TEARTH & PLANETARY SCIENCES

Terra Firma

WINTER 2024 NEWSLETTER

Geochemistry Thread Ties Multidisciplinary Research Together

UT's Department of Earth and Planetary Sciences (EPS) has long been at the forefront of geochemical research, both terrestrial and planetary. Our students and faculty continue this tradition of excellence today with a wide variety of research topics, in both low- and high-temperature geochemistry, and we continue expanding our research capabilities through new faculty hires and acquisition of new analytical instruments. Understanding the chemical composition of geologic materials is a thread that runs throughout our department and is a key touchstone that unites our disparate research programs.

The Stable Isotope Laboratory, headed by Associate Professor Anna Szynkiewicz, provides stable isotope services for research and commercial users. The laboratory has two Thermo-Finnigan Delta mass spectrometers and a variety of peripheral devices that enable the measurements of carbon, hydrogen, nitrogen, oxygen, and sulfur isotope ratios in a variety of materials, including rocks, sediments, water, and gas samples. These tools allow researchers to investigate questions related to how nutrient cycles function under different conditions, reconstructing paleoenvironmental and paleoclimatic conditions, human impacts on water resources and land use, and much more. Since 2014, the laboratory has been used for isotope analysis by many UT faculty, postdocs and students, and non-UT research groups studying geology, planetary analogs, biology, microbiology, and many environmental topics.

The Electron Microprobe Laboratory, headed by Associate Professor Molly McCanta, provides high precision geochemical analysis of solid geomaterials, including mantle xenoliths, volcanic tephras, Apollo samples, Martian meteorites, and experimental samples. The Cameca SX-100 electron microprobe is an analytical workhorse and heavily utilized by the faculty and students studying petrology, structural geology, and sedimentology in EPS, as well as the greater university community and researchers from other schools in the region.

Our newest analytical facility is our ICP-MS lab, headed by Associate Professor Shichun Huang, hosts a ThermoFisher ScientificTM iCAP TQ Inductively Coupled Plasma Mass Spectrometer (ICP-MS), and an ESL 193 nm Excimer NWR193 laser ablation system. The wet chemistry lab is equipped with a Milli-Q Integral Water Purification System, and a Savillex DST-1000 Acid Purification System. With such facilities, this lab provides elemental abundance measurements of almost all non-volatile elements in both natural and synthetic samples, ranging from water/ice, soils to silicate rocks. The detection limits can be as low as ppt to ppb level, depending on the sample matrix. The external reproducibility is typical at several percentage levels, but can be pushed to 1% level if needed. The ICP-MS lab serves not only faculty and students in EPS, but also users from inside and outside of UT.

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what's inside:

MESSAGE FROM DEPARTMENT HEAD

Hello again! I am so glad to have the opportunity to connect with you and share some of the incredible things happening here in the Department of Earth and Planetary Sciences. After serving my first full year as head, I am even more enthusiastic about the current state and trajectory of our department. As you will read throughout this newsletter, the faculty, students, and alumni of EPS are a remarkable group of people engaging in leading edge science and education. We cannot fit everything I'd like to share into these pages, but the momentum is exciting.

As I shared last year, the University of Tennessee, Knoxville, is a "university on the rise," and our department is growing as well. This fall, we welcomed more than 1,600 students to our classes and are providing more credit hours to campus than at any other time in department history. We are thrilled to have the opportunity to educate so many students about the importance of geoscience and scientific analysis. We recruited an outstanding graduate cohort, and we welcomed two new lecturers. Jordan Burkey is stepping in this year to teach structural and introductory geology. Meilian (Maggie) Chen has joined as an environmental geoscience lecturer who is also coordinating the environmental geochemistry teaching lab. They are both wonderful additions to our department.

The College of Arts and Sciences (CAS) began a three-year pilot divisional structure on August 1. EPS is in the Division of Natural Science and Mathematics. In practice, this means greater support for our department due to increased staffing at the college and divisional levels. The increased staff combined with greater tuition revenue from the expanding student population provides a solid framework for future growth for our department.

