EARTH & PLANETARY SCIENCES

Terra Firma

FALL 2022 NEWSLETTER

Diversifying Undergraduate Education

EPS has begun to diversify our undergraduate offerings to meet the needs and expectations of students and the job market they will graduate into. As such, the department has added two new major concentrations that complement the pre-existing geology and environmental studies concentrations. These new concentrations, which are active as of the fall 2022 catalog, are planetary geoscience and water science.

With them, we hope to capitalize on the existing strengths of the department and reach students that might have interests in specific career paths in these rapidly growing fields. Planetary geoscience will help our graduates find employment with the exciting new developments in space exploration. Water science will complement our existing environmental studies major to meet the demand by students who want to focus on water-related aspects of environmental issues including pollution and water management.

We have also introduced several new minors to better allow us to reach students in other STEM fields, specifically chemistry and biology, that might want to work on geoscience-related problems. These new minors are paleontology and geochemistry, either solid earth or aqueous. These complement our existing minors in geology and environmental studies.

what's inside:

A Time of Exciting Changes

Alycia Stigall, Department Head

Fall is a season of change, and we have many exciting and positive changes in the department and university this fall and over the past year. Overall, the university and department have returned to fully in-person operations, while retaining some of the advantages of remote connections learned during the main COVID years, and Strong Hall is a vibrant and busy place.

Administratively, we have a new office manager, Tammy Berry. Marie Ballard is our new academic and travel administrator, and Angie Straley has moved into managing grants and contracts.

EPS welcomed five new faculty to the department this fall, which has generated a great deal of positive energy and exciting new ideas in the department. Shichun Huang, whose research ranges from the composition of Hawaiian basalts to diamond inclusions to understand mantle processes, will manage our new ICP-MS lab, that when completed will be the most advanced and powerful facility of its kind in the southeastern United States. Dan Hembree brings expertise in trace fossils and paleosols to examine climate change in the geologic past. Amelia (Amy) Robinson joins as our new instructor in environmental geology with a hydrology focus, and Greg Snyder is our new lecturer for geophysical topics. You can learn more about each of them in their introduction articles.

In addition, I am delighted to join the Department of Earth and Planetary Sciences as head this fall. My research focuses on using the fossil record of marine invertebrates to understand the long-term impacts of invasive species, how new species form, and diversification and mass extinction events. My students and I use methods ranging from field studies to phylogenetics and ecological niche modeling to test hypotheses about how community and evolutionary responses to environmental change. My work often uses articulated brachiopods as the focal taxon. I am partial to Ordovician bioevents and serve as an officer of the Ordovician Subcommission on Stratigraphy. I spent the first 18 years of my career at Ohio University where I served as department chair for the past two years. As a child, my family spent part of each summer in Gatlinburg, and the Smokies have always felt like part of my home. I am thrilled to have the opportunity to make a difference and help faculty, students, and staff achieve at their highest levels here on Rocky Top.

UT welcomed its largest freshman class ever this year and there are more students on campus this fall than at any time in the university's history. Our introductory courses are completely full with waiting lists due, in part, to the tremendous work of our lecture staff to innovate and redevelop our courses with student-focused pedagogy. Mineralogy, our classic gateway major course, has more students enrolled than at any time in the recent past. Students are enrolling in our new major concentrations in water science and planetary science alongside our long-standing geology and environmental studies concentrations. Our number of minors continues to grow with the addition of the new paleontology and geochemistry options. We also welcomed a fantastic class of seven new graduate students this fall and anticipate welcoming additional students in January.

Our outstanding faculty and graduate students are pursuing meaningful questions of societal impact and advancing our knowledge of basic science in fundamental ways. You can learn about some of their successes in this newsletter, but there is so much more than we can share in a few short pages. I invite you to follow our social media for real-time updates.

As Chancellor Plowman often says, "UT is a university on the rise," and EPS is a key part of that trajectory. As part of the department's decadal academic program review this year, the faculty are working together to develop a vision and plan for the next ten years. We envision a future that builds on and consolidates our historic strengths in planetary geoscience, earth history and processes, and environmental geoscience while enhancing our ability to train the next generation of students with the skills they need to succeed in the careers of today and tomorrow and to tackle important societally-relevant research that impacts both Tennessee and beyond. We welcome your insights on these topics as we continue our planning and assessment process.

