Jon Raberg and Professor Gifford Miller set sail.

Organic Geochemistry Group Spring 2022. Brooke Holman, Katie Eaman, Sebastian Cantarero, Jon Raberg, Harry Allbrook, David Harning, Lina Pérez-Angel, Julio Sepúlveda, Robert Kelleher. Missing: Nadia Dildar and Nicolò Ardenghi.

Julio Sepúlveda

The Organic Geochemistry Group congratulates the students who graduated this year; The group is so proud of them! Dr. Jonathan Raberg, co-advised by Profs. Giff Miller and Áslaug Geirsdóttir, graduated from the dual PhD program between the University of Colorado Boulder and the University of Iceland. He will continue working with the OGG as a postdoctoral researcher on two collaborative NSF grants. Dr. Sebastian Cantarero will join Project Vesta, a non-profit researching ocean carbon sequestration, as a project scientist in May 2022. Sebastian was also awarded a graduate fellowship from CU's Graduate School in Fall 2021. Dr. Lina Pérez-Angel, co-advised with Prof. Peter Molnar, will continue working with them as a postdoctoral researcher until the end of summer 2022. In the fall, she will join the Institute at Brown for Environment and Society (IBES) at Brown University as a Postdoctoral Research Associate after being awarded a Voss Fellowship. Lina was also received a Bruce Benson Scholarship for the last year of her PhD. Additionally, OGG congratulates former honors student and recent lab PRA Katie Eaman for having been accepted in the PhD program in Geological Sciences at the University at Buffalo, where she will work with their colleague Elizabeth Thomas. The OGG wish everyone all the best in their future endeavors! OGG welcomed two new

Spring 2022 graduation. Jon Raberg, Lina Pérez-Angel, Julio Sepúlveda, and Sebastian Cantarero

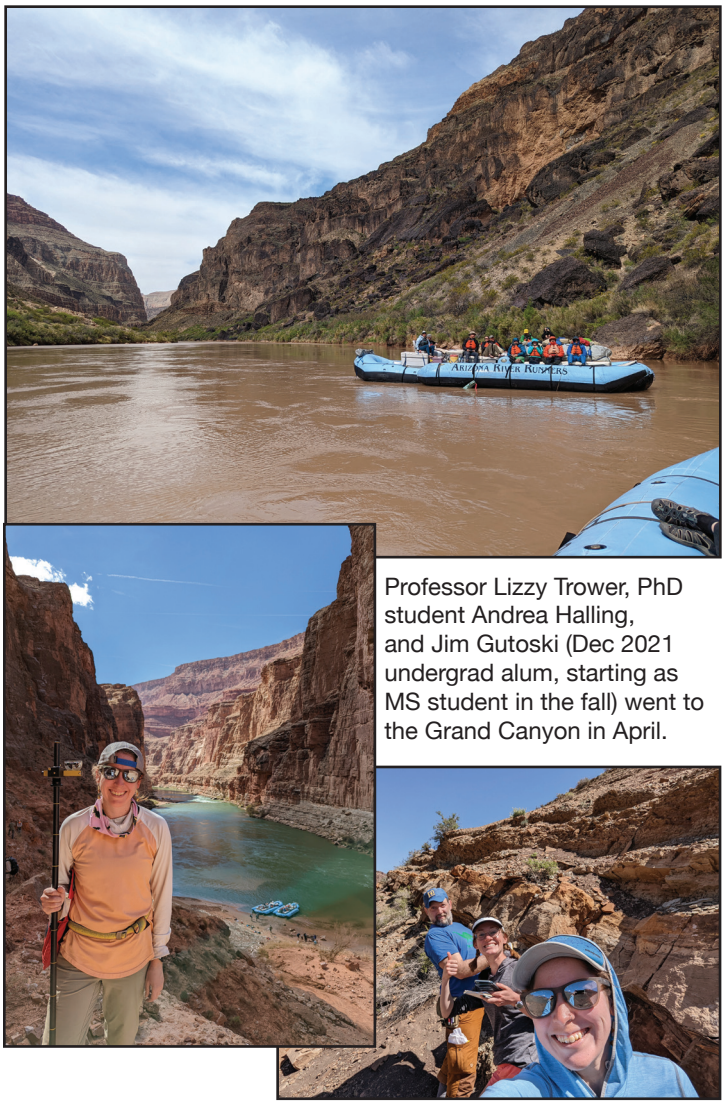
Lab manager Dr. Nadia Dildar, PRA Katie Eaman, and graduate student Lina Pérez-Angel with visiting student Hanaa Baniowda.

Organic Geochemistry Group Fall 2021. Hanaa Baniowda, Nadia Dildar, Harry Allbrook, Sebastian Cantarero, Nicolò Ardenghi, Julio Sepúlveda, Lina Pérez-Angel, Jon Raberg, Profs. Giff Miller and Áslaug Geirsdóttir (collaborators), Robert Kelleher, Brooke Holman: Missing: Katie Eaman, David Harning.

graduate students in fall 2021: Robert Kelleher, a recent graduate from the undergraduate program at CU Boulder, and Harry Allbrook, a MSc. graduate from the University of Bristol, England. The group also welcomed and mentored visiting student Hanaa Baniowda in fall 2021, a recent graduate from the An-Najah National University in Nablus, Palestine, supported by a travel fellowship from the Boulder-Nablus Sister City Project (BNSCP). Furthermore, the group started two new awards, an NSF CAREER from the Chemical Oceanography, Biological Oceanography, and Ocean Education Programs, and an NSF grant supported by both the Marine Geology and Geophysics and the Sedimentary Geology and Paleobiology Programs. Lastly, Julio was thrilled to learn that his promotion to Assistant Professor with Tenure passed with flying colors. All look forward to entering a new phase of their group!

Lizzy Trower

Lizzy Trower and her students were part of a group of 24 geologists (primarily sedimentologists, paleobiologists, and detrital zircon geochronologists) who floated down the Grand Canyon as the “Grand Canyon Great Unconformity Field Forum IV”. The CU team’s goal was to examine carbonates and shales in the upper Chuar Group to better understand what shallow marine environments and ecosystems were like just before the Sturtian Snowball Earth glaciation. Spending 11 days in the Grand Canyon was amazing and the geology is incredible - they’re grateful that they had the opportunity to go!



Professor Lizzy Trower, PhD student Andrea Halling, and Jim Gutoski (Dec 2021 undergrad alum, starting as MS student in the fall) went to the Grand Canyon in April.

Paul Weimer

Paul Weimer has served as President of the American Geosciences Institute (AGI) since last October. His term continues until October 2022 at the GSA Convention in Denver. His activities have included: helping bring the new Executive Director online, hosting a two-day virtual conference with the 50 AGI member societies on the future of geosciences and geoscience societies, dissolution of the AGI Foundation and transfer of assets to AGI, dissolving trustees and replacing them with the new position of Ambassadors, and implementing new efforts and major policy in the role of geosciences in sustainability and sustainability of the profession. He will also begin to serve as the acting Director of Geoscience Development Roundtable, the new body replacing the Foundation’s trustees.

For the spring semester, Paul taught remotely again after an unfortunate interaction with a frozen stepping stone in mid-January, and a follow-up appointment a week later with a surgeon who operates a side business at the hardware store. His new Sobriquet-Herr Doktor Professor TrueValue.

In January, his IGP group's YouTube video titled "A Short History of Colorado Through Time (Geology of Colorado)" exceeded 1 million views. And that… is successful educational outreach.

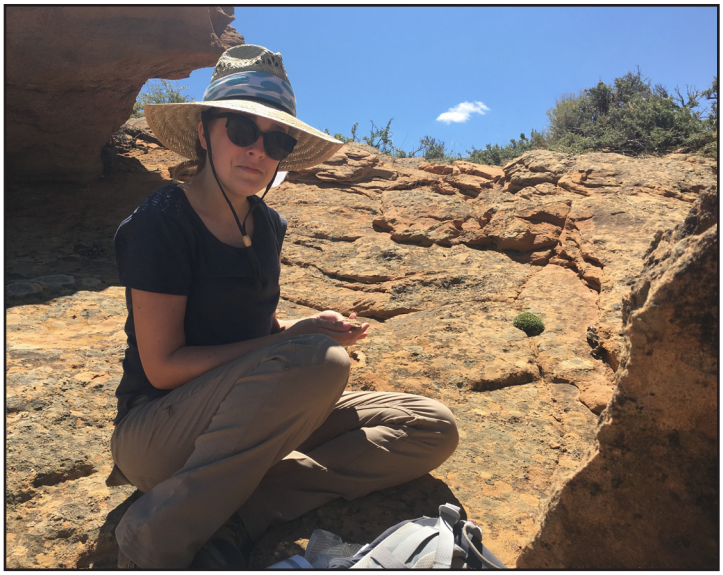
X-ray views of Paul Weimer's "hardware store" ankle.

Professor Anne Sheehan retrieving part of the 2 km fiber optic cable deployed at FORGE geothermal site in Utah.