Presently, we are also searching for tenure-line faculty in the areas of structural geology and hydrogeology and water science, and I look forward to introducing you to these new department members next fall. We plan to keep this momentum going, and recently submitted a long-term hiring plan to the college with a plan to continue growing tenure-line faculty over the next three years.

Our research programs are robust and internationally recognized. As a small example, our faculty and students are leading missions on Mars, organizing international conferences in biogeochemistry, and conducting field work in places from Tennessee to Chile. At the annual GSA meeting in October, department members from undergraduates to emeriti presented 15 presentations ranging from planetary and structure to sedimentology and paleontology. We will be similarly strong at the upcoming AGU and LPSC meetings. Please join us at an alumni event at these conferences if you are nearby.

Last year, the department received an extremely strong decadal academic program review. We are working to implement recommendations from this review to make our program even stronger. Many of these initiatives will help us improve the student experience, including augmenting our field training program with targeted short term field courses. This will allow us to offer more of the field geology training our students need in department while also reducing barriers to participation for students from backgrounds traditionally less represented in the geosciences, including those with family obligations or financial need. We will be launching our first week-long intensive field course this May with a transect across the Appalachian Basin from Kentucky to the Blue Ridge of Virginia, where students will engage with sedimentary data collection, structural geology, petrology, geomorphology, and more. Stay tuned for updates on our social media streams and our newly revamped department website.

The support of our alumni and friends is so critical to ensuring the success of our students and faculty. The strength of our endowments and the continued new gifts over the past year have provided new support for graduate student fellowships, created a new endowed professorship, and provided funds that will help to offset the costs for students to participate in the new field courses. It is through your support that we are a department on the rise. We are so grateful for your continued support for our program and its people.

Please stay in touch and share your updates so we can include these in a future newsletter. Send an email to me or your favorite faculty or mentors. Stop by and visit Strong Hall when you are in Knoxville.

GO VOLS!

Alycia Stigall, Department Head

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In addition to the research labs, EPS is home to the Environmental Geochemistry Teaching Laboratory, initiated by Annette Engel, our Donald H. and Florence Jones Professor of Aqueous Geochemistry, and now facilitated by Lecturer and Laboratory Coordinator Maggie Chen. It provides equipment to train student users in the analysis of water samples for chromophoric organics, major cation and anion analyses, the analysis of atmospheric gasses, and the analysis of trace metals in solution. This lab offers students, both undergraduate and graduate, experiential training on state-of-the-art analytical tools and the ability to conduct classroom-based and independent research.

With such robust major labs and associated minor equipment, our faculty and students conduct research at the leading edge of science that truly pushes the boundaries of scientific knowledge. Whether we are investigating the chemical composition of meteorites, weathering products of Precambrian granites or Apollo-returned lunar samples, characterizing water quality in Third Creek, identifying the chemical composition of fossil echinoderms, or analyzing sulfur fractionation in Icelandic hot springs as analogs for Martian environments, geochemistry is one touchstone that brings our department together.

FACULTY SPOTLIGHTS

Professor Jeff Moersch is a planetary scientist who has been a valued EPS faculty member for over 23 years. He was born in Nantucket, Massachusetts, and grew up mostly in Southern California. After earning his undergraduate degree in physics from Cornell University working with Professor Carl Sagan as his research advisor, he completed a Master's degree in geology from Arizona State University under the tutelage of Professor Phil Christensen.

Moersch then returned to Cornell for a second MS and a PhD in astronomy working with Professor Steven Squyres. Prior to coming to UT, Moersch was a resident research associate of the National Research Council at NASA Ames Research Center in Silicon Valley, working with Jack Farmer. He started at UT as a research assistant professor and transferred to the tenure track a few years later. Moersch is now the longest-serving active member of the department's planetary group and is director of UT's Planetary Geoscience Institute, an umbrella organization for all researchers on campus who conduct research in that area.

Moersch's research interests can be divided into two broad categories related to planetary geology and remote sensing. First, he is interested in using the clues provided by Martian geology to understand Mars's present and past surface environment and its potential for having once harbored life. He works with infrared spectroscopic and imaging observations of the Martian surface to understand its mineralogic composition, which in turn provides clues about things like the presence or absence of liquid water on the surface in the past.