In my short time as head, I have already appreciated the incredible dedication and support of EPS alumni both individually and collectively. The EPS Advisory Board is engaged, active, and provides tremendous support to our students. I look forward to getting to know more of you.

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

Daniel Hembree, a new professor in EPS, specializes in the interpretation of ancient landscapes and soil ecosystems through the study of fossil soils (paleosols) and trace fossils (burrows, tracks, and trails). He is especially interested in the impact of major episodes of climate change, such as during the Pennsylvanian-Permian and Eocene-Oligocene, on landscapes and terrestrial biota. Hembree earned his MS and PhD from the University of Kansas in 2002 and 2005, respectively. He then worked as an assistant, associate, and full professor from 2007-2022 at Ohio University before making the move to UT.

Hembree has worked extensively on Late Paleozoic continental strata of southeastern Ohio, West Virginia, and Kansas, the Eocene to Miocene of Colorado, Nebraska, and Wyoming, and the Miocene of southern Bolivia. A new research project Hembree has just become involved with will take him to Ethiopia to study Pliocene soils associated with human ancestors.

"My research has provided me with the opportunity to travel to many interesting places and work with a variety of people across different scientific disciplines. Whenever I go to the field, I'm able to learn new techniques and gain new perspectives. A real strength of geology is how interdisciplinary it is, which is reflected by the diversity of research conducted in EPS."

In addition to his field work on paleosols and trace fossils, Hembree also conducts experimental work in a laboratory setting with modern invertebrate animals to better understand how and why they construct burrows, how they alter the sediment by burrowing, as well as document the different types of traces they can produce. These data are critical to interpreting fossil burrows in terms of their behavioral and environmental significance and their potential trace makers.

"In my work with living animals I've been most surprised by the number of different types of burrows a single individual can produce in addition to how specific some animals are to the type of soil they will occupy. Simply by observing them,

we can learn a great deal about the role soil animals play in the production and maintenance of soils. This information is critical to the conservation of modern soils and to our understanding of how soils have evolved through time."

To ground truth his laboratory work, Hembree conducts field investigations of modern soils and soil animals. This work helps Hembree and his students better understand the complex connections between soil properties, biota, and climate. These observations then help inform on the causes of changes in paleosol properties in the rock record.

"In my work I try to demonstrate the broad environmental, climatic, and ecological applications of paleosols and ichnofossils, especially in evaluating the effects of long-term climate change on terrestrial ecosystems through Earth history. These archives provide us with key insight into how soils, a critical global resource, may fundamentally change in the coming decades."

Shichun Huang is the new analytical geochemist in the department to set up and to manage the ICP-MS (inductively coupled plasma mass spectrometer) lab. He was born, grew up, and received his BSc degree (at the University of Science and Technology of China, USTC) in Anhui Province, China. He did not leave his home province until he went to MIT for graduate school. Then he was a postdoctoral researcher at Florida State University and Harvard University until 2014. Following an eight-year spell on the faculty at the University of Nevada, Las Vegas, he joined UT in August 2022.

Huang will set up an ICP-MS lab on the seventh floor of the Strong Hall. This lab includes an iCAP TQ ICP-MS, an NWR193 laser ablation system, and a Neoma MC-ICP-MS. This core research facility will provide both elemental and isotopic measurements, at both in situ and bulk sample scales, to support the research and education activities of UT faculty and students, as well as their collaborators.

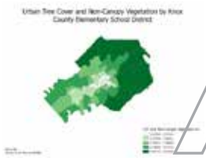
Huang uses elemental and isotopic tracers, as well as petrology, to understand the origins and evolution of the Earth's mantle and the early solar system. His recent study focuses on metal stable isotope geochemistry of major rock-forming elements, such as Mg, Si, K, Ca, Ti, and Fe, and their applications in high-temperature geochemistry, igneous and metamorphic petrology, and cosmochemistry. At UT, he will continue his research effort on the geochemical and isotopic heterogeneity of ocean island basalts, and their constraints on our understanding of mantle dynamics. Complementary to this approach, he will also study the chemical compositions and mineralogy of high-pressure inclusions entrapped in deep sourced diamonds, which provide a direct sampling of the Earth's deep interior. This research effort continues the long history of diamond inclusion study in this department led by Larry Taylor. His extraterrestrial research effort focuses on the understanding of chondrite formation, using both analytical and modelling approaches. His research activity is collaborative and benefits from partnerships with a broad range of experts. He is actively seeking interdisciplinary collaborations within and outside of the department.

