GRAD STUDENT HANDBOOK

MASTER OF SCIENCE IN HYDROGEOLOGY

DEPARTMENT OF ENVIRONMENTAL ENGINEERING AND EARTH SCIENCES

COLLEGE OF ENGINEERING AND SCIENCE

CLEMSON UNIVERSITY

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INTRODUCTION

Welcome to the Master of Science in Hydrogeology program at Clemson University! We, the faculty and staff of the Department of Environmental Engineering and Earth Sciences, are glad that you have chosen to pursue your graduate studies here, and we look forward to getting to know you better over the next couple of years.

This handbook is designed to introduce you to our program. We hope that the information it contains will assist you in your graduate work by providing answers to your questions, or at least by pointing out whom to seek to find the answers. Among the topics covered in this handbook are the degree requirements; graduate course descriptions; academic policies; faculty and their research interests; financial aid information, including duties/responsibilities of graduate teaching and research assistants; and facilities and equipment.

The organization of the MS program in Hydrogeology is an interdisciplinary program and, as such, draws on the expertise not only of faculty in Geological Sciences, but also of faculty in related disciplines, most notably Environmental Engineering and Environmental Science. Faculty, staff, and students in these disciplines form the Department of Environmental Engineering and Earth Sciences. A complete listing of Geological Sciences faculty (along with associated staff) is given in Appendix A.

The faculty are actively involved in a variety of research projects (refer to Appendix B for descriptions of the research of individual faculty). Major research funding comes from the South Carolina Universities Research and Education Foundation (SCUREF), the U.S. Environmental Protection Agency (EPA), the U.S. Department of Energy (USDOE), and the National Science Foundation (NSF).

DEGREE REQUIREMENTS

The Master of Science degree in Hydrogeology requires 24 semester credit hours of course work and six semester credit hours of thesis research. Candidates must write a thesis based on original research and defend it at an oral examination. For students on leave from industry, a special non-thesis option is available, which requires 30 semester credit hours of course work and the passing of a comprehensive written examination.

All students must take a field course (GEOL 875 is recommended) and a modeling course (GEOL 808 is recommended). They must also take a minimum of three additional 800-level geology courses, to be selected from the following:

GEOL 801	Field Geophysical Techniques
GEOL 803	Geostatistics
GEOL 805	Advanced Stratigraphy
GEOL 806	Aquifer Characterization
GEOL 809	Subsurface Remediation Modeling
GEOL 810	Analytical Methods for Hydrogeology
GEOL 811	Rock Physics
GEOL 813	Environmental Geochemistry
GEOL 814	Environmental Sedimentology
GEOL 816	Aquifer Systems
GEOL 818	Hydrogeology of Fractured Aquifers

All full-time students in the Hydrogeology graduate program must register for GEOL 851 every fall and spring semester, and regular attendance at the weekly seminar is required. Only one credit for GEOL 851 counts toward the requirements for the Master's degree.

For those students who enter the Master's program lacking a baccalaureate degree in the geosciences, deficiencies in their geological education need to be made up during the first year. This should include coursework in structural geology, mineralogy or petrology, sedimentation or stratigraphy, and hydrogeology. Students entering this program should also have a strong mathematics background. Two semesters of calculus are required; a third semester of calculus and a course in differential equations are recommended. Students lacking the two required semesters of calculus will be required to take calculus through MTHSC 108 (Calculus of One Variable II). GEOL 615 (Analysis of Geological Processes) is recommended for students who have not had a third semester of calculus or differential equations.

The expectation is that full-time students should complete all degree requirements within two years. Candidates with one or more academic deficiencies may require one or two additional semesters. A checklist of required actions, including a suggested timetable for their completion, is provided on the following page. More specific details are given in the section entitled "Academic Policies and Procedures". Deadlines for submitting official forms (GS2, GS4, etc.) to the Graduate School are published by that office for each of the three annual graduations (May, August and December). Check the Graduate School web pages for the latest information about forms and deadlines.