Postdoc Manuel Mendoza working with fiber optic cable deployed at FORGE geothermal site in Utah. photo credit Anne Sheehan

Maddy Atteberry Published in the Journal of Systematic Palaeontology

Department of Geological Sciences alumnus and current Undergraduate Program Assistant, Madelaine Atteberry recently had her first paper, "New earliest Paleocene (Puercan) periptychid 'condylarths' from the Great Divide Basin, Wyoming, USA" published in the Journal of Systematic Palaeontology. Madelaine along with her advisor Jaelyn Eberle describe three new periptychid 'condylarths', *Conacodon hettingeri*, *Miniconus jeanninae*, and *Beornus honeyi*, and report first occurrences of *Maiorana noctiluca*, *Ampliconus antoni* and *Conacodon harbourae* from the Great Divide Basin in Wyoming.



Maddy in the Great Divide Basin, Wyoming, close to the field site where the newly discovered animal fossil samples were collected.

citation: Madelaine R. Atteberry & Jaelyn J. Eberle (2021): New earliest Paleocene(Puercan) periptychid 'condylarths' from the Great Divide Basin, Wyoming, USA, *Journal of Systematic Palaeontology*, DOI: 10.1080/14772019.2021.1924301

CU TRaIL (Thermochronology Research and Instrumentation Lab) Update

- James Metcalf

This past year has been busy for everyone in the CU TRaIL (Thermochronology Research and Instrumentation Lab). This year marks 10 years since the arrival of the ASI Alphachron and the establishment of the TRaIL facility. In the last decade, the lab has produced thousands of (U-Th)/He dates and continues to expand its capabilities. This year the lab oversaw the installation of one of its newest pieces of equipment, a 193 nm Excimer laser for laser ablation analysis. This laser will allow the lab to perform in situ sampling of material that can be then analyzed on either the existing ICP-MS, or on a new, custom, noble gas analysis apparatus being built by Dr. Jim Metcalf (lab manager). Jim, Dr. Ellen Alexander (postdoc), and Professor Becky Flowers (lab director) have spent much of the last year commissioning, calibrating, and streamlining the laser ablation line, as well as developing protocols for U-Pb dating of minerals and mapping isotopic and elemental concentrations of individual crystals. The new noble gas line is now being automated and calibrated, and should be analyzing samples this summer.

The Flowers' research group has continued to work on a range of projects. Morgan Baker successfully defended her MSc thesis focusing on better understanding and correcting for the process of alpha-particle ejection from mineral grains during radioactive decay. Morgan has begun a new position as a staff scientist at Yosemite National Park. PhD student Barra Peak published her first manuscript from her graduate research using thermochronology to understand paleotopography and the Great Unconformity in the journal Geology. This research was also picked up and shared by national and international news organizations, including Forbes and the BBC. Barra is currently working on samples from the Lake Superior region to continue her work constraining the origin of the Great Unconformity. PhD student Spencer Zeigler has now collected a suite of (U-Th)/He data from kimberlites in the Canadian Arctic, and is working on interpreting these new results. Postdoc Peter Martin has just submitted a manuscript describing methods for better calculating and understanding uncertainties in (U-Th)/He dating. Peter is also using low-temperature thermochronology to understand the timing of exhumation in New Guinea and its potential effects on global climate, and has been working with colleagues at the University of Wisconsin to develop a database system for collecting, organizing, and preserving TRaIL data. Peter also received an NSF grant as lead PI to develop laser-ablation hematite (U-Th)/(Pb-He) double-dating here at CU (co-PI Becky). Becky published a set of companion papers describing best practices for collecting, describing, and interpreting (U-Th)/He data. These papers were co-authored by other leaders in the field of (U-Th)/He dating. Postdoc Dr. Ellen Alexander has developed laser ablation protocols, helped fully commission the new laser ablation line, and is now working on a suite of detrital zircon samples. Jim continues to work on building the new He line, and has completed the initial calibration and automation phases of construction. This spring the TRaIL also hosted Dr. Jeff Benowitz for three months. Jeff helped the lab keep up with producing data, and also had a chance to work on some of his own projects investigating the evolution of the Denali Fault System.

In the fall of 2021 five members of the group travelled to Santa Fe for the in-person International Conference on Thermochronology, where Barra, Spencer, Peter, and Becky presented their recent research, and were able to collaborate with colleagues in person. Spencer will also be attending and presenting their research at the International Conference on Arctic Margins in Ottawa this summer. The TRaIL has also continued to participate in numerous outreach efforts. Barra is designing an exhibit for the CU Earth Sciences and Map Library that highlights her work on the Great Unconformity. Barra has also done virtual visits to college and K-12 classrooms discussing her recent work in the Grand Canyon and helped produce Spanish language news coverage of her research. Jim continues to participate in the Skype a Scientist program and has now visited six K-12 classrooms in the US and Canada to share his research and answer questions about geology. The TRaIL also continues to work with CU undergraduates, and helped produce data for two CU honors theses defended by Sabrina Kainz and Eddie Riccio this Spring. This Spring also saw the introduction of the TUnDRA (TRaIL Undergraduate Directed Research Awards) program, which allows CU undergraduates to apply for up to $1000 of analytical work in the TRaIL facility.

1000-ton Multianvil Press Makes Its Way to The Basement of the Benson Earth Sciences Building!

- Alisha Clark

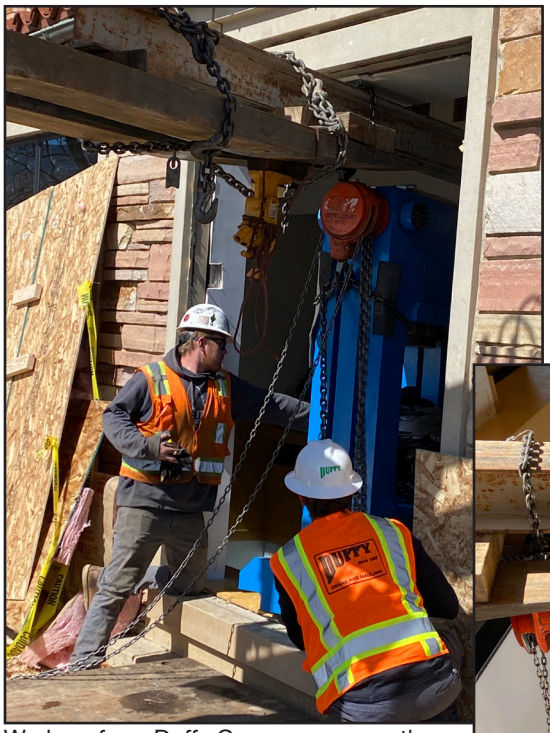
This spring was a much more eventful time for the Clark lab group than the last year or so, which is likely a common case – thanks, COVID. Spring semester began with the whole lab group taking the Machine Shop and Technology Safety class in Physics (highly recommended), and in April all the graduate students made it out of the department for various research trips – Lindsay Harrison and Melia Kendall traveled to Sandia National Laboratories for experiments, and Tyler Wickland performed field work in New Mexico for sample collection. But perhaps the most exciting event is that this March the much-awaited multianvil press made its way to the basement of the Benson Earth Sciences Building!

The Walker-style 1000-ton multianvil press is the largest single piece of equipment in Alisha Clark's high-pressure experimental lab which will routinely generate hydrostatic pressure-temperature conditions found in the crust, upper mantle and into the mantle transition zone (with more extreme conditions achievable with modifications). The press is used both for conventional experimentation at high pressures (e.g., elemental partitioning, atomic diffusion at high pressure electrical conductivity measurements, viscosity, phase equilibria, among others) as well as material synthesis (i.e. starting samples for shock experiments, material synthesis for materials science, etc.). As such, the multianvil press is a workhorse for exploring the materials that exist and the processes that operate in planetary interiors.

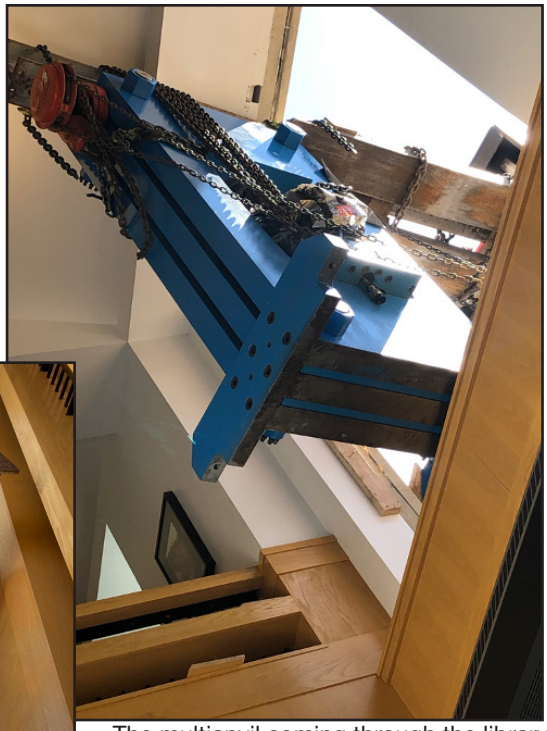
The multianvil is about the size of 2 people standing shoulder to shoulder: about 4 feet wide, 2 feet deep (not counting the supporting feet) and a bit over 6 feet tall. So, while not that physically imposing, the multianvil weighs 11,000 lbs. – the weight of 1-2 elephants depending on species and sex, or the weight of a large orca. And so, as one might imagine, the process of getting the press into the basement of the building was a bit of a saga. The first step was getting a safe path for the press from outside and down into the basement. The small footprint for the 5.5-ton press – less than 10 square feet – meant that the first plan of coming down the hallway and being lowered down the elevator shaft wouldn't work, as the press would overload the joists in the flooring. After many, many, many, meetings and building walk throughs and engineering consultations, it was decided that the best path into the building was through one of the Benson Earth Sciences Library store front windows on the ground floor. Just behind the store front windows are floor cutouts that allow natural light to reach the map library in the basement. The plan was to remove the window, lower the multianvil press through the cutout directly to the basement floor and then move the multianvil press on skates down the hallway to the high-pressure lab. The first attempt to move the press into the building was in early March, but the press proved to be too much for the equipment brought that day. So, a week later, the press came back with double the manpower, 2 forklifts, and 7 metric tons of counterbalance weight for move-in attempt number two – which was a success! And as they say, a picture is worth a thousand words, and so we hope you enjoy some of the pictures of the move in. On a final note, thank you everyone who helped in this process, in particular Duffy Crane (the rigging company), Dan, Bob, and all the CU people who helped to orchestrate the arrival of the press!