Amy (Amelia) Robinson ('97, '02) grew up in Martin, Tennessee, with a strong desire to learn and teach. She grew up finding fossils in the gravel piles at her grandfather's paving company and loved to explore nature and spend time at the Land Between the Lakes in northwest Tennessee. Robinson earned her BS in geology and BS in natural resources management from UT-Martin. She went on to earn a MS in geology at UT and a PhD in geology from the University of California-Davis.

Prior to her return to UT, Robinson was an earth science professor at UALR (2007-2010), where she created multiple courses to actively engage students through water sampling and data collection programs. This was followed by a five-year stint as a petroleum geochemist, Robinson was a lead inventor and co-inventor on numerous US and world patents (9+ patents). During this time she also established two endowed scholarships at the UT Martin, the Bob Robinson memorial scholarship in Early Childhood Education and the Robinson Geoscience Research Fellowship for students to complete field studies in geology or soil science. Following her time in industry, she started a tutoring company, Amelian Academic, that provides customized lessons for students who struggle in the areas of math and science. Robinson also became the Principal and 7th-12th grade math and science teacher at The Academy at World Champions Centre (home of Simone Biles), a school for junior Olympic and elite gymnasts located in Spring, Texas, in 2018.

Robinson is excited to return to UT as a postdoctoral teaching associate in fall 2022 and share her passion for teaching and challenging students to develop their scientific curiosity and critical thinking skills by providing them with enriching educational experiences. She is teaching GEOL 103: Earth's Environments and GEOL 485: Hydrogeology during the fall semester. She looks forward to sharing what she has learned since her time at UT and bringing relevant and timely material to courses while exploring her research interests. These include: mineral-organic reactivity, carbon sequestration and cycling from terrestrial and marine environments, modern soils and paleoVertisols in mixed siliclastic-carbonate sequences, aqueous and hydrocarbon geochemistry, novel applications of nanotechnology, and developing geochemical tools used in industry applications.

To read more from EPS, please visit us online at **eps.utk.edu/newsletter**.



Hannah Williams

Access to green spaces in the outdoors is a key resource for human mental and physical wellbeing. Knox County has almost 300,000 acres of urban tree cover and other vegetation, with 64% of the land area in Knoxville being vegetation. Knoxville is a city known for its urban wilderness, with Ijams, Fort Dickerson, and several other large recreation areas just over the river from downtown, but who has access to these green spaces and where they are located throughout Knox County is not equitable across socioeconomic groups.

Working with the Director of Environmental Studies, Professor Michael McKinney, master's student in the agricultural and resource economics department, Williams has been using LiDAR data of Knox County vegetation to better understand who has access to urban green spaces in Knox County and where these green spaces are primarily located. Collecting US Census and TNDOE data by census tract and elementary school district in Knox County allowed Williams to look at the relationships between socioeconomic and health factors of Knox County residents and urban tree cover/vegetation in their area. This showed that by elementary school district in Knox County, the higher the urban tree cover in the district, the higher the student success rate is at the school. Furthermore, the percentage of economically disadvantaged students at the school decreases as urban tree cover in the district increases. By census tract in Knox County, the rate of asthma is negatively correlated with urban tree cover, and tracts with a high median household income also have high urban tree cover. Once these relationships were established, Williams created maps of urban tree cover and the statistically significant variables in ArcGIS to better visualize the relationships between the variables and urban tree cover.

Williams's findings tell us that urban tree cover is not equally distributed among socioeconomic groups in Knox County and are among the first to document the luxury effect in a medium-sized city. Moving forward, this study will be used to document and quantify social health benefits from urban green space and make policy recommendations for Knox County.

Jake Perez

Doctoral student **Jake Perez** is using fieldwork in the high Arctic and supercomputer-based simulations to better understand how thawing permafrost will influence the Earth's carbon cycle.

Permanently frozen soils, or permafrost, are rapidly thawing in the Arctic. Microbes in these newly thawed soils transform organic matter to greenhouse gasses, such as carbon dioxide and methane. Perez and his advisor Drew Steen, along with colleagues Karen Lloyd of the Department of Microbiology, Tatiana Vishnevetskaya of the Center for Environmental Biotechnology, and collaborators at Princeton University, Oak Ridge National Lab, and Pacific Northwest National Lab have been funded by the Department of Energy to study the microbial processes that drive these transformations.

