Tulane University

DEPARTMENT OF

EARTH AND ENVIRONMENTAL SCIENCES

SCHOOL OF SCIENCE AND ENGINEERING • 2012 NEWSLETTER

IN THIS ISSUE

MESSAGE FROM THE CHAIR

After a few years of silence, it is time to reconnect with all of you through our departmental newsletter. I took over as Department Chair in January of this year, after Steve Nelson stepped down from a long and productive term. Let me first thank Steve for an exceptional job done, under exceptional circumstances. He has been in charge for about 15 years in total and during his last term, from 2003 to 2012, he skillfully maneuvered the department through Katrina and its aftermath. This included the hiring of a large number of new faculty members, plus a move to our current home: Walter E. Blessey Hall. The department currently has 12 faculty members; 8 of us started here after Katrina. After these turbulent years things have thankfully settled down a bit, so we are now in a better position to look toward the future.

This edition of our newsletter is the first to go all-electronic. Therefore, we are in the process of updating our alumni database, with the goal to obtain e-mail addresses of everyone. You may notice that the format of the newsletter has changed a little bit. In the following pages you will meet some of the new faces of the department, including new faculty members Jeff Agnew and Kyle Straub, and Ph.D. candidate Jade Mohajerin Haug. In addition, we have included some recent, brief news stories about exciting research findings and other departmental news. Of course we are interested in your feedback, so please don't hesitate to share your thoughts.

Tulane as a whole is as vibrant as ever, with unprecedented numbers of undergraduate applicants (some 40,000 annually) in recent years. As a department, we take notice. Several of our introductory courses have lengthy waitlists. Our graduate program, after going through some tough post-K years, is also thriving. Since 2006, we have seen increased student applications every single year, and we are currently welcoming nine new graduate students to the department.

The new academic year has started with our biggest test since Katrina, but we bounced back quickly after Hurricane Isaac and we look forward to Homecoming Weekend and our annual Alumni Party which will take place on Friday, November 2. Of course we hope to see many of you here!

Torbjörn Törnqvist
Chair, Department of Earth and Environmental Sciences

INQUIRY IN THE CLASSROOM

Spring 2012 Earth History students on a field trip to collect Oligocene marine fossils near Jackson, MS.

Tulane's strengthened commitment to undergraduate education in the post-Katrina years includes the hiring of "Professors of Practice", a new rank of highly qualified and dedicated instructors. Jeff Agnew shares his experience as a Professor of Practice in Geology.

I joined the faculty in the Department of Earth and Environmental Sciences at Tulane in Fall 2010 as a Professor of Practice – a position dedicated primarily to instruction and instructional methods. I am a native of Michigan, and I earned my B.S. in geology from Central Michigan University, M.S. in geology from the University of Florida, and Ph.D. in geology from Louisiana State University. My research focuses on the taphonomy, systematics, evolution, and functional morphology of crab claws and shark teeth. Prior to joining the faculty at Tulane, I was a Lecturer of Geology at Centenary College of Louisiana for three years.

In my two years at Tulane, I have supervised graduate teaching assistants, mentored 8 undergraduate research projects, worked with 17 local K-12 teachers, and taught Physical Geology, Earth History, and Shark Paleobiology. Acting as a motivator and facilitator, I have involved teachers and students across multiple disciplines and grade levels in the process of scientific inquiry. I am particularly fond of using shark teeth as tools for teaching science, especially earth science, because they are perfect for inquiry-based activities and research projects. Our natural fascination with sharks helps motivate inquiry. Shark teeth also are abundant and inexpensive so it is very easy to get fossil shark teeth in the hands of students. In addition, many aspects of shark paleobiology are controversial and little studied.

Last year, I developed and taught an interdisciplinary, project-based, service learning course on fossil shark teeth called Shark Paleobiology. Students in this course used scientific inquiry to develop their understanding of the nature of science and science education as well as the patterns and processes of shark speciation, diversification, macroevolution, and extinction. Students worked with local K-12 teachers to create and implement inquiry-based shark tooth activities for K-12 classrooms. These learning activities allowed K-12 students to do science to satisfy the math and science content standards and Grade Level Expectations (GLEs) in Louisiana's Comprehensive Curriculum. My Shark Paleobiology students also completed independent research projects and contributed to a problem-based lesson plan involving K-12 teachers and their students in meaningful research on shark teeth. To these ends, students enrolled in Shark Paleobiology (1) collected fossil shark teeth in the field, (2) examined fossil shark faunas from around the world, (3) reviewed and synthesized the literature, (4) identified research questions, problems, and strategies, (5) built an image database of shark teeth from museum and other professional collections, (6) collected, analyzed, and interpreted data, (7) created figures, posters, and web pages, and (8) wrote and presented a professional paper. In so doing, students enrolled in Shark Paleobiology learned the course content, enriched the educational experiences of K-12 students, and contributed to our understanding of modern and fossil shark teeth.