The first arrival of the multianvil and 9 pallets of associated equipment. photo credit: Alisha Clark

Students making a day of it for attempt 1 with the multianvil press rigged for an attempt into the library window.



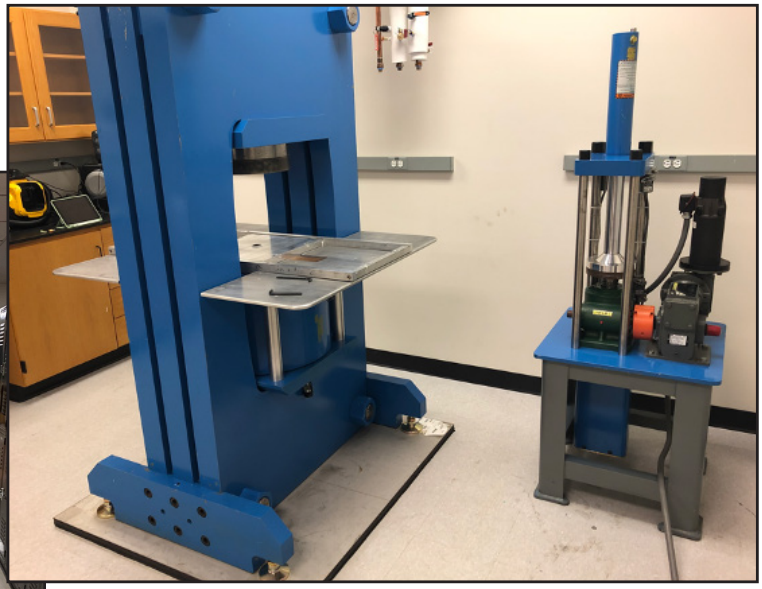
Workers from Duffy Crane maneuver the multianvil through the library window.



The multianvil coming through the library window during attempt #2.

Steering the multianvil through the library stacks.

Masonite was used to help protect the floor as the multianvil was moved through the building.



1000 Ton multianvil undergoing installation at CU Boulder May 2022. The multianvil can reach pressures of >15 GPa and temperatures of >2000C, simulating the P-T conditions deep in the Earth. The multianvil press sits on a 1” thick steel plate on top of a 1” thick rubber mat to distribute its 11,000+ lbs.

In the Field

Fall 2021 Field Geobiology co-taught by Professors Boswell Wing and Lizzy Trower. Great Salt Lake (incl. some bison near our camp), where the students explored for a day and then designed and conducted their own field research projects. photo credit: Lizzy Trower

Students in the Fall 2021 Field Geobiology class measuring section and describing the Eocene Green River Fm in Colorado, Utah, and Wyoming.
photo credit: Lizzy Trower

Students in the Fall 2021 Field Geobiology class measuring section and describing the Eocene Green River Fm in Colorado, Utah, and Wyoming.
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Students in the Fall 2021 Field Geobiology class at Great Salt Lake, where the students explored for a day and then designed and conducted their own field research projects.
photo credit: Lizzy Trower

What Raised the Rockies? – Insights from Undergraduate Thermochronology Research

– Lon Abbott

Rocky Mountain Biological Laboratory and Gothic Mtn 2016
photo credit: Lon Abbott

Geoscientists have puzzled over the origin of today's Colorado Rocky Mountains for over 150 years. A series of mountain ranges that resembled Colorado's modern ones first rose during the Laramide Orogeny, a compressional event that occurred between 70-45 million years ago. The Laramide mountains rose much farther from the active plate boundary than is typical, but otherwise the tectonic processes that raised the Laramide Rockies were conventional. Movement on Laramide thrust and reverse faults thickened the continental crust, raising the ranges above sea level and supporting them with buoyant crustal roots. But structural studies document that the magnitude of Laramide crustal shortening was insufficient to build a crustal root thick enough to support a range as tall as today's Colorado Rockies, and in any case seismic studies, starting with the pioneering work of departmental Professor Anne Sheehan, reveal that any crustal root the mountains once possessed is now gone – the Colorado Rockies are "rootless".

How then did Colorado become the "Roof of the Rockies", boasting the highest peaks in the entire 4800-kilometer-long Rocky Mountain chain? The bottom line is that we don't yet know, but many of the department's researchers are devising programs to interrogate the range's properties and history to answer that question. Among those efforts is one mounted by a team of undergraduate researchers mentored by Teaching Professor Lon Abbott in collaboration with the Thermochronology Research and Instrumentation Lab (TRaIL) run by Professor Rebecca Flowers and Dr. James Metcalf. TRaIL does (U-Th)/He dating (He dating for short), a technique that enables researchers to track the cooling histories of uranium-bearing minerals. Rocks cool as erosion of overlying material brings them toward Earth's surface, so He-dating of Colorado rocks allows us to track when they were exhumed from a depth of several kilometers to the surface. There are multiple possible reasons for rock exhumation – a change in climate that invigorates erosional processes, reorganization of the river networks that accomplish most erosion, or tectonic uplift of the Earth's surface. By using He dating to document the exhumation trajectories of Colorado rocks and comparing those exhumation histories with independent evidence of the timing of climate shifts and river network reorganization, the TRaIL team is contributing useful insights into Colorado's surface uplift history, helping to answer the big question of when the modern Colorado Rockies, and the anomalously high Colorado Great Plains, rose.

TRaIL's study of Rocky Mountain uplift history began in 2016, when Teaching Professor Lon Abbott received a research grant from the Tim Wawrzyniec Fund at the Rocky Mountain Biological Laboratory (RMBL) located in Gothic, Colorado, near Crested Butte. The grant funds work on the geology surrounding RMBL, and honors the life and work of Tim Wawrzyniec, a prominent Colorado geologist who was associated with RMBL and Western Colorado University in Gunnison. CU alum Coleman Hiett did the initial work, Helium dating the granites he collected from Treasure Mountain, northwest of RMBL, for his undergraduate Honors thesis in 2016. Alum Noah McCorkel added He data from Whiterock Mountain, east of RMBL, for his 2017 Honors thesis. Coleman and Noah's data corroborated and extended work by New Mexico Tech graduate student Rebecca Garcia documenting Miocene exhumation in the Elk Mountains.

Alum Noah McCorkel on Whiterock Mountain, east of Rocky Mountain Biological Laboratory. photo credit: Lon Abbott

Meanwhile, Fatima Niazy, a Tufts University geology student who did a summer RESESS (Research Experiences in Solid Earth Sciences for Students) internship with the TRaIL team, discovered that He dates for granites near Salida were Eocene, revealing that rocks near Salida were exhumed much earlier than were those near Crested Butte. The team concluded, in a paper published this year in Geosphere, that Eocene exhumation near Salida was caused by a post-Laramide episode of surface uplift that affected an area stretching from the Sawatch Range to the Great Plains of northeastern Colorado.

Fatima's Salida results showed an unexpected mismatch in the exhumation histories of the Crested Butte and Salida areas, suggesting that there isn't a "one size fits all" explanation for uplift of the Colorado Rockies. The TRaIL team suggested in the Geosphere paper that different parts of the state rose at different times in response to the activity of serial "mantle drips" – blobs of gravitationally unstable lithospheric mantle that drip into the deep mantle like beads of paint dripping off a ceiling. Departmental Distinguished Professor Peter Molnar's work over the last 30 years has been instrumental in developing the now widely accepted theory of mantle drips.