The first step in soil organic matter degradation process is mediated by extracellular enzymes, digestive enzymes that soil microbes secrete to begin the degradation process. In 2022, Perez, Drew and the rest of the Arctic Microbial Permafrost Degradation team travelled to Svalbard, an archipelago in the Arctic Ocean that is among the fastest-warming places in the Arctic, to sample soils. The team measured gas fluxes in situ and collected soils for enzyme measurements, as well as for DNA to understand what microbes are present in the soils and what their metabolic capabilities are. Drilling frozen soil in cold weather was a challenge, but he helped to collect 10 meters of rocky, frozen soils from four boreholes around the study site.

Back in Knoxville, Perez is working with Professor David Keffer of the Department of Materials Science and Engineering to create computer simulations of how these extracellular enzymes interact with soil minerals. Once extracellular enzymes are secreted by soil microbes, they interact with the chemically complex soil environment. Since enzymes are often charged, many will sorb, or attach, to soil minerals. It has long been assumed that this causes the enzymes to deform, making them less effective at breaking down organic matter. However, this has been a challenge to study empirically, because most of the microbes in soils that produce extracellular enzymes do not grow in labs, so it is difficult to obtain samples of their enzymes to study directly. However, new breakthroughs in deep learning have allowed us to accurately predict the structures of enzymes based only on the DNA that codes for them. Armed with those predictions, Perez is using UT's supercomputer ISAAC to simulate what happens to these enzymes interact with soil minerals. These simulations will reveal which enzymes sorb most effectively to soil minerals, which minerals they sorb to most effectively and whether they are likely to become deformed and therefore change function when they do. We hope these environmental measurements combined with simulations will lead to a better understanding of how the warming Arctic will change the Earth's climate.

Ethan Sweet

All life on Earth depends on the Critical Zone, which includes plants and trees, soil, and the subsurface, including groundwater. Research in the Critical Zone examines how disturbances and climate change affect ecosystem services and energy, food, and the water cycle.

Rivers and streams are vital for nutrient and water transport within the Critical Zone. Ethan Sweet, a Masters student working with Jones Professor of Aqueous Geochemistry Annette Engel, is focusing his research where surface water and groundwater meet, an area called the hyporheic zone. As much as 90%–98% of biogeochemical processing within a watershed is controlled by the hyporheic zone, which means the hyporheic zone has the potential to buffer against the effects of climate change that impact surface water temperatures, dissolved oxygen and nutrient concentrations, contaminant transport, and altered flow conditions due to drought. Their project is funded by the US Army Corps of Engineers' Aquatic Nuisance Species Research Program's focus on Next Generation Ecological Modeling.

For the past two summers, Sweet participated in fieldwork with colleagues from Texas State University. So far, they have collected hundreds of water samples from nine different river systems across the state of Texas. These include the Colorado River and its tributaries, and tributaries to the Red, Rio Grande, Guadalupe, and Neches rivers. Sweet's thesis research focuses on evaluating hydrologic, geochemical, and microbial data from a series of pools and riffles located in the San Saba River within the Colorado River watershed.

Sweet is uncovering details about microbial metabolism tied to dissolved oxygen, nitrate, sulfate, and methane concentrations, which fluctuate depending on how much groundwater is discharging into the hyporheic zone. In the absence of oxygen, metabolically diverse microbes process carbon and provide essential organic matter for organisms like mussels. The microbial processes will change the type and availability of carbon within the hyporheic zone and river system as water contributions are affected by climate change. Sweet's results will be used by the US Army Corps of Engineers in ecological models to understand the distribution of river organisms and to improve river restoration projects.

Constance Cooper

Braided rivers, and their terminal deltas, played a critical role in clastic terrestrial deposition prior to the Devonian. After which, rooting land plants profoundly impacted fluvial systems by stabilizing channels, this facilitated a transition to abundant meandering rivers. While commonly over-looked and misidentified in modern and ancient environments, braid-deltas are found in the sedimentary record and in remote locations, today. Constance Cooper and advisor Professor Christopher Fedo have identified and studied an active ephemeral, river-dominated, braid-delta in order to provide a Holocene example of a braid-delta depositional environment.