The second broad category of his research deals with the technical aspects of building new science instruments for use on planetary spacecraft missions and optimization of the science yield from instruments in new operational environments, sometimes known as "exploration science." Much of this work is carried out at so-called "terrestrial analogs," which are sites on Earth that share some of the geologic and environmental characteristics of other planets.

Moersch has extensive experience with NASA missions. As a student, Moersch worked on the Voyager 2 mission's encounters with the planets Uranus and Neptune, the Galileo mission's Earth-Moon encounters, and the Mars Observer mission.

As a professional, Moersch has served on the science teams for NASA's Deep Space 2/Mars Microprobe mission, the dual Mars Exploration Rover mission (Spirit and Opportunity) and the Mars Science Laboratory rover mission (Curiosity), as well as the Thermal Emission Imaging System (THEMIS) experiment on the Mars Odyssey orbiter mission. He and his students have used data from these missions to study a wide variety of science topics, including the composition of rocks and regolith (and what they imply about past conditions), the distribution of subsurface water, and the nature of sedimentary features, such as dunes, alluvial fans, and paleolake basins.

Professor Jeff Moersch (center) with PhD advisee Udit Basu, and Michael Phillips (PhD '21) at work on a Mars mission simulation at the Holuhraun lava field in the Icelandic Highlands.

His terrestrial analog research has taken him around the globe to sites such as Ellesmere and Axel Heiberg islands in the High Canadian Arctic, the Atacama Desert and Altiplano of Chile, the Mojave Desert, and most recently, the Icelandic Highlands. In the latter project, Moersch, current PhD advisee Udit Basu, and former advisee Michael Phillips (PhD '21) helped conduct Mars rover mission simulations with the assistance of a scientifically capable drone to aid the rover as it explored a relatively pristine lava field.

As technologies have advanced, Moersch and his group have become deeply involved in remote sensing from drones. They currently have drones capable of mapping surface mineral compositions using hundreds of wavelengths of reflected light in the visible and near-infrared portion of the spectrum and imaging in the thermal infrared for mapping grain-size distributions, all at a previously unheard-of spatial resolution of a few centimeters per pixel.

A second hyperspectral camera, capable of measuring emitted light in hundreds of thermal infrared channels from a drone for mineral composition, is currently being built for the group and will come online by the end of the year. It is anticipated that using these assets at terrestrial analog sites will lay the groundwork for scientifically-advanced drones on future missions, now that the wildly successful Ingenuity Mars helicopter has demonstrated the ability to conduct autonomous drone flights on the surface of the Red Planet. Stayed tuned for the next chapter of exciting investigations.

Lecturer and laboratory coordinator **Meilian (Maggie) Chen** is an environmental geochemist whose research centers on studying the characteristics, sources, transformations, and fates of organic matter in aquatic ecosystems in the context of intensified anthropogenic activities and climate change. Her approaches include field investigation, remote sensing, and biogeochemical modeling. In addition, she is interested in water quality improvement and environmental sustainability.

Chen currently teaches GEOL 103 Earth's Environments and coordinates an environmental geochemistry teaching lab. She looks forward to more chances to serve and collaborate with both students and faculty members.

Jordan Burkey is a new lecturer in the EPS department. She grew up in Winston-Salem, North Carolina, with a love for nature. As a child, she always had a fascination with marine life and geology. Growing up she always played in the local creek and in dirt piles outside of the local baseball field, fished to identify what fish species were in the waters at the beach, and kept a personal rock and leaf collection. Still staying in North Carolina, she earned her BS in geology and MS in geoscience at the University of North Carolina, Wilmington.

While in undergrad Burkey bounced between many ideas for a major. Started off as a nursing major, then switched to biology due to her interest in marine life. But then she took a prehistoric life class and started learning about the geologic timescale—it finally clicked. When she took the structural geology course, she knew that was the path made for her.

Burkey's love for geology further grew while conducting research for her MS degree. During that time, she developed a love for geoscience education.