As the years passed, more undergraduate researchers joined the TRaIL team's efforts to define the boundary where Eocene exhumation gave way to Miocene exhumation. That team included alums Kristin Putnam, Evan Schanock, Eric Ruggles, and Shelby Litton during 2018-2019 and reached a crescendo in 2020, with three students completing lab analyses for their Honors theses just days before COVID temporarily shut the TRaIL lab down. Mitchell Ramba documented He dates for Mount Lamborn, near Paonia, Robert Kelleher did the same for Taylor Mountain, near Aspen, and Hector Camm analyzed the granites of Gothic Mountain, which rises directly above the RMBL campus. This growing data set revealed the presence of a dome of Miocene exhumation that stretched from Paonia to Aspen and reached a peak magnitude of 4-6 kilometers at Gothic Mountain and RMBL. We named this feature the "Gothic Dome". Edward Riccio added yet more data this year, obtaining He dates for samples from the Crested Butte ski area, work begun by Evan and Eric, and nearby Snodgrass Mountain for his Honors thesis. The case for the Gothic Dome has become airtight and is consistent with the serial drip hypothesis; the team is currently writing up this work for publication.

Shelby started her undergraduate research career doing He dating of rocks from the Gothic Dome, but her true love is geochemistry, so for her Honors thesis she worked with Dr. Aaron Bell on the department's microprobe to determine the depth of intrusion for the Huerfano Butte lamprophyre south of Pueblo. Sabrina Kainz built on Shelby's work using He dating, documenting that the butte's rock, which was intruded 25 million years ago, was still at least 1.5-2 kilometers below the surface 8 million years ago. She also added to data collected by TRaIL alum and former PhD student Rachel Landman's work on the nearby Spanish Peaks, revealing that exhumation ramped up in southeastern Colorado about 17 million years ago. Sabrina's work thus documented yet more diachroneity in Colorado's exhumation history, again consistent with the serial drip hypothesis. She went on to obtain He dates for Two Buttes, a small volcanic plug near the Kansas border, and several intrusive rocks from northeastern New Mexico's Chico Hills for her recently completed Honors thesis. Her southeastern Colorado He work has been augmented by current departmental undergraduate Skye Fernandez's 2021 RESESS project and work the same summer by local Fairview High School student Aidan Olsson on a lamprophyre near Walsenburg. Days after Sabrina's May 2022 graduation, she set to work writing a paper describing this prong of the team's research.

The Colorado Rockies have guarded their secrets through 150 years of geologists' probing; the TRaIL team knows their work won't be the last word on the reason Colorado's elevation is high and it is graced by such beautiful mountains. But this dedicated group of undergraduate researchers is making significant contributions to our collective understanding of the state's geologic history while preparing themselves for the next steps in their respective careers.

Sabrina Kainz on Greenhorn Mountain. photo credit: Lon Abbott

Recent Activities of the Department's Collaborative, Inquiry-based Research Community (CIRC)

– Lon Abbott and Jennifer Stempien

The Collaborative, Inquiry-based Research Community Group photo May, 2019. photo credit: Lon Abbott

It is helpful for undergraduate students to get exposure to what is involved in doing geological research – to ascertain if they would enjoy a career in research or to give them needed experience to make the most of graduate school if they know research is a fit for them. But it can be tough for an undergraduate to take the first step on the road to doing research. Often students are unsure what research even entails or what aspect of geological science they would most like to focus on. Reading the primary scientific literature can be daunting, compounding the challenges. For those reasons, in 2016 Teaching Professor Lon Abbott and Associate Teaching Professor Jennifer Stempien created the Collaborative, Inquiry-based Research Community (CIRC). The community gathers once each week for a seminar in which we exchange ideas about research and how it is done. Most meetings entail discussion of a scientific paper of the group's choice. Other sessions are devoted to guest presentations by department faculty, graduate students, or researchers, professional development seminars by Career Service professionals, or practice talks by CIRC students preparing to defend their Honors theses.

Because paper topics run the gamut from paleontology to geophysics, thermochronology to field geology, every participant is out of their disciplinary comfort zone on a regular basis. In that way, CIRC participants learn the challenges and joys involved in delving deeply into a subject and they soon learn how to learn from each other as we collectively grapple with how to inform ourselves about complex topics that we aren't all experts in. The students also benefit from observing the model provided by professional scientists who demonstrate how to distill the essence of each paper's scientific arguments and help illuminate subtle but important considerations like the experimental methodology or the statistical approaches taken by the paper's authors. Such expert modeling is provided by Dr. James Metcalf, manager of the department's Thermochronology Research and Instrumentation Laboratory (TRaIL), who has participated in the CIRC since it began (and is its most popular member in part because of his tradition of bringing donuts!) and Dr. Peter Martin, a TRaIL post-doctoral researcher who has participated regularly since his arrival at CU.

So far, 39 students have participated in the CIRC, with 31 having graduated as of Spring 2022. Throughout its history, 51% of CIRC participants have been women and 23% have been members of groups traditionally underrepresented in STEM (Science, Technology, Engineering, and Mathematics). Both those percentages exceed the numbers for the department. CIRC students are strongly encouraged, but not required, to participate in an individual research project in whatever sub-discipline has excited them during their studies or from the seminar readings. CIRC student research projects have ranged from thermochronology to hydrology, geomorphology to space science. Twelve different departmental researchers have mentored those

The Collaborative, Inquiry-based Research Community and Northglenn High School students at Big Thompson Canyon. photo credit: Lon Abbott

The Collaborative, Inquiry-based Research Community and Northglenn High School students at Devils Backbone.
photo credit: Lon Abbott

projects, 19 of which culminated in Honors theses. CIRC participants have consistently highlighted the supportive atmosphere and the multi-modal mentoring, including from their individual research mentors, the professional CIRC researchers, and their more seasoned undergraduate peers, as primary benefits of their CIRC participation.

Many CIRC students are the first in their families to pursue college or study of science. Navigating the challenges of paying for their educations is a common theme in the CIRC cohort. For those reasons, a real passion of the group has been to "pay it forward" by helping the next generation of geoscientists navigate a path to college geoscience study. In November 2019 CIRC students shared their paths to college and their passion for geology with students in six Northglenn High School (NGHS) geology classes. NGHS is a STEM Magnet School, 64% of whose students come from low-income families and 79% of whom belong to groups traditionally underrepresented in STEM. These students receive excellent scientific training, but many find the obstacles to college enrollment too great to overcome. After each presentation, the CIRC students were surrounded by NGHS students peppering them with questions seeking tips on how they could follow in the footsteps of these near peers who had succeeded in making their college science dreams real.

In the spring of 2020, the CIRC team was busy organizing a joint field trip with NGHS to build on the collaboration begun with the 2019 presentations. The arrival of COVID in Colorado put the brakes on that trip just two weeks before it was scheduled to occur. This spring, after a three-year postponement, the joint CIRC-NGHS field trip finally happened. The current CIRC student team organized and led a one-day trip to the Big Thompson Canyon and Devil's Backbone. They shared their knowledge of the area's petrology, structure, geomorphology, and flood history with seven enthusiastic NGHS students and their award-winning geology teacher – Kent Hups. This trip, and follow-up trips scheduled for next year, are made possible by funding from a CU Outreach grant and a GEO Allies grant to professors Stempien and Abbott.

The CIRC team is currently working on grant proposals to fund scholarships to make it possible for deserving NGHS students to attend CU geology, supported every step of the way by the tight-knit CIRC community. If you'd like to read more about the CIRC philosophy, check out Kenna Bruner's article about it in the Spring 2022 edition of the CU Arts and Sciences magazine: https://www.colorado.edu/asmagazine/2022/04/20/geology-undergrads-are-rocking-graduate-style-research.

The Collaborative, Inquiry-based Research Community and Northglenn High School students at Devils Backbone.
photo credit: Lon Abbott

Northglenn High School students at Devils Backbone.
photo credit: Lon Abbott

Undergraduate Student Awards

Outstanding Senior - Gustafson Endowed Scholarship Award
Jim Gutoski

Outstanding Senior - Kenneth Allen Johnston Memorial Award
Nick Kelly

Outstanding Geology Major - Kolber Scholarship Award
Edward Riccio
Franklin Duffy
Sabrina Kainz

T. Keith Marks Scholarship Award
Fardeen Qasemi
Nicholas Ayres
Sedi Biassey-Bogart
Leo Zook

Association of Woman Geoscientists Outstanding Woman Geoscience Student, O'Dunn Scholarship Award
Katherine Thompson

Outstanding Geology Major - Philip G Worchester Scholarship Award
Rudy Peterson
Nolan Tanguma

Graduate Student Awards & Fellowships

Department Fellowship Award
Ciara Asamoto
Claudia Corona
Eva Jorn
Melia Kendall

Department Research Award
Tristan Caro
Claudia Corona
Brianna Hibner
Tyler Lincoln
Stephen Sheehan

Department Travel Grant Award
Richard Archer
Ciara Asamoto
Harpreet Batther
Claudia Corona
Abigail Eckland
Anne C Fetrow
Liam Friar
Michael Frothingham
Vanessa Gabel
Toby Ann Halamka
Andrea Halling
Ellie Hara
Lindsay Harrison
Sarah Leventhal
Elizabeth Ashley Menezes
Teodora Mitroi
Lina C. Pérez-Angel
Jennifer Reeve
Stephen Sheehan
Amanda Steckel
Scott Stokes
Austin Sorscher
Liza Wernicke
Tyler Wickland
Collette Wilfong

Benson Fellowship Award
Ciara Asamoto
Abigail Eckland
Liam Friar
Michael Frothingham
Vanessa Gabel
Melia Kendall

Evans Fellowship Award
Eva Jorn
Melia Kendall

Patterson Fellowship Award
Hayley Bennett
Tristan Caro
Lindsay Harrison
Brianna Hibner
Naomi Ochwat
Tyler Wickland

T. Keith Marks Scholarship Award
Ciara Asamoto
Hayley Bennett
Eva Jorn
Tyler Wickland

Graduate Student First-authored Publications

Corona, C. R., & Ge, S. (2022). Examining subsurface response to an extreme precipitation event using HYDRUS-1D. Vadose Zone Journal, https://doi.org/10.1002/vzj2.20189.

