Statement of Research and Teaching Interests

Speleology is the scientific study of karst systems and related processes. My ambition is to use speleology, hydrogeophysics, hydrogeology and other branches of geosciences to better understand karst systems. I will do this by building an externally funded and internationally recognized collaborative research group which integrates graduate and undergraduate students in innovative research projects. Karst research has tremendous potential to benefit societies around the world; especially with regards to protecting clean water supplies and understanding the hazards and problems associated with disturbance of fragile karst landscapes. I will compliment my research goals by developing unique and relevant karst-oriented courses that teach geoscientists the importance of understanding how karst systems function and how we depend on them in our world.

Research experience

Dissertation research

By applying hydrogeophysics, soil science, and numerical modeling to the problem of characterizing the vadose hydrogeology of soil-mantled sinkholes, my Ph.D. research addresses the question of how infiltration and recharge processes occur in soil-mantled sinkholes. Understanding these processes is central to providing a science-based foundation on which to build useful best management practices (BMPs) for agricultural karst settings. This information is also critical to development of watershed-scale karst hydrology models which incorporate sinkholes using a realistic conceptual model.

My dissertation research is comprised of three primary objectives: 1) Use access-tube Time Domain Reflectometry (TDR) in conjunction with physical and chemical characterization of deep heterogeneous soil profiles to calibrate TDR readings (in prep for Journal of Hydrology). 2) Combine Electrical Resistivity Tomography (ERT), soil borings and monitoring wells to aid in physical characterization of the same sinkholes, and use differential ERT simultaneously with TDR moisture profiling to examine how resistivity changes through time relate to measured (with TDR) variations in soil moisture. 3) Integrate results and data from objectives (1) and (2) into a sinkhole-scale 2-D numerical model of the vadose hydrology and use the results in a GIS-based model of a small karstic agricultural watershed where infiltration and recharge rates in sinkholes can be investigated and linked to potential contaminant loading of an aquifer.

Hydrogeophysics

While a student at Radford University, I participated in research aimed at characterizing portions of Hatteras Island, N.C. using geophysics. My undergraduate advisor, Dr. William Anderson, was conducting research on the island and our field work was intended to compliment his work to understand the hydrogeology of this barrier island. My primary research objective was to perform a high resolution microgravity survey-transect across a portion of Hatteras Island, NC. This study focused on identifying small magnitude gravity changes associated with changes in local sedimentary and hydrogeologic conditions as well as larger scale changes associated with changes in deeper sediments.

Physics of karst springs

Recently initiated fieldwork and preliminary data analysis in a project designed to characterize flow patterns in an unusual ebb-and-flow karst spring in Bath County, Virginia provides a unique opportunity to study an uncommon phenomenon. Here, complex relationships exist between several distinctly different, but overlapping, periodic discharge signals and the average flow rate of this karst spring. The spring exhibits both positive and negative discharge spikes which are not associated with any documented environmental or anthropogenic influences. Potential mechanisms responsible for this behavior are being evaluated by a collaborative research group (William K. Jones, members of the Virginia Speleological Survey (VSS), and others) and could lead to development of a new model for ebb-and-flow in this hydrological setting.

Hydraulic lift tubes in caves
To estimate the magnitude of past flood events in a Virginia cave, I am combining base flow and flood stage discharge data from different locations in an active stream cave with boulder and passage morphologies in a related hydraulic lift tube and overflow route. Preliminary results indicate the existence of flood events that were several orders of magnitude larger than the maximum historical flood events: a discovery with potential for many new research opportunities. Both active and paleo hydraulic lift tubes in caves preserve records of past flow conditions in the form of residual sediments, which can be used to understand more about flow dynamics within cave systems an. These data can then be linked to passage morphologies and regional hydrologic conditions to make inferences about past climatic conditions as well as recurrence rates for catastrophic floods. This collaborative research effort includes members of the Virginia Speleological Survey and was partly funded by a research grant from the Cave Conservancy of the Virginias.