Her research is in structural geology and tectonics with a focus on active deformation within the Eastern California Shear Zone. In her investigations, Burkey helps determine quaternary slip rates for the active normal faults and compares those rates with the regional geodetic velocity. She also determines paleoseismic histories of the normal faults within the region.

Aside from her research, teaching is incredibly important and rewarding to Burkey. She strives to engage students, stimulate their curiosity, ensure their success, and act as an approachable mentor. She provides innovative and student-centered approaches to her classroom. She will be teaching GEOL 101 – The Dynamic Earth and GEOL 370 – Earth Structure and Geophysics.

STUDENT SPOTLIGHTS

Most of **Catie Caterham**'s friends and family assume that she decided to pursue a graduate degree in geology because of her passion for the subject.

"While that is true, I am certainly not going to argue about the free vacations," said Caterham. "Carbonate rock, in particular, leads to some of the world's most beautiful destinations—pink sand beaches, snorkeling—all in the name of science of course!"

This summer she had the privilege of traveling to two idyllic locations: San Salvador Island, Bahamas, and Sardinia, Italy. Caterham's advisor, Professor Linda Kah, found an opportunity to send their lab group to the Gerace Research Center for a one-week course run by AIPG and the University of Kentucky.

"San Salvador Island is a dream destination for a carbonate sedimentologist," said Caterham. "The island is surrounded by modern reefs and pink sand beaches while the island interior is comprised of a series of inland lakes, and outcrops of older beach and reef facies. As an avid SCUBA diver, I was quite partial to the daily snorkeling. However, nothing will quite top the experience of observing the modern stromatolites of Storrs Lake with my own eyes—and squishing them with my own feet! The amount of microbial extracellular polymeric substances (microbial mucus) was amazing."

Her second field trip of the summer was to Iglesias, a mining town in southwestern Sardinia, Italy. This trip was less vacation and more work, as she was there to collect samples from the Cambrian-aged calcimicrobial and archaeocyathid reef complexes to search for herringbone carbonate.

"Herringbone carbonate is an unusual carbonate cement where the c-axis of the crystals rotates during growth," said Caterham. "This fabric was first identified in Archean rocks and is often thought to be a Precambrian phenomenon. The focus of my thesis is to better understand the origin and neomorphism of the carbonate that comprises herringbone cement and to identify commonalities between samples from different time periods and locations."

She is thankful to UT to have provided these two field experiences in 2023.

"As a chemistry/environmental science undergrad, I lacked a traditional field-camp experience and was worried that my textbook knowledge would not translate well into the field," said Caterham. "But with the expert help of Professor Kah, I was able to piece together observations and ideas and began to visualize these ancient environments. I think my experiences encapsulate the true importance of field work. Textbooks and papers can only take you so far, but outcrops never lie."

Aidan Littleton is a junior with a passion for paleontology. Relatedly, he began working with faculty on paleontology projects during his sophomore year and has conducted research in the Stigall and Sumrall labs with plans to continue engaging with additional faculty in the diverse UT paleontology group.

During summer 2023, Littleton was supported by Faculty Research Assistants Funding (FRAF) to conduct research in Department Head Alycia Stigall's lab. His project focused on comparing the shallow marine community structure before and after the Richmondian Invasion, a dramatic species invasion event in the Late Ordovician that is preserved in the strata around Cincinnati, Ohio, and Nashville.

Though this event is well-studied around Cincinnati, Littleton's work was the first quantitative comparison of community change across this event in Nashville and represents a critical early step in a larger project in the Stigall Lab. He conducted field, lab, and quantitative analyses for this project, which he presented as a poster at the Annual Geological Society of America Meeting in Pittsburgh this past October.

Littleton is presently working with Associate Professor Colin Sumrall's group on fossil echinoderm evolution.