Corsa, B., Barba, M., Tiampo, K.F., Meertens, C., Integration of DInSAR time series and GNSS Data for continuous volcanic deformation monitoring and eruption early warning applications, Remote Sensing, 2022., https://doi.org/10.3390/rs14030784.

Corsa, B., Jacquemart, M., Willis, M., Tiampo, K.F. Characterization of large tsunamigenic landslide and their effects using digital elevation models: A case study Taan Fiord, Alaska, Remote Sensing of the Environment, 2022., https://doi.org/10.1016/j.rse.2021.112881.

Frothingham, M. G., Mahan, K. H., Schulte-Pelkum, V., Caine, J. S., & Vollmer, F. W. (2022). From crystals to crustal-scale seismic anisotropy: Bridging the gap between rocks and seismic studies with digital geologic map data in Colorado. Tectonics, 41, https://doi.org/10.1029/2021TC006893.

Halamka, T.A., McFarlin, J.M., Younkin, A.D., Depoy, J., Dildar,N., Kopf, S.H., 2021, Oxygen limitation can trigger the production of branched GDGTs in culture: Geochemical Perspectives Letters, v19, doi: 10.7185/geochemlet.

Hoover, R. H., Robbins, S. J., Putzig, N. E., Riggs, J. D., Hynek, B. M., 2021. Insight Into Formation Processes of Layered Ejecta Craters on Mars From Thermophysical Observations. JGR Planets 126:12. https://doi.org/10.1029/2020JE006801.

Ochwat, N., Scambos, T., Fahnestock, M., Stammerjohn, S., Characteristics, Recent evolution, and ongoing retreat of Hunt Fjord Ice Shelf, Northern Greenland. Journal of Glaciology, 2022.

Peak, B.A., Flowers, R.M., Macdonald, F.A., and Cottle, J.M., 2021, Zircon (U-Th)/He thermochronology reveals pre-Great Unconformity paleotopography in the Grand Canyon region, USA: Geology, v. 49, p. 1462–1466, https://doi.org/10.1130/G49116.1.

Peak, B.A., Flowers, R.M., Macdonald, F.A., Cottle, J.M., 2022, Zircon (U-Th)/He thermochronology reveals pre-Great Unconformity paleotopography in the Grand Canyon region, USA: REPLY: Geology, v. 50 (3): e544. https://doi.org/10.1130/G49965Y.1.

Peak, B.A., Latychev, K., Hoggard, M.J., and Mitrovica, J.X., 2022, Glacial isostatic adjustment in the Red Sea: Impact of 3-D Earth structure: Quaternary Science Reviews, v. 280, p. 107415, https://doi.org/10.1016/j.quascirev.2022.107415.

Graduate Student Research, Outreach, and Recognitions

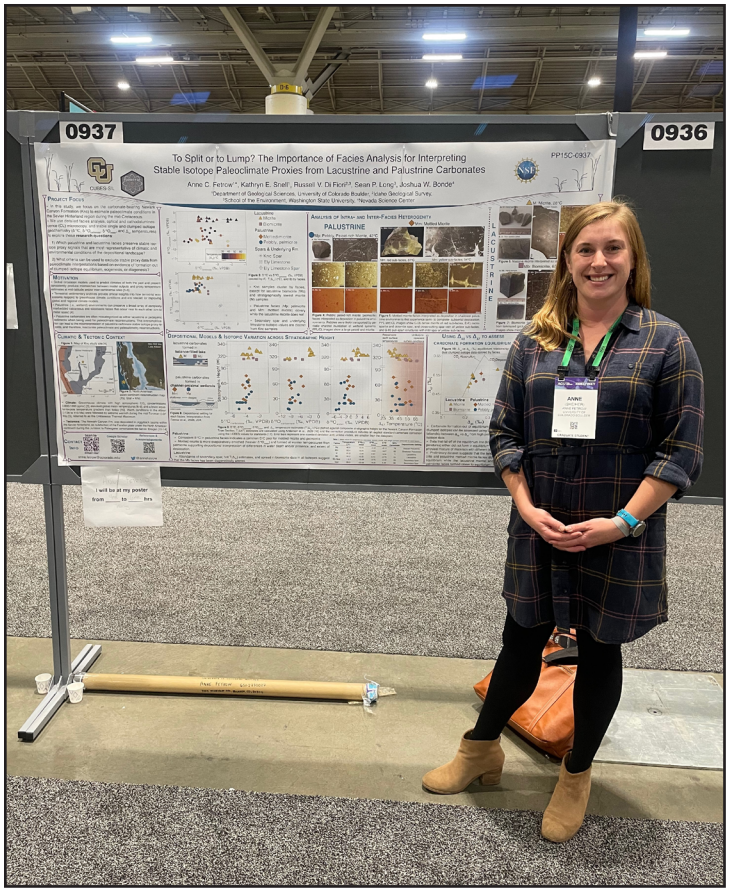
Brianna Corsa gave multiple presentations including; CIRES Rendezvous Meeting 2022, AGU Fall Meeting 2021, UNAVCO Workshop 2021, EarthCube Annual Meeting 2021, FRINGE 2021, CIRES Rendezvous Meeting 2021. All have focused around her contribution to the collaborative GeoSCIFramework (GSF) project. Differential Interferometric Synthetic Aperture Radar (DInSAR) and Global Navigation Satellite System (GNSS) document comprehensive ground motions or ruptures at or near the Earth's surface. These datasets may be independently applied to detect and analyze natural hazard phenomena, such as ground motion leading to major volcanic eruptions. Additionally, when combined into a single dataset, assimilated DInSAR + GNSS deformation results have improved accuracy [Corsa et al., 2022]. Here, the group attempts to generate a synthetic dataset that best matches the integrated DInSAR + GNSS time series results over Hawaii from November 2015 through January 2022 by comparing multiple volcanic deformation source models, including a Mogi, diking and distributed source models. They discuss the benefits and limitations of such models and the applicability to other volcanic systems with varying parameters. They then demonstrate how the synthetic- and real- time series will be streamed through machine learning algorithms to help identify precursor motion leading to major eruptions, contributing towards improved early warning systems.

In this photo, taken at the Cold Regions Research and Engineering Laboratory permafrost tunnel in Fox, AK, Tom Douglas (CRREL) uses an ice corer to drill a permafrost core, while **Tristan Caro** (CU Boulder) and Jamie McFarlin (CU Boulder) stabilize. This field work is part of a project led by Sebastian Kopf (CU Boulder) with Tristan Caro and Jamie McFarlin looking to understand rates of microbial growth in permafrost as these systems undergo thaw.

Abigail Eckland used the Patterson funds for her research project focused on sediment transport and depositional processes at the Elephant Butte Reservoir Delta along the Rio Grande River in New Mexico. The purpose of this research is to understand how highly sediment-laden river flows and widely fluctuating reservoir levels influence delta processes and their resultant morphology. Since rivers and deltas are highly dynamic environments, it is important to collect observations and physical data at each phase of the discharge hydrograph. This means that several trips to the field site are necessary to fully understand the physical mechanisms at play. The Patterson research funds allowed Abigail to conduct an additional field trip to Elephant Butte Reservoir Delta so that she could collect data during each phase of the discharge hydrograph: winter low flow, spring snowmelt, and flashy summer monsoon-driven flow. This fellowship funded the May (spring snowmelt) trip. In addition, she purchased a Shallow Water Tilt Current Meter (TCM-4) from Lowell Instruments. Abigail deployed the TCM-4 on the channel bed of the Rio Grande to provide current velocity data, which she is using to calculate local discharge at high temporal resolution. Finally, Abigail purchased a time-lapse camera which is currently deployed overlooking the delta to capture how it responds to lowering reservoir levels and monsoon-driven flash floods over the summer. She would like to thank Penny Patterson for her generous donation of these funds that have greatly enhanced this PhD research.

Abby Eckland (right) and Brandee Carlson (left) preparing an instrument package for deployment on the Rio Grande channel bed. photo credit: Irina Overeem

In April 2022, **Anne Fetrow** defended her PhD that explored paleoclimate conditions and estimated surface elevations of the western USA in the Cretaceous, one of the hottest periods of Earth's history. Using clumped isotope geochemistry and carbonate sedimentology, her research found that average summer time temperatures in shallow wetland ecosystems were persistently hot (~40°C) for the Early Cretaceous (~110 Ma). Anne presented these findings at the AGU annual conference held in New Orleans in December 2021. She anticipates submitting this work for publication this summer. After graduation, Anne is starting a one-year Visiting Assistant Professor in the Earth and Climate Sciences department at Bates College, Maine. She is looking forward to teaching courses in paleoclimatology, and environmental and stable isotope geochemistry. In June 2023, she will then start a two-year NSF Postdoctoral Fellowship at



Anne Fetrow presenting her poster at the AGU annual conference held in New Orleans.