I also helped develop an outreach

INQUIRY *continued on page 7*

EXPERIMENTAL EARTHSCAPES

One of the most spectacular new additions to our department is the Sediment Dynamics Laboratory in 100 Blessey Hall. Assistant Professor Kyle Straub, who will receive the 2013 SEPM (Society for Sedimentary Geology) Wilson Medal for outstanding contributions by an early career geologist, describes how this facility has become reality.

Why doing experiments?
Tulane and the city of New Orleans sit atop one of the largest and most dynamic river deltas in the world. Prior to human intervention, the Mississippi River supplied the delta region with sediment necessary to counter land loss due to subsidence and sea-level rise, and during sea-level lowstands it supplied sediment to the continental slope where it was transported to deeper waters via turbidity currents.

In addition to the importance of sediment deposition for the ecological health of the delta, coarse sediment deposits in shallow and deepwater act as the reservoirs for hydrocarbons which the oil and gas industry explore for and produce out of along the Louisiana shoreline.

Given the importance of the Mississippi River and its sediment for the history and future of south Louisiana, many geologists are interested in better understanding how this system, and others like it, function. While the Mississippi Delta and continental slope of the Gulf of Mexico are geologically dynamic features, unfortunately, they still evolve incredibly slowly when compared to the life span of humans. As a geologist and sedimentologist, this simple, but true fact has always bothered me.

Starting early in our geological education, for example in classes like Physical Geology, we are trained to think about much longer timescales than is the norm in other disciplines. To answer questions across these timescales, sedimentologists and stratigraphers learn how to date deposits, to interpret depositional settings from the architecture of stratigraphy in outcrop and core, to develop numerical models based on our understanding of the relevant physics of sediment transport and deposition, and to use a host of other tools to overcome our inability to see these systems evolve with our own eyes. While all of these techniques are vitally important to improving our understanding of how sediment is transported and deposited, I have never gotten over a desire to see rivers on delta tops avulse and watch turbidity currents (rare and infrequent events that usually occur at thousands of meters of water depth) interact with submarine channels.

To overcome the time and space scales associated with natural sediment transport systems, much of my research utilizes reduced scale experiments, in which we generate small sediment transport systems in controlled laboratory settings, thus allowing us to monitor these systems comprehensively. To accommodate these experiments, much of my work and my group's work since I arrived at Tulane as an Assistant Professor in 2009 has focused on building a state-of-the-art sediment transport laboratory housed in 100 Blessey Hall. The construction of this facility is now all but complete and we are more than one year into running experiments on sediment transport and development of stratigraphy in two new experimental basins.

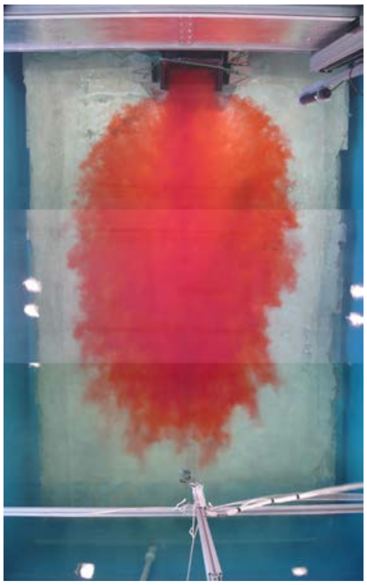
The appeal of experiments in stratigraphy and geomorphology is not hard to understand. Experimental landscapes evolve under controlled conditions, so they allow study of steady states and response to changes in a single variable that would be difficult to observe in nature. In addition, a small, self-contained system can be studied and measured comprehensively to a degree that is rarely possible in the field. Finally, experiments greatly speed up time, through two main effects: characteristic time scales typically increase with spatial scale, so that small systems have intrinsic time scales that are shorter than large systems. The second effect is that in the field, system evolution is usually intermittent, occurring only during floods or storms. Experimental systems can be continuously active – for instance, a steady-state experimental river on a delta top is in effect permanently in flood.