CHECKLIST FOR MASTER'S STUDENTS

	What	When	How/Who	Date
1	Selection of Research Advisor	Beginning of 2nd semester	Notify Graduate Coordinator of choice	
2	Appointment of advisory committee	Before 5th week of 2nd semester	In consultation with research advisor	
3	Preparation of study program	Before 7th week of 2nd semester	In consultation with research advisor	
4	Filing of study plan	*Before pre-registration for 3rd semester	GS Form 2	
5	Approval of thesis project	Before end of 2nd semester	Signed thesis proposal submitted to graduate student file	
6	Fundamentals of	Before 5th week of fall	Administered and evaluated by	
	Hydrogeology Skills Assessment	semester of second year	faculty	
7	Admission to candidacy for degree and diploma application	*Before beginning of 4th week of semester during which degree is expected	GS Form 4	
8	Submittal of thesis to advisory committee	Draft at least 3 weeks before date of final examination	By student	
9	Notification of Graduate School of time and place of final examination	At least 10 days prior to final examination	Advisor schedules exam; student notifies Graduate School	
10	Final examination (oral)	*At least 3 weeks prior to date on which degree is expected	GS Form 7 to be filed by research advisor after examination is completed	
11	Filing of thesis format review form	*At least two weeks prior to date on which degree is expected	GS Form 32 signed by research advisor and submitted by the student with a check copy of the thesis to the Graduate School	
12	Submittal of approved thesis to Graduate School	*At least two weeks prior to date on which degree is expected	By student	
13	Cap and gown rental	*Early during semester during which degree is to be conferred	By student	
14	Final Checkout	At least one week prior to graduation	Obtain all required signatures on checkout form, which can be obtained from Cindy Gravely	

*The guidelines above are subject to change, see Graduate School schedule for last possible dates. It is the student's responsibility to be aware of and to meet the Graduate School deadlines.

ACADEMIC POLICIES AND PROCEDURES

Admissions

Applicants to the graduate program may apply by submitting the normal paper application to the Graduate School or by submitting an electronic application on the World Wide Web www.grad.clemson.edu. Applicants may check the status of their application at this same Internet address.

Deadlines for submitting applications follow those specified in the current edition of the Graduate School Announcements, which contains additional information regarding application and admission. Currently, the deadline for receipt of applications from United States citizens and residents is no later than five weeks prior to registration. For international students, applications should be completed by April 15 and September 15 for the fall and spring semesters, respectively. All required items, including the completed application, fee, transcripts, recommendation letters, and test scores, must be on file in the Graduate School office by the deadlines.

To be considered for financial assistance beginning in the fall semester, completed applications should be received by February 15. Applications received after that date may be considered for financial assistance depending upon availability of funds.

Minimum requirements to be considered for graduate study in Hydrogeology generally follow those of the Graduate School (see Announcements). Minimum requirements include at least a four-year bachelor's degree from an institution whose scholastic rating is satisfactory to the University, high quality of previous academic record, and satisfactory scores on the general portion of the Graduate Record Exam (GRE). The GRE subject test in geology is neither required nor recommended for admission.

International students whose native tongue is not English are required to submit a satisfactory score on the Test of English as a Foreign Language (TOEFL). International students who are applying for a graduate assistantship are encouraged to submit scores from the Test of Written English (TWE), which is administered simultaneously with the TOEFL at most locations.

Admission to the Hydrogeology program is restricted to applicants whose academic record indicates a high potential to be successful in graduate studies. This determination is made by the faculty of the Department of Environmental Engineering and Earth Sciences and is affirmed by the Graduate School. The various indicators used to arrive at this determination may include (but are not limited to): previous academic performance, letters of recommendation, standardized test scores, personal interviews, and statements of interest. In reviewing transcripts, both the difficulty of the courses taken and the grade point ratio are considered.

The admission policies and criteria are periodically reviewed by the Department faculty. This review normally takes place once each year.