Sarah Leventhal in front of some conglomeratic channel deposits of the Cabrillo Fm.

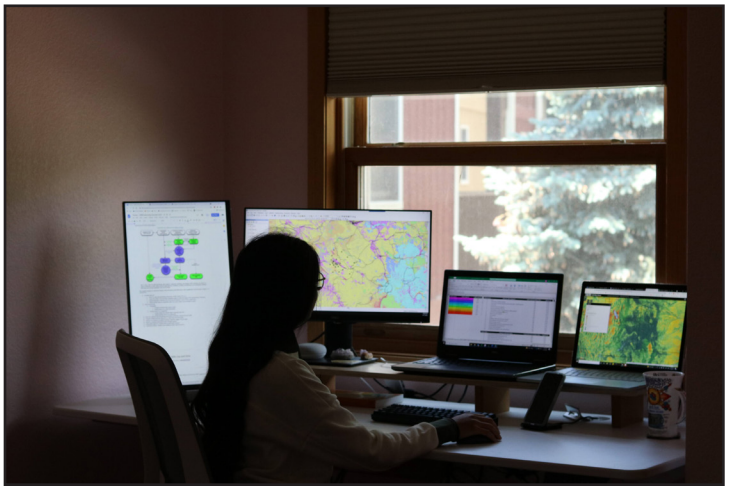
PhD student Michael Frothingham showing his grilling skills at the deparmental BBQ in Spring 2022. photo credit: Kara Bajdas

the University of Michigan working to better evaluate the role of evaporation on Mono Lake and the surrounding catchment hydrology in eastern California using novel stable isotope and hydrologic modeling tools.

Last May, **Sarah Leventhal** received funding through the Patterson research fund, which allowed her to conduct field and museum work that are essential for the completion of her dissertation. In December 2021, Sarah used this research funding to travel to San Diego County, California, where she collected Cretaceous-age bryozoan fossils from the Cabrillo and Point Loma formations. These formations capture the stages of the Cretaceous immediately preceding the end-Cretaceous mass extinction event. Bryozoans, which are modular animals, evolved new structures in their colonies at this time in Earth's history, which are believed to play a large role in the subsequent diversification of these animals. The collection of new fossil specimens is essential for understanding how emergent structures in bryozoan colonies played a role in bryozoan diversification, which is a central focus of her research.

Your generous support helps to fund many of our graduate programs and research initiatives enabling our graduate students the ability to positively impact the world around us. Thank you!

The COVID-19 pandemic has forced many employees to work from home.

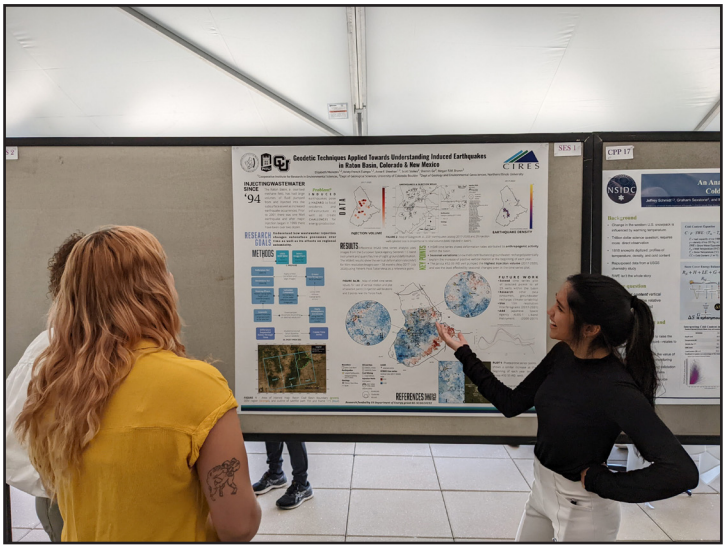


In an effort to be flexible graduate student, Elizabeth Menezes, made the most out of the COVID-19 situation and brought the computer lab home with her.

Elizabeth Menezes new favorite quote is “WFH: / werk frøm høm/ verb. Work From Home - the ability to do your JOB, do it well, and do it at home in sweats.” – random online quote

Now that things are opening back up Elizabeth was able to present her research in person at CIRES Rendezvous 2022!

Elizabeth is working with Dr. Kristy Tiampo and Dr. Anne Sheehan to understand how regional seismicity is changing due to subsurface processes and stress changes. Her research uses C-band Sentinel-1A/B interferometric synthetic aperture radar (InSAR) data to perform a differential InSAR (DInSAR) time series



Elizabeth Menezes presenting her work on using remote sensing to understand subsurface interactions and induced seismicity at CIRES Rendezvous 2022.

analysis using the multidimensional small baseline subset (MSBAS) method to observe regions of potential surface subsidence and uplift in the Raton Basin. In addition, she is working on a spatiotemporal analysis to see if induced earthquake sequences can reveal details about preexisting fault structures and explain the evolution of stresses due to changes in fluid pressures and poroelastic stresses.

Naomi Ochwat presented a poster at WAIS and gave talks at AGU and EGU.

Naomi Ochwats’ presentation discussed the Hunt Fjord Ice Shelf in Northern Greenland. This ice shelf experienced a series of changes since the 1970s. By using various remote sensing methods (optical imagery, laser altimetry, etc.) the changes were analyzed. The ice shelf experienced thinning and the tributary glaciers likely sped up prior to the calving events in recent years that removed 56% of the ice area.

In April, 2022, **Tyler Wickland** and **Michael Frothingham** set out into the desert hunting for Cretaceous-Tertiary andesitic lavas. A three-day gauntlet through the southern reaches of New Mexico took them to many volcanic terra firma and remote mountain ranges. The trip was filled with long hikes, rough roads and a multitude of maps to help navigate the Bootheel Volcanic Field. While enjoying the winding roads and beautiful forests of Pinos Altos to the long reaching desert playas near Lordsburg, Tyler and Michael were able to sample 9 separate andesites of 71 – 45 million years in age. After long days sampling in the field, some of Tyler and Michael’s highlight moments were enjoying decadent ice cream cones in Silver City and ancient dwellings and petroglyphs along the old Butterfield Trail!

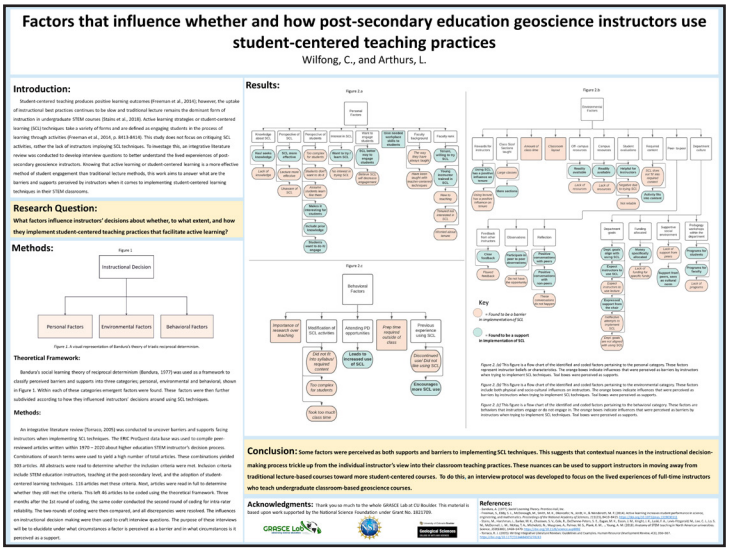
Tyler and his advisors Alisha Clark and Lang Farmer are interested in the origin of mafic lavas in southwest North America and their significance in understanding the destruction of the lithosphere. Mafic lavas represent primary melts of the mantle and were recently identified as either lithospheric or asthenospheric melts by pairing Ta/Th ratios with Nd isotopes (see Farmer et al. 2020 for details). Lithospheric opposed to asthenospheric melts would suggest different melting compositions of the mantle and different processes affecting the ‘base’ of the

Safety Advisor and field hand Michael Frothingham looking out for elusive andesite formations.

lithosphere. The broad spatiotemporal trends of Ta/Th values amongst mafic lavas have led to new insights on the disruption, alteration, and destruction of the NAM lithosphere caused by the converging Farallon slab. The Cretaceous-Tertiary andesites of the Bootheel region have received little research attention and could be the remnants of an ancient volcanic arc's most eastward extent or perhaps lithospheric melts coeval with the Colorado Mineral Belt. If the Bootheel andesites are old arc eruptions they would express the easternmost reaches of Cenozoic subduction in North America before and during the onset of the Laramide Orogeny to the north.