Top left: Active experimental delta top in the Tulane Delta Basin (flow dyed blue to aid visualization).

Top right: Graduate student Chris Esposito cutting experimental deposit.

Bottom: Experimental stratigraphy from the Tulane Delta Basin.

Beyond these practical reasons, graduate students in my research group and I find an irresistible fascination in watching small, controlled landscapes evolve, creating dynamic patterns that seem to appear from out of nowhere. The surface of a 1 m^2 experimental landscape made of fine, noncohesive sediment could easily comprise some 10^{10} particles, all capable of independent motion. While decades of research has focused on the laws by which fluids and particles interact, we presently only have an imperfect and highly empirical understanding of sediment transport physics. So the capacity of particle-fluid experiments to inform and surprise us should not in itself be surprising.


Unconfined turbidity current in the Tulane Deepwater Basin (flow dyed red to aid visualization).

Tulane Deepwater Basin
The largest deposits of sediment on Earth are found in submarine fans. In addition to occupying a critical place as the final sink in source-to-sink transport systems, submarine fans host many of the largest producing petroleum reservoirs. These fans and the channels that construct them are largely built through deposition of sediment carried as turbidity currents. Unfortunately, very few direct observations exist to define turbidity current interactions with submarine topography because infrequent occurrence (specifically in today's sea-level highstand world), great water depths, and high current velocities make measurements difficult.

Given the obvious difficulty of studying submarine fans in the field, it is not surprising that they have attracted the attention of experimenters. To examine sediment transport and deposition in these settings, we have constructed the Tulane Deepwater Basin. This basin, the largest facility in the new Sediment Dynamics Laboratory, went into operation in the summer of 2011. The basin is also one of the largest and best equipped facilities in the world designed to investigate deepwater systems. The basin measures 6 by 4 m in plan view and is 2.2 m deep. Given the size of the basin and its weight when filled with water, the construction of this basin presented a number of engineering and logistical challenges, all thankfully overcome.

To the untrained eye, the facility might appear to be a large, above ground indoor swimming pool, but over the last year our group has used this facility to improve our understanding of how levees are constructed from turbidity currents and how sediment of different shapes and densities segregate in unconfined turbidity currents and the turbidites they form. Work in this facility is currently funded through a mixture of funds provided by industry (including support from Shell Exploration and Production and Chevron Exploration and Production) and the Petroleum Research Fund of the American Chemical Society.

One of the most exciting aspects of this basin is its data collection system. The basin is outfitted with a measurement carriage system designed and constructed by engineers at the St. Anthony Falls Laboratory at the University of Minnesota. This measurement carriage allows the Tulane sediment dynamics team to generate Digital Elevation Models (DEMs) of experimental deltas and deepwter fans/channels with incredibly high lateral and vertical resolution. For example, when scaling up the experimental landscapes to field scale the maps will have a resolution comparable to high-resolution LIDAR surveys. In addition, the measurement carriage is used to deploy equipment capable of characterizing flow and sediment transport fields (e.g., flow velocities with acoustic Doppler velocimeters and sediment concentrations with siphons) at high resolutions. Finally, the carriage allows for the collection of images of preserved stratigraphy that can be placed in xyz space with high precision.

Tulane Delta Basin
Sitting on the Mississippi Delta, here at Tulane, the second largest facility constructed in the Sediment Dynamics Laboratory is the Tulane Delta Basin. We designed this basin to be a premier research facility dedicated to studying delta morphodynamics at a range of spatial and temporal scales. The basin incorporates leading-edge technologies for ocean-level control, sediment and water delivery, as well as data acquisition systems that allow description of topography, and visual changes in the surface and subsurface architecture.

This basin is 0.65 m deep, 4.2 m long, and 2.8 m wide, which is large enough to conduct experiments focused on delta construction under conditions of varying base level. Millimeter resolution base-level (ocean) control, sediment feed, and water feed to the basin are controlled through a computer interface, while topography in the basin is collected using a laser elevation system. Finally, the basin also houses a system to collect grain-scale digital images of large experimental sedimentary deposits.