Ivanpah Dry Lake (IDL) is located within the Southern Basin-and-Range Province in California, directly adjacent to the Nevada state line near Primm, Nevada in the Mojave Desert. The Northwest margin of IDL is fed by an ephemeral braided-fluvial system ending with a braid-delta complex that appears to be active during extreme, short-lived rainfall events. Changes in braid-delta configurations are identified using time-series images from the past decade to indicate the multiple depositional and degradational events that have occurred. Analysis will be paired with Landsat/ Copernicus images from GoogleEarth ProTM and a small unmanned aircraft system image to monitor the evolution of the braid delta. In each sequential image details of each facies boundary position, channels, braid-delta lobes, and jet deposits will be documented for semi-annual comparisons. This provides the capacity to establish both the geometry of a deposit and the rates of formation and erosion.

Preliminary analysis also identified that the delta appears to prograde, utilizing multiple styles of sedimentation moving along the base of channels. This includes what appears to be "jet" deposits mentioned above, which get their name from high-velocity flow and sediment scatter through a narrow restriction. This form of deposition is important in understand the intense energy behind depositional events. From existing reconnaissance analysis, degradation of the braid-delta lobes and jet deposits are happening across a short period of time, so erosion of these braid-delta lobes and jet deposits are happening on an inter-annual scale. To identify what is driving this relationship between deposition and degradation at IDL, observations of hourly rain and wind records allows a year-to-year potential for documenting specific events of sediment deposition and their subsequent erosional modification with implications for preservation potential. Methods are established for gathering research data to make modern facies assessments and to define an active braid-delta environment. The importance of this research is to build a stronger modern facies assessment from pre/post major storms to understand the evolution of braid-delta deposition and their preservation potential within the rock record.

Jake Alexander (MS '20) wrote his thesis on the relationship of deep- and shallow-water facies of the carbonate rocks in the Archean Transvaal Supergroup in South Africa. Alexander was active in both academics and industry during his time at UT. He interned at ExxonMobil in Houston working on the Permian Basin and served as the first alumni relations officer to the EPS Advisory Board.

After defending his thesis, Alexander immediately headed to Reno, Nevada, and began work as a field geologist intern for LithiumNevada, a subsidiary of LithiumAmericas. His team focused on exploration for sedimentary-hosted lithium deposits across the Cordillera of the western US.

"That internship was essentially a field course in physical volcanology, a crash-course in economic geology, and a great first taste of mineral exploration," he said about the summer of 2020 at LithiumNevada. "I was hooked."

In 2021, he relocated to Salt Lake City, Utah, and joined a consulting firm as a staff geologist. In that position, Alexander performed every step of exploration for minerals—from regional targeting to boots-on-the-ground geological investigations. With clients' target commodities ranging from aggregate to gold to critical minerals, he learned to target mineral systems across diverse geological terranes.

"Every day was a new challenge," he said. "I was fortunate to spend almost two years in consulting and be exposed to many different mineral systems. To go from reviewing maps and literature to collecting data on the outcrop by sampling, mapping, and remote sensing methods was incredible."

He's b-a-a-a-ck! After a 23-year hiatus, **Greg Snyder** is back in the Department of Earth and Planetary Sciences, this time as a lecturer in geology. In 1990, Professor Larry Taylor brought Snyder to UT as a post-doctoral fellow studying NASA-funded research on lunar rocks and meteorites and NSF-funded research on diamond inclusions from Russia. Snyder had just completed a PhD in geochemistry at Colorado School of Mines and brought his expertise in trace-element and radiogenic isotopic analyses to UT. Over the course of his nine years at UT, from 1990 to 1999, Snyder served as research associate professor in the department (then the Planetary Geosciences Institute in the Department of Geological Sciences) publishing more than 100 abstracts and 60 articles in peer-reviewed journals. During that time he continued his research with Taylor and many other collaborators on various planetary projects and Taylor encouraged him to expand his interests into studies on several kimberlite pipes in Siberia, on volcanics from Syria, and layered mafic intrusions and associated Ni-Cu and PGE deposits from the Kola peninsula and Karelian regions of Russia. Snyder felt that in his last few years at UT that he was "a kid in the candy store" taking interest in and being afforded the opportunity to research many disparate areas of geochemistry.