Delineating karst drainage basins
During three summers of work, first as an undergraduate research project, and later with Wil Orndorff at the Virginia Department of Conservation and Recreation, Division of Natural Heritage (DCR-DNH), Karst Program, I worked both independently and in collaboration with others to delineate many karst drainage basins and flow-paths using dye-tracing and other hydrogeologic methods in several regions of Virginia. Extensive field work contributed to a better understanding of how these drainage basins relate to the regional geology and interact hydrologically both above and below ground. Results of this work were entered into a GIS and used to develop conservation site areas designed to help protect and manage natural heritage resources (including nearly 400 significant caves) during state project review procedures. They are also being used in the ongoing development of a Virginia karst hydrology atlas. During my undergraduate studies, this research was funded through an Undergraduate Fellowship in Karst Studies from the Cave Conservancy Foundation

Speleogenesis
As an undergraduate I performed a detailed in-cave analysis of passage morphology and geologic structures observed in Doe Mountain Cave, Giles County, VA. This allowed me to construct a speleogenetic model that explains how geologic and hydrologic conditions influenced sequential passage development in this cave. This research was funded through an Undergraduate Fellowship in Karst Studies from the Cave Conservancy Foundation.

Cave mapping and exploration
I have extensive experience mapping, exploring and documenting caves and karst features in the U.S. and other countries. My passion for this work has been the motivation for pursuing a career in speleology and karst research. I intend to continue these activities and use the related skills I have developed to compliment my future research objectives.

Directions for Future Research
As indicated in the information above, I am interested in pursuing a career that is centered on karst research. A few of the topics that currently interest me are: using geology, caves, and karst hydrologic patterns to relate the evolution of subsurface drainage patterns to surface geomorphology in karst regions, develop new applications for existing geophysical tools to characterize and understand near-surface hydrogeology in both karstic and non-karstic settings, and use GIS and a mass-balance approach to estimate infiltration and recharge in karst aquifer systems from a 'bottom-up' rather than 'top-down' perspective. I am also interested in pursuing collaborative research relating to mineralogy, carbonate stratigraphy and depositional environments, tectonics, biology, low-temperature geochemistry and surface hydrology.

Linking surface and subsurface evolution in karst to hydrologic conditions
Caves and karst systems frequently preserve evidence of ancient conditions in near-perfect condition for much longer than surface environments do. While significant work has and is being done in this area, I believe much remains to be understood. Techniques such as paleomagnetic and cosmogenic dating of cave sediments have allowed the evolution of karst systems to be related to surface evolution. Analysis of

paleo flow routes and hydrologic conditions in caves also contributes to a better understanding of surface conditions in the past. There are many areas where using these tools together can make significant contributions toward understanding geomorphic processes and rates of surface and subsurface evolution. I am a co-manager of the Powell Mountain Karst Preserve (owned by the Cave Conservancy of the Virginias), which contains the 23-mile long Omega Cave System and other caves. After 10 years of exploration and study in these caves, we are just now beginning to understand how the karst system has evolved and been influenced by surface processes. I will continue working with this group of scientists and cavers to learn more about these relationships. I am currently working with Dr. Ira Sasowski to develop a project involving dating and other work with ancient stream sediments deposited in paleo-levels of several Virginia caves. The objective is to better understand regional and local evolution of the Appalachians over time.

Vadose hydrogeophysics
During my dissertation research I have become very interested in using geophysical tools to model and understand infiltration processes in the vadose zone. Hydrogeophysical methods are attracting more attention recently and there are many promising directions for research and development of new applications to both vadose and saturated hydrology. During my dissertation work, I have developed ideas for more efficient design and deployment of the ERT and TDR tools I am currently using. I see many opportunities for applying hydrogeophysical techniques to understanding unsaturated hydrology.

Aquifer-scale ET and recharge estimation
Much research has been done to estimate and measure rates of infiltration, ET, and the resulting recharge to aquifer systems in a variety of geologic and climatic settings. Many of these studies have been done at a very small or site-specific scale. I have been intrigued by the problem of modeling or measuring these parameters in the Edwards Aquifer in Texas. I plan to collaborate with Geary Schindel and others at the Edwards Aquifer Authority in taking a different approach to quantifying these parameters. Modern technology, combined with an enormous and comprehensive data-set available for this aquifer, provides a unique opportunity to take a GIS-oriented `bottom-up' approach to understanding infiltration and ET, rather than the traditional `top-down' approach.