"The research which I am currently involved in with Sumrall deals with determining the faunal diversity of ophiuroids (brittle stars) and how their diversity changes across the Carboniferous Period, from the Colony Creek Shale in Texas," said Littleton. "To do so, the lateral arm plates of brittle stars, which line the exterior of the animal's limbs, are isolated from samples sourced from multiple stratigraphic layers representing different sections of time. These arm plates are identified to which taxon they belong and counted for abundance. However, quite a few taxa in our dataset are new to science and have yet to be named! For these, we use placeholder names. One such unnamed specimen from Colony Creek shows persistent dominance and has been classified as the 'smooth modern' type, while other less common taxa such as *Furcaster* and *Suchaster* occur in lower abundances."

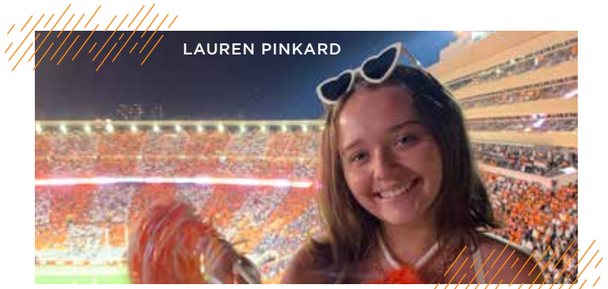
Lauren Pinkard is an undergraduate whose impact is felt not only within the department but also in the city of Knoxville. As an environmental studies major with a minor in sustainable landscape design, her passion for science is a defining thread in her academic and professional journey.

Pinkard came to EPS in spring 2023 when she enrolled in Geology 101. Her academic excellence was quickly recognized, and she earned the Jimmy Walls Award for excellence in physical geology.

After consulting with her instructor, Lecturer Robert Jacobsen, Pinkard embarked on a summer internship.

Her research explored the perceptions, interests, and expectations of students in introductory geology and environmental studies courses. Surveying approximately 900 students across five introductory courses, she unearthed a common desire among them: to explore careers that contribute to the betterment of the environment, society, and business.

These findings align with the geoscience education literature that emphasize students' aspirations to make a meaningful impact in the world. Pinkard culminated her internship with an impressive presentation at the university's Discovery Day, an annual symposium celebrating undergraduate research.


LAUREN PINKARD

Reflecting on her time in the department, Pinkard praises the faculty's unwavering commitment and enthusiasm in aiding students to achieve their academic goals and experiences.

Beyond the academic realm, she has begun working with the Knoxville community, serving as an apprentice at the Muse Knoxville, an award-winning children's science museum. This role perfectly complements her mission to introduce young minds to the captivating world of STEAM.

"These experiences have made me more passionate about teaching individuals about the career opportunities available in STEAM," she said.

As she begins her new position at the Muse Knoxville, Pinkard will undoubtedly be an inspiration for young minds exploring the wonders of science.


HANNAH RIGONI

PhD student **Hannah Rigoni** and her advisor, Professor Annette Engel, are working to shed light on cave and aquifer dwelling organisms and their interactions with groundwater geochemistry and microbial communities.

Karst groundwater aquifers provide drinking water to billions of people worldwide, but they are vulnerable to pollution. Aquifers are home to stygobionts—groundwater dwelling fauna—that aid in maintaining water quality by consuming microbial and surface-derived organic matter. Microbial communities in aquifers depend on both surface-derived organic nutrients and inorganic nutrients from water-rock interactions. Despite the global importance of karst aquifers, the relationship between stygobiont communities to groundwater geochemistry and microbial diversity, and their possible utility as water quality indicators, is unknown.

With two highly biodiverse study sites, the Dinaric Karst in Croatia and the Edwards Aquifer in Texas, Rigoni is using geochemical and molecular biological sequencing techniques (including amplicon sequencing, lipidomics, and metagenomics) to characterize groundwater chemistry, microbial community diversity and metabolic processes across these spatially extensive aquifers. These methods provide a foundation to characterize the food-web interactions between stygobionts and microbial communities.

Rigoni has so far uncovered microbial metabolic processes tied to nitrogen, carbon, and methane cycling in both aquifers. In the Dinaric Karst, she has quantified the contribution of microbial biomass produced from ammonia- and methane-oxidizers to stygobiont diets. With as much as 50% of the stygobionts food coming from microbial sources, Rigoni's research emphasizes the importance of prioritizing water quality maintenance to ensure the survival of endangered stygobionts and the microbial communities on which they rely.