Registration

Prior to registering for the first semester of study, beginning graduate students should meet with the Graduate Program Coordinator, who will help them plan their initial program of study and select suitable courses to take. The actual registration may be done on-line via Tiger Web (tigerweb.clemson.edu) or by telephone using TigerLine (864-656-8447). See the section on Registration under "General University Information" for some additional information. In addition to registering, fees must be paid, or arrangements for payment made, by deadlines established by the university.

> NOTE: Graduate assistants must be enrolled in a minimum of 9 credit hours per semester (three hours is required during both summer sessions).

Research Advisor/Advisory Committee

Selection of a research advisor is one of the most important decisions facing a graduate student. This should be done as early as possible preferably no later than the beginning of the second semester of graduate school. Even candidates with significant deficiencies should choose a research advisor before the end of their second semester. Students are encouraged to approach faculty during their first semester to explore mutual research interests and discuss the possibility of doing a Master's thesis under their guidance. As an initial step, read carefully the faculty research profiles in Appendix B to get an idea of the sorts of research projects being conducted by different faculty members. Then seek out the faculty whose research interests seem most in line with yours.

Once chosen, the research advisor will help select the student's advisory committee. The advisory committee must consist of a minimum of three members who hold professorial appointments at Clemson University. A majority of the committee members must hold appointments in the Department. The chairman is the research advisor, and is required to hold a professorial appointment in the Department. Part-time, visiting and other non-tenure-track faculty employed by Clemson University may serve on the advisory committee. Persons not employed by Clemson may serve if they have been appointed to adjunct faculty status.

The advising policy and the curriculum are reviewed periodically by the Department faculty. This review normally takes place once every two years or when the Graduate Handbook is revised.

GS2 Form

This form outlines the planned graduate degree curriculum of the student and should be filed according to the timetable given on page 3. The GS2 Form serves to appoint the student's advisory committee and to notify the Graduate School of all classes the student will take to fulfill his/her degree requirements. The GS2, and the other required forms may be obtained from the Graduate School office in E-106 Martin Hall or from the Graduate School's web site www.grad.clemson.edu. The

form should be completed as soon as the student talks with his/her research advisor and determines a course of study. Undergraduate deficiencies (if any) should be listed at the designated place. The GS2 must be signed by all members of the advisory committee. It is then submitted to the department chair and to the college dean for approval before being forwarded to the Graduate School for final approval and distribution. It is important to note that any class listed on the GS2 must be completed before graduation. Therefore, any change in the course of study will necessitate submission of a revised GS2 Form.

Thesis Proposal

In concert with the advice and consent of his/her research advisor, each Master's student is responsible for developing a thesis research topic. Upon selection of a suitable topic, the student will prepare a brief, written proposal describing the objectives, methodology and significance of the research project. This proposal must be distributed to the advisory committee for formal approval. Subsequent changes in scope or methodology that significantly deviate from the original proposal should be presented to, and approved by, all committee members.

GS4 Form

No later than three weeks after the beginning of the final semester (or first summer session) prior to graduation, an application for graduation and diploma order for a graduate degree (Form GS4) must be submitted to the Graduate School. This form notifies the Graduate School of the date the student plans to graduate. The GS4 must be signed by the candidate's research advisor. A substantial late fee will be assessed if the form is submitted after the deadline specified by the Graduate School; this fee is increased daily (excluding Saturday, Sunday, or University holidays).

Final Oral Examination

The final oral examination must be given at least three weeks before the date on which the degree is to be conferred. The research advisor will schedule the examination, which is administered by the advisory committee. The Graduate School must be notified of the time and place of the examination at least 10 days prior to the scheduled date. (NOTE: students must be officially enrolled in at least one credit hour at the time of the final examination.) During the examination the candidate will be expected to orally present the findings of his/her research, support various aspects thereof, and answer questions about the research performed or pertaining to related coursework. Members of the faculty and Hydrogeology graduate students are invited to attend the examination. Procedurally, the examination consists of a 30-to 45-minute presentation by the candidate, followed by questions posed first by non-members of the advisory committee and then by the members of the student's advisory committee.