International interests
I also have research interests related to speleology and geomorphology in China, Mexico and the Dominican Republic. I have visited Mexico and the Dominican Republic and intend to pursue multi-disciplinary research in both countries involving hydrogeology, speleology, geomorphology and biology. I have not yet visited China, though Dr. Chris Groves at Western Kentucky University and I have some common interests and have discussed future collaboration possibilities. China, in particular, presents many opportunities for research of great societal and scientific importance. I plan to aggressively pursue my research objectives in these areas.

Potential funding sources
Funding sources that I anticipate will support my research include: karst-oriented foundations and organizations (especially for student support and smaller research projects), Edwards Aquifer Authority, NSF, NSF-REU, EPA, USDA and other federal and state agencies. I have significant experience writing funding proposals for my own research and have also taken important roles in writing proposals for several large USDA grants. My success in obtaining funding for my Ph.D. research, as well as unrelated external projects, attests to my potential in this. I have also written two proposals for the EPA STAR Fellowship program which, while unsuccessful, provided me with valuable proposal-writing experience. I believe that a successful research program supporting graduate students requires a successful funding program. I intend to pursue collaborative interdisciplinary research objectives, recognizing that these projects are more likely to receive funding from many sources.

Teaching and Advising Interests
The most stimulating and rewarding learning environments are those that create a careful balance between lectures and hands-on learning by integrating active research projects into class materials, lab exercises and field trips. When linked with student mentoring and advising, this environment ensures that

students develop scientific inquiry, test hypotheses and perform critical reviews of primary scientific literature while developing oral and written communication skills – all of which are essential to any geoscience career. I also believe that providing undergraduate students with opportunities to play important roles in research projects should be a significant part of their education and preparation as geoscientists.

Aside from exposure to a very demanding academic research environment, one of the most important parts of my education has been my interaction with exceptional advisors at both undergraduate and graduate levels. Advising and mentoring students as they work toward their goals, and encouraging them to work toward new and difficult objectives, are truly rewarding experiences for everyone involved. I believe that advising and taking an interest in students' goals are nearly as important as teaching. Undergraduate students who worked for me as lab assistants, and graduate and undergraduate students who assisted me in the field, have challenged me to enthusiastically articulate my research objectives and accomplish my goals. Evaluating my interactions with them allows me to develop my skills as an advisor and supervisor. Advising and supervising students during my career as both researcher and teacher will let me build on these early experiences and become a better geoscience educator.

Because I learn subjects more thoroughly when I present them to others, I feel strongly that in graduate-level (and smaller undergraduate-level) classes, in-class presentations and discussion by students are excellent tools for both student and teacher to learn and approach topics from different perspectives. I also have a strong preference for written assignments, which creates an opportunity for students to not only demonstrate subject knowledge, but also develop good written communication skills. In classes requiring a hands-on lab section, I will expect students to turn in written reports detailing items such as methods and tools used, data collected, analysis techniques, and results. Not only are these excellent learning tools, but they also allow students to document their work in a format that will be understandable if they need to reference it in the future.

Presenting my research ideas and results at professional conferences has been an integral part of my academic direction and has led to collaborations and contacts that will be important throughout my career. I intend to encourage and support students who work with me to attend conferences and present the results of their research, anticipating that they, too, will benefit greatly from these opportunities.

Some undergraduate courses that I am qualified to teach include Groundwater Hydrology, Physical Geology and Environmental Geology. Advanced topics I anticipate developing and teaching as graduate and/or undergraduate classes, or seminar courses include; Karst Hydrology, Karst Geology, GIS in Karst Settings, Hydrogeophysics, and Speleology as an Interdisciplinary Science.

I look forward to developing a robust and interdisciplinary research program that includes students at all levels and produces graduates who are not only knowledgeable but, more importantly, have a foundation of research-related experience and education on which to base future work and learning.