In October of 2021, **Collette Wilfong** presented her research about factors that influence whether and how post-secondary education geoscience instructors use student-centered teaching practices. Student-centered teaching produces positive learning outcomes (Freeman et al., 2014); however, the uptake of instructional best practices continues to be slow and traditional lecture remains the dominant form of instruction in undergraduate STEM courses (Stains et al., 2018). To investigate the reasons for this slow uptake and the persistence of traditional lectures, Collette investigated the question: What factors influence instructors' decisions about whether, to what extent, and how they implement student-centered teaching practices that facilitate active learning? She conducted a systematic literature review, to identify potential barriers and supports. Whether factors are viewed as a barrier or support depends on contextual details relevant to instructors. These findings suggest that contextual nuances in the instructional decision-making process trickle up from the individual instructor's view into their classroom teaching practices.

Collette Wilfongs poster



Factors that influence whether and how post-secondary education geoscience instructors use student-centered teaching practices

Wilfong, C., and Arthurs, L.

Introduction:

Student-centered teaching produces positive learning outcomes (Freeman et al., 2014); however, the uptake of instructional best practices continues to be slow and traditional lecture remains the dominant form of instruction in undergraduate STEM courses (Stains et al., 2018). Active learning strategies or student-centered learning (SCL) techniques take a variety of forms and are defined as engaging students in the process of learning through activities (Freeman et al., 2014, p. 8413-8414). This study does not focus on critiquing SCL activities, rather the lack of instructors implexing SCL techniques. To investiage this, an integrative literature review was conducted to develop interview questions to better understnd the lived experiences of post-secondary geoscience instructors. Knowing that active learning or student-centered learning is a more effective method of student engagement than traditional lecture methods, this work aims to answer what are the barriers and supports perceived by instructors when it comes to implementing student-centered learning techniques in their STEM classrooms.

Research Question:

What factors influence instructors' decisions about whether, to what extent, and how they implement student-centered teaching practices that facilitate active learning?

Methods:

Figure 1

Instructional Decision

Personal Factors | Environmental Factors | Behavioral Factors

Figure 2. A visual representation of Bandura's theory of triadic reciprocal determinism.

Theoretical Framework:

Bandura's social learning theory of reciprocal determinism (Bandura, 1977) was used as a framework to classify perceived barriers and supports into three categories, personal, environmental and behavioral, shown in Figure 1. Within each of these categories emergent factors were found. These factors were then further subdivided according to how they influenced instructors' decisions around using SCL techniques.

Methods:

An integrative literature review (Torraco, 2005) was conducted to uncover barriers and supports facing instructors when implementing SCL techniques. The ERIC ProQuest data base was used to compile peer-reviewed articles written within 1970 – 2020 about higher education STEM instructor's decision process. Combinations of search terms were used to yield a high number of total articles. These combinations yielded 999 articles. All abstracts were read to determine whether the inclusion criteria were met. Inclusion criteria include STEM education instructors, teaching at the post-secondary level, and the adoption of student-centered learning techniques. 116 articles met these criteria. Next, articles were read in full to determine whether they still met the criteria. This left 46 articles to be coded using the theoretical framework. Three months after the 1st round of coding, the same coder conducted the second round of coding for intra-rater reliability. The two rounds of coding were then compared, and all discrepancies were resolved. The influences on instructional decision making were then used to craft interview questions. The purpose of these interviews will be to elucidate under what circumstances a factor is perceived as a barrier and in what circumstances is it perceived as a support.

Results:

Figure 2.a

Figure 2.b

Figure 2.c

Key

= Found to be a barrier in implementation of SCL

= Found to be a support in implementation of SCL

Figure 2. (a) This figure is a flow chart of the identified and coded factors pertaining to the personal category. These factors represent instructor beliefs or characteristics. The orange boxes indicate influences that were perceived as barriers by instructors when trying to implement SCL techniques. Teal boxes were perceived as supports.

Figure 2. (b) This figure is a flow chart of the identified and coded factors pertaining to the environmental category. These factors include both physical and socio-cultural influences on instructors. The orange boxes indicate influences that were perceived as barriers by instructors when trying to implement SCL techniques. Teal boxes were perceived as supports.

Figure 2. (c) This figure is a flow chart of the identified and coded factors pertaining to the behavioral category. These factors are behaviors that instructors engage in or do not engage in. The orange boxes indicate influences that were perceived as barriers by instructors when trying to implement SCL techniques. Teal boxes were perceived as supports.

Conclusion: Some factors were perceived as both supports and barriers to implementing SCL techniques. This suggests that contextual nuances in the instructional decision-making process trickle up from the individual instructor's view into their classroom teaching practices. These nuances can be used to support instructors in moving away from traditional lecture-based courses toward more student-centered courses. To do this, an interview protocol was developed to focus on the lived experiences of full-time instructors who teach undergraduate classroom-based geoscience courses.

Acknowledgments: Thank you so much to the whole GRASCE Lab at CU Boulder. This material is based upon work supported by the National Science Foundation under Grant No. 1821709.

References:

Usually, the Thermochronology Research and Instrumentation Lab uses a jaw crusher and grinder to turn their rock samples into a fine crush. However, small and/or precious samples can require another method, so **Spencer Zeigler** and **Barra Peak** asked, "Will it blend?"...and it did! The blender turned hard, volcanic rocks to dust!

Attention Alumni

You can help us do a better job of keeping up with you, your whereabouts, and your career or family news. We all enjoy reading about classmates and not-so-close-mates who survived Boulder in whatever era!
So send us some news or some recollections—we promise to use them.

Email your Alumni News to: GeoAlum@Colorado.EDU

Degrees Awarded (Fall 2021- Spring 2022)

BA Geology Majors

Jumana Abdullah
Dane Abernathy
Yousef Alnasrallah
Ahmed Al Rawahi
Evan Bates
Katherine Baugh
Matthew Bondar
Sarah Brookins
Racheal Burger
Shea Burnham
Kevin John Corboy
Franklin Duffy
John Thomas Fauntleroy
Geoffrey W Flora
Katelyn Goen
James Richard Gutoski
Catherine Ann Harper
Sabrina Josephine Hiu-Tung Kainz
Nicholas Kelly
Natalie Kissner
Maya Krygiel
Clayton Frank La Monica
Keely Lawrence
Dante Liguori
Henriett Modes Lindeke
Randi Mathieson
Jessica BW Perron
Rudy Peterson
Edward J. Riccio IV
Marcus Lee Tamburro
Joseph Taparauskas
Katherine Thompson
Carly Ann Trimbach
Benjamin Luke Trunko

Graduating with honors

	Advisor(s)	**Thesis**
Sarah Brookins - **cum laude**	Dr. Katie Snell	Texture and Mineralogy: How soil characteristics help to understand soil formation.
Shea Burnham - **magna cum laude**	Dr. Kevin Mahan	Description, age, petrochemical analysis, and a comparison of two REE-rich mineralization occurrences near Jamestown, CO.
Franklin Duffy - **summa cum laude**	Dr. Karen Chin	Analysis of the Likely Defecators of Greensand Coprolites and the Possible Implications for a Warm Late Cretaceous Arctic Ecosystem.
Geoffrey Flora - **summa cum laude**	Dr. Jaelyn Eberle	Uintatherium anceps from the Uinta Formation, Piceance Creek Basin, Colorado with Implications on the morphological variation in Uintatherium anceps.
Sabrina Josephine Hiu-Tung Kainz - **summa cum laude**	Dr. Lon Abbott	Constraining Cenozoic Exhumation in Southeastern Colorado and Eastern New Mexico Using Low-Temperature Thermochronology.
Keely Lawrence - **magna cum laude**	Dr. Gregory Tucker	Mapping the Mancos Shale Badlands in Caineville, Utah using historic aerial imagery.
Edward J. Riccio IV - **cum laude**	Dr. Lon Abbott	Thermochronological Study on the Elk and West Elk Mountain Ranges and Interpretations of Exhumation Processes in Western Colorado.

L-R:
Julio Sepúlveda,
Lina Pérez-Angel
and Peter Molnar.

Fall 2021 Department Graduation Ceremony.

MS Candidates Graduating with Degrees

	Advisor(s)	Thesis
Morgan Baker	Dr. Rebecca Flowers	Correcting for Systematic Error and Estimating Uncertainties of Alpha-Ejection Corrections and eU Values for the Zircon (U/Th)/He Method.
William Bennett	Dr. Leilani Arthurs	How Eye-Tracking and Instructor Experiences Can Help Us Become Better Geoscience Instructors.
Emily Roeder	Dr. Tom Marchitto	A Multi-Proxy Reduced Dimension Reconstruction of LGM Equatorial Pacific Sea Surface Temperatures.
Austin Alexander Rogers Sorscher	Dr. Karen Chin	An herbivorous dinosaur coprolite from the Lower Cretaceous Ruby Ranch Member of the Cedar Mountain Formation, Utah, USA: organic contents, taphonomy, and diagenesis.
Scott Stokes	Dr. Shemin Ge	Pore Pressure Diffusion and Onset of Induced Seismicity.
Clay Woods	Dr. Kristy Tiampo	Using Sentinel-1A/B SAR to better characterize flood hazard and DInSAR time series analysis to map subsidence of the Ganges-Brahmaputra-Meghna Delta.