Within three days after the final oral examination, the advisory committee, through Form GS7, will notify the Graduate School of the results of the examination. Unsatisfactory performance on the final examination, as determined by the advisory committee, will result in one or both of the following actions to be taken: (1) additional work on the thesis and its resubmission to the advisory committee for

further review or (2) additional coursework or other study. In the case of failure, the advisory committee will make a recommendation to the Graduate School relative to a second final examination. Failure of a second examination will result in the candidate being declared ineligible for a Master of Science degree in Hydrogeology at Clemson University and his/her dismissal from the Graduate School.

GUIDELINES FOR PUBLICATIONS IN THESES AND DISSERTATIONS

Department theses and dissertations must meet all Graduate School requirements. Detailed information, including "The Guide: Manuscript Preparation and Graduation Clearance," is available at www.grad.clemson.edu/manuscript.php. In addition to Graduate School regulations, the Department has established the following requirements for the incorporation of material in publication or journal styles and formats in Hydrogeology theses and dissertations. Herein, such material is referred to as paper or papers.

- Theses or dissertations may include one or more separate papers that have been or are being prepared for publication. Each paper included should appear as a single chapter within the document. Journal format is acceptable to the extent that it is not in conflict with Graduate School guidelines. For example, the format of each chapter, including citation style, figures, tables and headings must be consistent throughout the thesis or dissertation.

- Multiple author papers can be included in a thesis or dissertation, however, the student submitting the thesis or dissertation must be the first and primary author on each paper that is part of the document. Exceptions to this requirement should be rare and must be approved by the student's advisory committee. Otherwise, that paper should not be included in the thesis or dissertation, and may be replaced by a chapter that is written by the M.S. or Ph.D. candidate. (Note that this means implicitly that the same paper can not appear in more than one student thesis or dissertation, since there is only one first and primary author on any given paper.)

In addition to these main requirements, additional requirements are:

- Each thesis or dissertation should contain a comprehensive "introduction and objectives" that are separate from the shorter and more focused introduction section(s) and objective statement(s) found in the paper chapter(s). The introduction and objectives themselves may be separate chapters or combined into a single chapter.

- If not described completely within the papers, the methods utilized in the research must further be described using chapters, appendices, or electronic media. Results and raw data used in the thesis or dissertation must be treated in the same manner.

- Contributions of co-workers must be clearly cited or footnoted in the thesis or dissertation, beyond what may be given in each of the papers. The citation style must be consistent with the overall document style.

- A separate "closure chapter" must be written that relates back to the separate introduction and objectives and incorporates the results and overall conclusions of the individual papers. This chapter should include a broad, perceptive and integrative evaluation of the work, along with avenues for future research.

Preparation of Master's Thesis

Sufficient time must be allotted for writing the Master's thesis. It cannot be overstated that the writing of a thesis is a major undertaking; plan on several months of intensive effort. Start writing as soon as possible. For example, the introduction and background (literature search) can be written shortly after approval of your research proposal. Writing of the results and discussion should be initiated as soon as the research is completed.

The Master's thesis must be prepared in a style acceptable to the Graduate School. A *Guide for Preparing Theses and Dissertations* may be purchased at the University Bookstore or accessed through the Graduate School web site. This guide provides rules for, and examples of, proper formatting of pages, tables, and figures. You may also want to look at Master's theses completed by previous Hydrogeology students; copies are kept in the Conference Room.

Two options are available for thesis format: a standard (traditional) format and a journal format. The journal format involves preparation of the thesis in two major parts, with each part suitable for submittal to a journal for publication. The thesis format is to be decided in consultation with your research advisor, and must follow Graduate School guidelines.