This research makes a scientific case for stygobiont conservation and management of groundwater resources that are an essential resource for many people across the world.

SARA SHIELDS

Sara Shields is a third-year PhD student working with Associate Professor Anna Szynkiewicz to study environmental processes controlling the formation of evaporitic salts and microbial activity in dry and nutrient depleted settings on both Earth and Mars.

This past summer, Shields successfully applied for a 2023 scholarship to the International Summer School in Astrobiology held yearly in Santander, Spain. The Josep Comas i Solà International Astrobiology Summer School is co-sponsored by the NASA Astrobiology Program and the Centro de Astrobiologia.

This year's school focused on icy ocean world investigations and provided lectures from international experts, opportunity for peer-to-peer round table discussions, and development of student projects. In addition, the school provided an opportunity for the students to visit the Astroland Interplanetary agency, the Altamira Museum to see and learn about Paleolithic cave art, and to El Soplao caves, which is a site of astrobiological interest.

The Astrobiology Summer School lectures focused on ocean worlds orbiting giant planets in our solar system including Enceladus, Europa, Ganymede, and Titan as key astrobiological targets for future exploration by both NASA and ESA missions.

Lectures were provided by outstanding international experts including Morgan Cable from the Jet Propulsion Laboratory, Shannon MacKenzie from the John Hopkins University Applied Physics Laboratory, Olga Prieto Ballesteros from El Centro de Astrobiología, and Nicolas Altobelli from the European Space Agency. Overviews of icy ocean world surfaces and future missions from an astrobiological perspective along with reviews of current laboratory and analog field work allowed students to create ideas for collaborative future projects.

ALUMNI UPDATES

The EPS Advisory Board had an active 2023, helping to sponsor a Career Day for students in February, convening for a spring meeting in May, and taking a field trip to Tellico Dam.

We also welcomed **Ashley Ramsey** ('18) as our new advisory board chair. A graduate of the master's program in the Department of eEarth and Planetary Sciences, she is a senior project manager at Atlantic Coast Consulting, Inc., in Roswell, Georgia.

We also spotlight **Syreeta Vaughn** ('05, '13), a distinguished alumni board member with a strong academic background and extensive professional experience. Holding a BS in geological and earth sciences ('02) from Florida State University, an MS in geological and earth sciences/geosciences ('05), and an MS in engineering/industrial management ('13) from the University of Tennessee, she's received accolades like the Young Alumni Award in 2011 and the UT Alumni Promise Award in 2019.

With over 18 years in roles related to nuclear industry practices, Vaughn has excelled in nuclear materials processing, waste operations, safety, and weapons production. Her expertise has driven numerous National Nuclear Security Administration and Office of Science capital projects. Managing staff, budgets, and ensuring project success, her foundational training in geological sciences enhances hazard assessment and safety controls.

Dedicated to empowering women in technical fields, Vaughn, a wife and mother of three, contributes community service hours to philanthropic organizations. As Chair of the Mentoring and Outreach Committee, her commitment to excellence, leadership, and expertise makes her a valuable member of our alumni community.

Julie Paque, undergraduate geology major ('79), was recently honored by the College of Arts and Sciences with its Philanthropy Award. Paque has an accomplished record as a research scientist at Caltech and elsewhere. Paque was recognized as a long-term supporter of EPS, including establishing an endowment to fund the Hap McSween Professorship. Read more about Paque at ***tiny.utk.edu/epspaque*** and more about our alumni board online at ***tiny.utk.edu/epsnews***.

RETIREMENT NEWS

Associate Professor Micah Jessup retired in June 2023 after a distinguished career in the Department of Earth and Planetary Sciences. Since 2007, Jessup significantly impacted the department, teaching GEOL 101 to more than 1,200 students and leading the structural geology program. His commitment extended to active participation in departmental committees, notably the graduate program. Jessup's curated 2012 exhibit at the McClung Museum comparing the Appalachian and Himalayan Mountains highlighted his diverse contributions. Read more at ***tiny.utk.edu/epsnews***.