Work in this basin is currently being funded by two National Science Foundation grants: one focused on quantifying processes associated with filling of sedimentary basins by mobile deltas and a second focused on improving our understanding of the linkage between surfaces preserved in the stratigraphic record and the geomorphic surfaces that created them.

This basin has been in operation since the spring of 2010 and has already been producing exciting data, some of which were recently published in the journal *Geology*, by Yinan Wang (M.S., 2011) and me, along with a colleague at Pennsylvania State University. Yinan's work focused on developing statistical methods for quantifying autogenic processes in sedimentary basins. Ancient sedimentary basins are archives of past climate,

EARTHSCAPES *continued on page 7*

FOR THE LOVE OF WATER

Thanks to a generous gift by the late alumnus George Herman, our department has recently established the Vokes Fellowship which provides a full-year research assistantship for our top PhD candidate. Jade Mohajerin Haug, our first Vokes Fellow, talks about her research interests.

Becoming a geochemist

The path leading to a doctorate in geochemistry, specifically researching thiotungstates, has been anything but direct. Despite the meandering course, the underlying theme for all of my career decisions has been the desire to help find a balance between anthropogenic appetites and their environmental impacts.After graduating with my bachelor's degree in biology from the University of Texas at Austin, I worked in Madagascar for two years as a Peace Corps volunteer, doing environmental education, wildlife monitoring, and a variety of community development projects. After returning to the U.S., I spent several years working for the National Park Service. The opportunity to do field work and help manage some of America's most beautiful environments further deepened my appreciation of natural places as well as opened my eyes to the fragility of ecosystems. The applied aspects of my job were very appealing, but I realized that to make a significant impact, research on how to mitigate environmental damage was essential.

After talking with Dr. Karen Johannesson about studying potentially toxic trace elements in freshwater sources, I decided to focus on water quality. I spent my first two years at Tulane taking classes and researching arsenic speciation in high arsenic groundwaters of West Bengal, India *(pictured above)* and studying trace elements in a local bayou. When Dr. Johannesson asked me if I would be interested in pursuing a doctorate focusing on tungsten in groundwaters, I eagerly accepted.

Why study thiotungstates?

The motivation to learn more about tungsten geochemistry was generated by findings that linked high concentrations of tungsten in blood and urine samples to human health issues, especially several clusters of high childhood leukemia rates. Preliminary data show that W has a strong and statistically significant positive correlation with dissolved sulfide concentration in the Carrizo Sand aquifer where groundwaters become anoxic. This finding has led to the hypothesis that thiotungstates may be important in sulfidic groundwater systems.

The study of thiotungstates

When the tungstate oxyanion (WO_4^{2-}) is combined with sulfidic water, thiotungstates are formed as sulfur replaces oxygen. In order to better understand the behavior and occurrence of thiotungstates in ground waters, I have four main goals: 1) Analyze groundwater from an oxic aquifer and an anoxic aquifer to determine the relationship of tungsten concentration and speciation with factors such as redox chemistry, iron speciation, pH, etc.; 2) Collect sediments from these same aquifers to identify solid phase speciation of W using X-ray absorption techniques; 3) Determine the stability constants for the four thiotungstate species; and finally 4) Create a biogeochemical model to predict the behavior of W in groundwater flow paths.

A milestone reached

I recently had the privilege of meeting some of the world's top geochemists while attending the Goldschmidt conference in Montreal, Canada. In addition to presenting my preliminary findings on thiotungstate stability constants (see this link to the poster), I was able to meet with professionals working with sulfidic solutions. Although several researchers were very interested in my work, I found the paucity of literature on thiotungstates was reflected in the lack of sessions on tungsten in general.

As informative as the oral sessions were, the wealth of knowledge I gathered tended to occur during the breaks in between. Speaking with others in this field gave me insight on some of the technical tricks of working with anoxic sulfidic solutions. Learning exactly how to implement the tactics I learned is another challenge. Even meeting with the top experts, some of the questions I had hoped to receive quick answers to, have yet to be resolved. I am discovering the biggest challenge inherent to all new research: there is no answer key!

Obstacles, acknowlegdements, and opportunities

The challenges of working with thiotungstates have been varied and vast. Not only should the solutions be kept completely anoxic, the rate of sulfide substitution is highly variable. The first reaction, equilibration of the monothiotungstate (WO_3S^{2-}) with tungstate, can be over in less than five minutes, whereas after several months, none of the solutions have reached equilibrium with respect to the tetrathiotungstate (WS_4^{2-}).