A draft copy of the thesis should be given to each member of the advisory committee for initial review well in advance of, and not less than three weeks prior to, the final oral examination. The committee members should complete the initial review prior to the examination. After the examination, any additional comments or corrections that must be made to the thesis will be provided by the advisory committee. After the corrections are made, the candidate must obtain the committee members' signatures (in black ink) on the approval page. It should be understood that a vote to pass a student on his/her performance at the final oral examination (Form GS7) does not imply final approval of the thesis. Approval of the thesis is given by faculty signing the approval page.

Following approval by the advisory committee and a format check by your advisor, the Graduate School will determine if the thesis meets their format requirements. If the thesis is not acceptable, then the student must make the requested corrections and schedule another review. The Graduate School deadline for approval must be met in order to graduate on time.

Upon approval by the Graduate School, the thesis is ready for duplication. A minimum of four hardbound copies of the thesis must be made -one for the library, one for the Graduate School, one for the Department, and one for the student's research advisor. A hardbound or softbound copy of the thesis is to be provided to each advisory committee member; it is courteous to offer each member the opportunity to obtain a hardbound copy. Additional copies (hardbound and/or softbound) may be made for the student's personal use. Once a student determines the number of copies needed, he/she should schedule an appointment with Printing Services (656-2041). At the appointment the student will need to pay the duplication fees and describe any special services required (off-set printing, photos, etc.). A binding fee for the hardbound copies must be paid at the Bursar's Office (located in Sikes Hall). Duplication usually takes no longer than one week. The duplicated copies of the thesis, along with the payment receipt for binding, should then be submitted to the Graduate School. This should be done at least one week before the graduation date (failure to meet this deadline will delay the student's graduation). Binding usually takes 4-6 weeks, at which time the hardbound copies will be distributed to the respective parties.

Final Checkout

Before graduation, students must complete the graduate student check out process. Obtain the check out form from Cindy Gravely and make sure that all required actions are taken care of and signed off on by the appropriate personnel. Note that all students are required to schedule an exit interview with the Department Chair.

Academic Integrity

A commitment to truthfulness, honor, and responsibility by every member of the Clemson community is fundamental to the University's vision of academic integrity. It is expected that students, faculty, and staff work together with mutual respect and concern for one another.

All graduate students are expected to be familiar with the University's policies on academic dishonesty and academic integrity. These policies are explained in the Graduate School Announcements.

HYDROGEOLOGY SUMMER FIELD CAMP

General Information

Hydrogeology Summer Field Camp (GEOL 875 and GEOL 475 – 6 credit hours) is taught during the first summer session, roughly from May 20 through June 25. It is open to students from other universities, as well as to working professionals. GEOL 875 is a graduate level class that is taught in conjunction with GEOL 475, which undergraduates may take to satisfy their summer geology field course requirement. Many of the projects involve collaborating with others in a group setting. This is necessary because some of the methods, like surveying, cannot be done individually. Also, it is often helpful to work with others while learning a new technique. Graduate students are required to write several reports during field

camp in addition to the assignments given to the undergraduate students.

The camp is designed to give the student a working knowledge of the methods and concepts of field hydrogeology, and to provide the opportunity to use those methods in several hydrogeologic settings. Additionally, the students are introduced to practicing hydrogeologists and scientists in related fields. The course begins with a review of principles and methods in the classroom, and then moves to practicing those methods doing field exercises local to Clemson. Topics include spatial mapping, well drilling, water quality and sampling, well testing, soil properties, air flow through the vadose zone, hydraulic fracturing, and near-surface geophysical methods. There are two field trips that visit different hydrogeologic settings: one to the Mammoth Cave area in Kentucky and to Oak Ridge, TN, and the other to Aiken, SC and then to the Carolina coast.

Further information can be obtained from the course instructor, Dr. Larry Murdoch. See the instructor for a list of suggested equipment prior to the field course. Additional details can be found at the website www.ces.clemson.edu/hydro.