Snyder also remembers with great fondness the many national and international colleagues, indeed friends, that he has nurtured over the years. After the last difficult years of Covid-19, Snyder looks forward to helping build a camaraderie amongst undergraduate and graduate students and faculty that was a hallmark of his time here in the 1990s.

Please visit **eps.utk.edu/newsletter** *to read their full stories.*

ALUMNI UPDATES

Now with 40 members, the EPS Advisory Board is not the small group that many may remember. In addition to providing professional mentoring and outreach to EPS students, the mission of the EPS Advisory Board is to provide external perspective, advice, recommendations, resources and related assistance as needed by the department.

During the 2021-2022 academic year, the EPS Advisory Board was able to provide almost $11,000 in scholarships to EPS students with various emergent and academic needs. Each year the EPS Advisory Board is honored to help recognize several alumni for career contribution awards and outstanding achievements. The EPS Advisory Board is excited to welcome fall 2022 new members, Mike Coffey and Preston Sitterly.

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DEPARTMENT OF EARTH & PLANETARY SCIENCES
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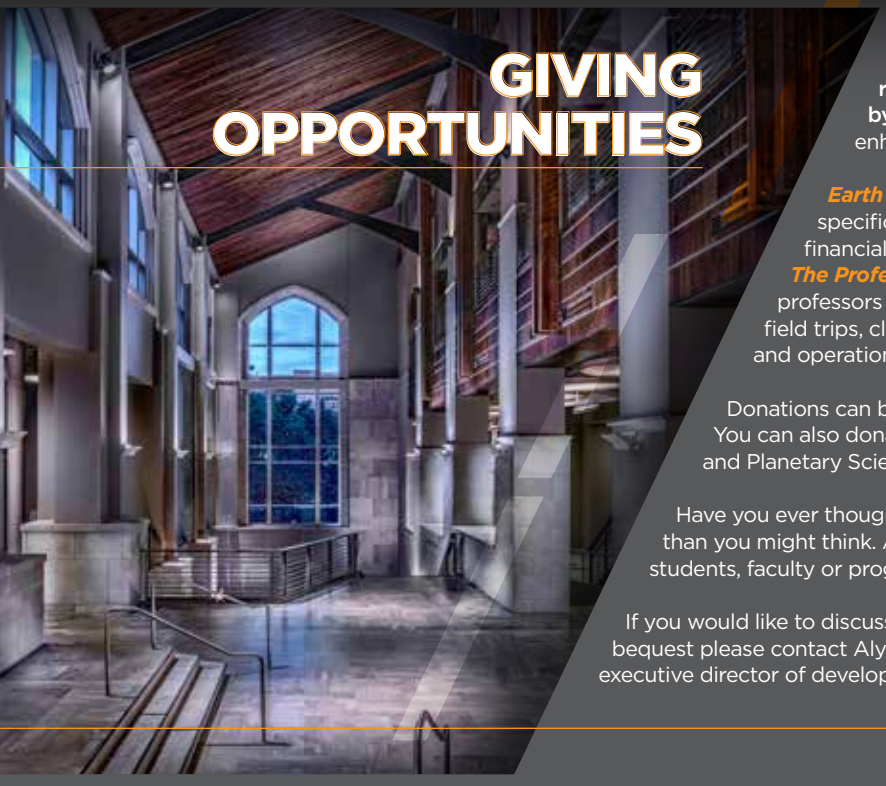

GIVING OPPORTUNITIES

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

Earth and Planetary Sciences Enrichment Fund specifically to assist undergraduate and graduate students with financial resources to complete and augment their degree programs. ***The Professor's Honor Fund*** recognizes the contributions of the many professors in the EPS history and is used to provide resources for class field trips, classroom equipment, and support research opportunities and operations.

Donations can be mailed to EPS, with check payable to the UT Foundation. You can also donate online at eps.utk.edu under the heading of "Give to Earth and Planetary Sciences."

Have you ever thought about setting up a departmental endowment? It is easier than you might think. An endowment is a gift with earnings that go to support students, faculty or programmatic activities as designated by the donor.

If you would like to discuss setting up a departmental endowment, major gift, or bequest please contact Alycia Stigall, at stigall@utk.edu or 865-974-5499 or Chris Cox, executive director of development for the college, at ccox65@utk.edu or 865-974-2365.

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