The sense of accomplishment, however, of overcoming obstacles has been great. After months of making experimental solutions that did not make any thiotungstates, I was thrilled when this January I finally made a solution worth measuring!

Working with anoxic thiotungstate solution in glove box.

Many of my achievements have been enabled by the assistance and advice of others. Erich Scholz has been invaluable in many of the technical aspects of setting up our lab. My fellow graduate students Elizabeth Williams and Alvaro Fernandez taught me the art of flame sealing glass ampoules. Talking with Dr. Gary McPherson has helped me to bridge the gap between geology and analytical chemistry. Most importantly, my dissertation committee, Dr. Karen Johannesson, Dr. George Flowers, Dr. George Helz, and Dr. Saugata Datta, has been of great assistance in providing insight when I have hit a wall.

I feel very fortunate to have been given the opportunity to work on such a complex project, and honored to have been chosen for the Vokes Fellowship. The number of new skills I need to develop for this project has been rather daunting at times; therefore the gift of time is a truly precious commodity. The chance to combine lab experiments with collection and analysis of water and sediments from field samples in order to develop a computer model enables me to gain expertise in learning and integrating all these important components.

I look forward to completing my education and gaining the experience to one day become a true expert in the field of water quality, hopefully making a significant contribution to the availability of fresh water for all.

Congratulations to our 2012 Award Recipients

The R. A. Steinmayer Award

Recipient: Holly Ann Jeffries

Holly Jeffries is the top graduating senior in the geology program this year. She has excelled in her coursework and has enthusiastically contributed to service at Tulane and within the department. She is three months away from completing her second Bachelor's Degree in Applied Computing through the School of Continuing Studies. Upon graduation, she will continue to work at the Naval Oceanographic Office redesigning and implementing geological databases. Living aboard her sailboat in Mandeville, LA, she is excited to remain in the area and be an active alum in the years to come.

The Harold E. Vokes Award and the 2012 Chairman's Award

Recipient: Emily Lewis Cardarelli

Emily Cardarelli is a top graduate in environmental science, with a minor in geology. She has always been interested in science and passionate about the outdoors. She authored a funded Louisiana Sea Grant to conduct research on nitrogen cycling in a freshwater diversion along the Mississippi River. Her research project was submitted as an honors thesis under the guidance of Dr. Brad Rosenheim. Funded by Louisiana Sea Grant, she carried out research which made her a top candidate for graduate school. In the fall, Emily will pursue a Master of Science degree at Stanford University.

Getting ready for another day of rafting on the Colorado River (Grand Canyon Colloquium, 2009).

Students present posters at State of the Coast Conference 2012

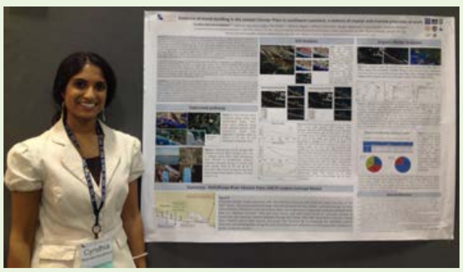
STATE OF THE COAST
PREPARING FOR A CHANGING FUTURE

State of the Coast 2012 is unique among conferences because it focuses entirely on the challenges of coastal land loss in Louisiana and its possible solutions. With 800 attendees and more than 230 presentations, this three-day meeting was held in the New Orleans Convention Center in June. Three Earth and Environmental Sciences students presented posters at the conference: Cyndhia Ramatchandirane, Jonathan Marshak, and Krista Jankowski.

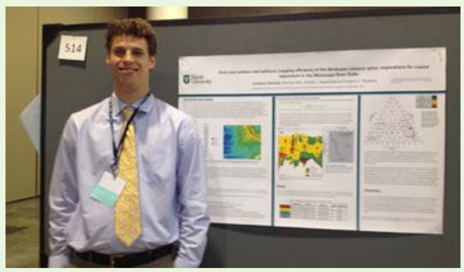
Cyndhia presented research suggesting that coastal lakes along the Chenier Plain in southwest Louisiana have infilled and converted into marshes in the last 50 years. The sedimentation processes appear to be natural, rather than diversion-induced. This natural marsh building process needs to be further investigated and incorporated into the Master Plan to restore critical habitats in southwest Louisiana.