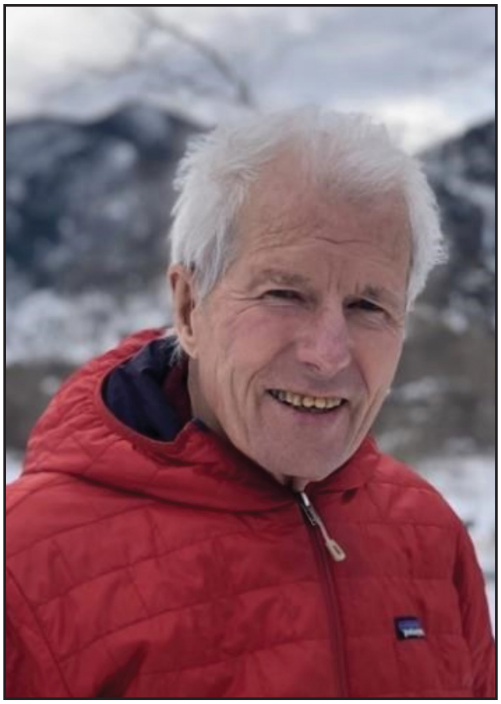
PhD Candidates Graduating with Degrees

Hannah Bonner	Dr. Eric Small Tilton	Applying the past to understand the present: Visualizing the Ancient Earth and improving predictions of snow water equivalent.
Sebastian Ignacio Cantarero	Dr. Julio Sepúlveda	Microbial Communities and the Biogeochemistry of the Eastern Tropical South Pacific; a Lipidomic Approach in Natural Environments and Mesocosm Experiments.
Geneviève Wheeler Elsworth	Dr. Thomas Marchitto Dr. Nicole Lovenduski	The Impact of Internal Climate Variability on Marine Phytoplankton in a Warming Climate.
Anne C. Fetrow	Dr. Kathryn Snell	Paleoclimate and paleoelevation changes of the Western US during the Cretaceous.
Lina Camila Pérez-Ángel	Dr. Peter Molnar Dr. Julio Sepúlveda	A refinement of biomarker-based tools to study the Pliocene-Pleistocene climate evolution of the northern tropical Andes.
Jonathan Raberg	Dr. Gifford Miller Dr. Julio Sepúlveda Dr. Áslaug Geirsdóttir	Lipids at high latitudes: investigation of sources, environmental controls, and new potential applications of brGDGT-based paleoclimate proxies.
Eric James Smyth	Dr. Eric Small Tilton	Improving Snowpack Estimation with Data Assimilation: The Influence of Observation Timing and Uncertainty, Climate, and Forest Canopy Cover.

Spring 2022 Department Graduation Ceremony.

Professor Greg Tucker speaking at the Spring 2022 Department Graduation Ceremony.

Peter W. Birkeland Obituary



Peter Wessel Birkeland died of natural causes in Boulder, Colorado on January 25, 2022, a snowy day befitting a lifelong skier. He was born in Seattle, Washington, on September 19, 1934, to Norwegian immigrant Ivar Wessel Birkeland and Marguerite Ellen O'Conner Birkeland of Rochester, Minnesota. He married Suzanne Franzke, also from Seattle, in August 1959. Pete and Sue's unconditional love for each other never waned, and they were nearly inseparable for more than 60 years.

He grew up attending the greater Seattle school system, graduating from Bellevue High School. In 1958, he graduated from the University of Washington in Geology, and in 1961 he completed a Ph.D. in Geology from Stanford University. He served in the U.S. Army from 1953–1955, ending his service as a ski trooper in the Mountain and Cold Weather Training Command at Camp Hale in Colorado.

Pete's professional career began as a professor at the University of California – Berkeley. In 1967, he took a position at the University of Colorado – Boulder, where he did research and taught in the combined fields of soils and geology until his retirement. Throughout his career, he traveled the western United States and the world with his wife and children studying soils in environments ranging from mountains to deserts to the tropics. He received several national awards for his research and teaching, and authored a successful introductory geology textbook, Putnam's Geology, with his colleague Ed Larson. In addition, he authored three editions of a book on Soils Geomorphology, a subfield of Geology he helped pioneer. Pete's proudest professional accomplishment was his mentoring and training of many successful students in this field. Those students went on to become both his colleagues and his cherished friends, and he stayed in touch with them long after he retired.

Pete was a lifelong skier, from the age of two to the age of 85. In high school he competed in all events (cross country, downhill, and ski jumping) in the Seattle ski league, which is where he first met Suzanne. He later raced for the U.S. Army at Camp Hale and for the University of Washington. The high point of his racing career was two NCAA silver medals in alpine skiing in 1956, one in the Downhill and one in the Alpine Combined (slalom and downhill combined). When the family moved to Colorado in 1967, they backcountry skied (on wooden cross-country skis) throughout the Front Range, and downhill skied at ski areas across the state almost every weekend.

Another thing Pete loved was riding his bike. He rarely used his car except to go to the mountains, and he enjoyed encouraging others to bike. He and Suzanne did numerous international bike trips with family and friends. These included using bikes to do geology fieldwork while traveling around the world in 1984-85, biking down the Danube River in 1994, and biking in the Spanish Pyrenees in 1996. In 2005, he and Suzanne and their friends biked in France and re-traced some of the classic stages of the Tour de France, an event he enjoyed watching on TV.

Not surprisingly, his retirement years involved geology, skiing, biking, and time in the mountains. He joined friends and former students to put on local geology field trips for national and international meetings, as well as for visiting students and professors. He volunteered for the Colorado Mountain Club, teaching backcountry skiing, making maps, and leading ski and hiking trips. When not skiing he enjoyed riding his bike and hiking in the mountains with Suzanne and their friends.

Though he had numerous professional and personal accomplishments, Pete's biggest passion was for people. He made many lifetime friends, and he cherished and nurtured those friendships out on the trails and over a beer or two. His love for Sue lasted over 60 years and never waned. He was incredibly engaged and supportive of the directions his children chose in life. In his later years he especially enjoyed his time with his three grandchildren, including hiking and skiing with them, and loved to hear about their adventures. Another hobby he took up late in life was drawing. Dubbing himself "Petecasso", he enjoyed drawing cubist-inspired pictures and humorous cartoons for family, friends, and neighbors.

He is survived by his wife Suzanne, son Karl (daughter-in-law Ginger and grandchildren Erika and Kelsey) of Bozeman, Montana, and daughter Robin (son-in-law John Jugl and grandchild Natasha) of Boulder. He was predeceased by his parents and his three siblings (Ivar "Buzzy" Birkeland, Jr., Sally Burklund, and Fred Birkeland). He loved his family greatly and was a wonderful husband, father, brother, and uncle. He relished his role as a grandfather and enjoyed engaging with his grandchildren on their level, whether that involved drawing funny pictures, joking around with them, being childish and goofy, or attending important events in their lives.

His final year of life was not an easy one, but he never complained. Pete took on the challenges of aging with grace and humility, and his innate inner kindness. He was visited frequently by his many friends and colleagues, who provided a great deal of support and love. We are particularly thankful for the kindness and care he received from everyone at hospice and from his caregivers. His children also would like to acknowledge the amazing support that he and Suzanne received during this time by their many friends and their incredible neighbors.

His primary concern later in life was for the future of our planet for his children, grandchildren, and all future generations. Contributions in his memory can be made to Earthjustice (earthjustice.org).

A memorial service will be held in Boulder at the Benson Earth Sciences Building on June 17th at 10am .

- taken from the Daily Camera

In Memoriam

John L. Dwyer (MGeol'93)
Jerome A. Eyer (PhDGeol'64)
Christopher M. Holl (MGeol'98; PhD'06)
Wesley P. Horner (Geol'50; MA'54)
James B. Judd (PhDGeol'77)
William H. Lee (Geol'66)
Charles G. Mull (A&S'57; MGeol'60)
Royal L. Shepherd (Geol'54; MS'68)
John W. Siple (Geol'55)
Ward T. Sumner (Geol'72)
Robert G. Swanson (Geol'57)
Frederic A. Tietz (Geol'54; MS'56)
Anthony R. Wagner (Geol'77)
George W. Whitney (Geol ex'55)

Your generous support helps to fund many of our graduate and undergraduate field trips.
Thank you!

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The Department of Geological Sciences enjoys the philanthropic support of generous donors. Geological Sciences uses this support to conduct research, teaching and learning opportunities for students, faculty members, visiting scholars and the public.

Since January 1st, 2020 Geological Sciences has received 743 charitable donations from 177 donors totaling $5,250,656.65.

Gifts given to endowed funds help to underwrite PhD student fellows, undergraduate fellows, visiting scholars, public lectures and events, and other programming. The Department also manages several “current use” gift funds which supplement its annual budget.

Thank you for your generous support of The Geological Sciences Department!

Spherical projection of the Benson Earth Sciences building. photo credit: Karl J. Mueller

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Geological Sciences Graduate Fellowship Fund

To support graduate student research including, but not limited to, travel and field work in the Department of Geological Sciences at the University of Colorado Boulder.

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