IN MEMORIAM

Jonathan Evenick (PhD '06) passed away unexpectedly August 5, 2023, at the age of 44 years. Evenick earned his doctorate under Professor Emeritus Robert Hatcher, added on a year post-doc, then went to work for BP in Houston for 13 years. Since 2020, he was employed by the energy company INPEX in Tokyo, Japan, where he lived with his wife and two children.

Garrett Briggs, former professor and department head, passed away December 31, 2022. Briggs moved to UT in 1968, as head of the Department of Geological Sciences, where he helped build the graduate program. He then was appointed associate dean for the College of Arts & Sciences.

Olivia Wilkerson, a junior geology major, passed away unexpectedly on November 12, 2023. Wilkerson was deeply engaged in the Department of Earth and Planetary Sciences. She was an integral member of her cohort at the top of her class and had many close friends among the student body. Her positive energy, organization, attention to detail, and generosity of providing help to others was widely appreciated. Read more about members of our community we lost over the past year at ***tiny.utk.edu/epsnews***.

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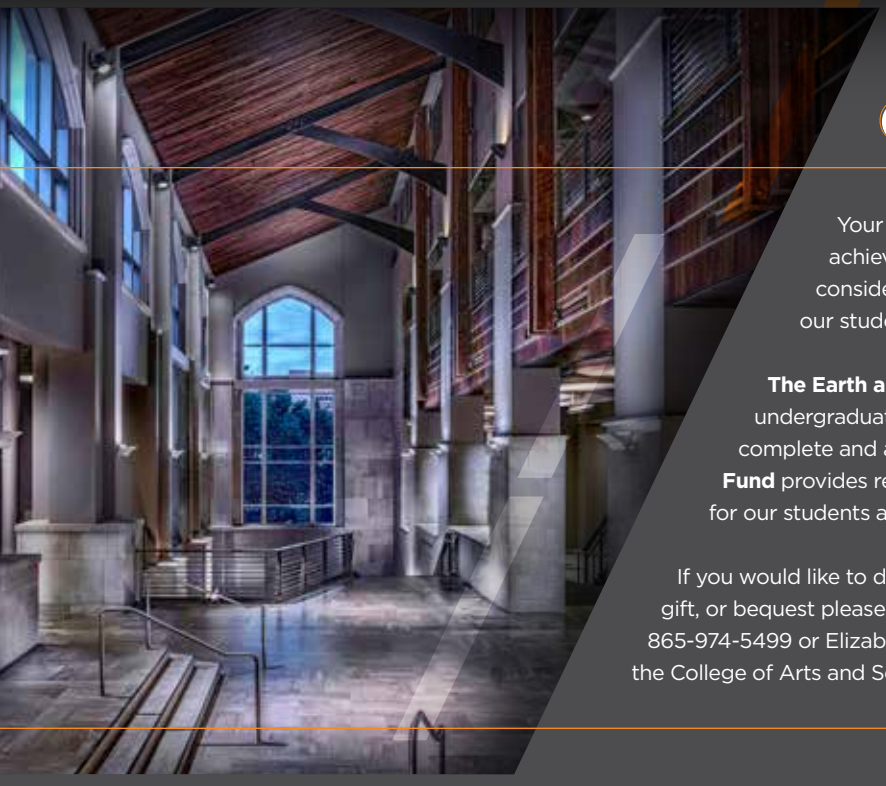

GIVING OPPORTUNITIES

Your contributions play a critical role in supporting academic achievement and research by students and faculty. Please consider a gift, no matter what the size, in support to enhance our students' experiences.

The Earth and Planetary Sciences Enrichment Fund assists undergraduate and graduate students with financial resources to complete and augment their degree programs. **The Professor's Honor Fund** provides resources for field trips, research and conference travel for our students and to support research opportunities and operations.

If you would like to discuss setting up a departmental endowment, major gift, or bequest please contact Professor Alycia Stigall, at stigall@utk.edu or 865-974-5499 or Elizabeth Weatherly, Executive Director of Development for the College of Arts and Sciences, at eweatherly@utfi.org or 865-974-8352.

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