Jonathan's project evaluated the effectiveness of vegetated swamp environments as river diversion sites by studying a natural analog for a river diversion called the Attakapas crevasse splay. Jonathan used grain size analysis of sediment samples to characterize the textural content of the splay and estimate its sediment trapping efficiency (STE). He found that the splay was much siltier than anticipated and that the Attakapas Splay environment had a STE of at least ~51%.

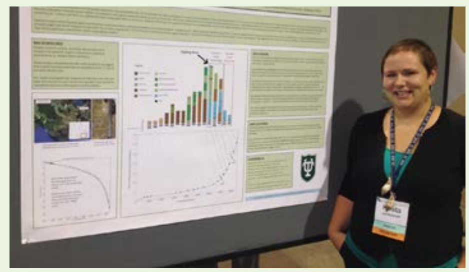
Krista is investigating the multi-decadal to century scale marsh response to varying rates of relative sea-level rise over the past 8500 years. She is using a detailed stratigraphic analysis in association with sea-level index points from the Mississippi Delta. Her preliminary results identify marsh sustainability tipping points where the rate of sea-level rise overwhelms marshes and these landscapes are turned into open water.



Cyndhia Ramatchandirane



Jonathan Marshak



Krista Jankowski

INQUIRY *continued from page 2*

program with Dr. Jeff Nunn at LSU called Louisiana Undergraduate Recruitment and Geoscience Education (LaURGE). Sponsored by Shell Foundation and the National Science Foundation, LaURGE seeks to increase the extent and quality of K-12 geoscience education in Louisiana with the hope of improving earth science literacy and recruiting undergraduate geology majors. LaURGE provides K-12 teachers with training and materials for hands-on, inquiry-based, earth and life science activities. These activities follow the learning cycle model to help students understand the fossil record, evolution, geologic time, and biogeochemical cycles. Initiated in 2007, LaURGE has helped 122 teachers and impacted between 25,000 and 38,000 students.

ABOVE: Shark Paleobiology student, Joshua Bia, answering questions from an 8th grade student in Ms. Traci Bourgeois' Earth Science class at P. F. Taylor Science & Technology Academy.

LEFT: Fall 2011 Shark Paleobiology students screening for shark teeth on a field trip to Point A Dam in Andalusia, AL.

EARTHSCAPES *continued from page 4*

tectonic, and land-surface changes on Earth. These deposits also contain important energy and water reserves and will serve as hosts for carbon capture and storage. In order to manage these resources and understand sedimentary deposits, we need improved methods for interpreting and predicting stratigraphic patterns. Yinan's work focused on determining the timescales of the longest internally generated (autogenic) dynamics in sedimentary systems and their stratigraphy signatures.

Future

With the completion of major construction of the new Sediment Dynamics Laboratory, we are looking forward to many years of experimentation to come. In the next few years we will be focusing on the construction of shelf-edge deltas and their linkages to continental slope systems and on quantifying the importance of sediment cohesion to the construction of deltaic stratigraphy. The lab is generally open during week days and we invite all alumni interested to stop by and witness geology in action in 100 Blessey Hall.

2012 DEPARTMENT GRADUATES

Ph.D. Earth and Environmental Sciences: Bryan Grace

M.S. Earth and Environmental Sciences: Glenn Fischer, Kelly Williams, Yinan Yang

M.S. 4+1 Environmental Science: Tyler Brown

B.S. Geology: Michael Fuchs, Holly Jeffries, Adam Laurie, Jonathan Marshak, Chris Ward

B.S. Environmental Science: Emily Cardarelli

EES HOMECOMING ALUMNI PARTY: Friday, November 2, 2012 • 6:00 to 9:00 pm • Blessey Courtyard
LET US KNOW WHAT YOU'RE UP TO: Click on this link to fill out the Alumni Update Form.

SUPPORT TULANE EARTH AND ENVIRONMENTAL SCIENCES

Please print, fill out, and include the donation form with your contribution. It will insure (1) the department's receipt of your gift; and (2) your acknowledgment by the University for tax purposes. After the department receives your donation and donation form, checks are sent to the Development Office of the University. The form will aid the Department in its accounting.

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Thank you in advance for your generosity and continued support of Tulane EES!