Registration and Fees
Registration for the Hydrogeology Summer Field Camp can be made on-line during the spring pre-registration period. Tuition for the class is based on 6 credit hours though graduate assistants pay a reduced tuition. Tuition must be paid by the deadline established for first summer session to avoid cancellation from the course. A late registration fee will be imposed to reenroll. For further information see the Graduate School's web site www.grad.clemson.edu.

Field Trip Accommodations
Combined, the field trips are about 2 weeks. Lodging is at the Mammoth Cave lodge or inexpensive motels (roughly $40-50 per night for each room split among the students, usually 2 to 4 per room). Meals are typical of road food (fast food or self-packed meals) and costs vary by individual.

FINANCIAL AID AND ASSISTANTSHIPS

The most common type of financial aid is a graduate assistantship. Usually, graduate assistantships require half-time employment, in which the recipient works 20 hours per week. Two different sources of funding are utilized: state monies, budgeted through the College of Engineering and Science, support graduate teaching assistants (TA's), and research contract monies, procured by the faculty and staff, support graduate research assistants (RA's). Selection of assistantship recipients is made by the graduate faculty based on many factors, including undergraduate GPR, GRE scores, recommendations, science and math background, and (for international students being considered for teaching assistantships) English language proficiency. Offers to new students are usually made in March-April for fall matriculation. Outstanding applicants may be nominated for a University fellowship, which may be used to augment the assistantship amount.

Payroll and Pay Checks

To be put on the payroll, new graduate assistants must report to Cindy Gravely (340 Brackett Hall) and complete the following forms: Personal Data Sheet, W-4 tax form and I-9 form. Students will need to provide their driver's license and original social security card. All forms should be completed and turned in at least four weeks before the beginning of the semester to ensure that the first pay check is received on time. To expedite the process, the necessary documents are mailed to new graduate assistants for completion. It is important that copies of the student's driver's license and social security card are made and notarized as "Being a true copy of the original" by a notary public.

International students need to see Mack Howard in E-302 Martin Hall to complete the required international forms and apply for a social security card (if not done previously). Then they should see Cindy Gravely for the above-mentioned documents. They should also bring their visa, passport and I-94 form.

Graduate teaching assistants are paid on an academic year basis (9 months) or on a twelvemonth basis. Research assistants are typically paid on a twelve-month basis, with pay rate, hire date and termination determined by the principal investigator (PI) of the grant through which they are paid. In either case, pay is made biweekly.

Research Assistant Responsibilities

The responsibilities of RA's vary according to the specific grant project(s) from which they are being paid, and are established at the discretion of the principal investigator. The work performed by an RA does not necessarily correlate with their MS thesis research.

Teaching Assistant Responsibilities

Teaching assistants play an important role in the department by teaching the laboratories that parallel the introductory courses in geology and physical science, serving between 500 and 600 students per semester. In general, TA's are required to work approximately 20 hours per week ("half time"). Specific TA duties and time requirements are described below.

Teaching

The primary duty for a half-time TA is to teach three laboratory sections per week. Different types of labs vary in length and in the number of meetings per week. But, in general, TA's will spend between six and eight hours each week in the classroom. The TA is the instructor of these labs. Therefore, the normal responsibilities and rewards of teaching come with the job. Each year an award is presented to the most outstanding graduate teaching assistant in the department; the recipient is chosen by the faculty based on nominations received from students and faculty involved in teaching introductory courses.

Lab Preparation and Clean-Up

Teaching assistants must prepare for each lab session in two ways. First, they must work through the material ahead of time to develop their lesson plans. This should be done in conjunction with their Lab Supervisor. Weekly meetings

with the Lab Supervisor are held to keep labs on track and in step with other similar lab sections. Our goal is to give students a consistent experience no matter which lab TA they have. Second, materials and equipment must be set up for lab and put away afterwards, and the lab room must also be cleaned after each lab session. The TA's will spend between two and four hours per week with this preparation and clean-up.

Grading, Test Preparation, and Record Keeping

TA's grade all assignments, large and small, given in their labs. Some grading will be required almost every week. More significant grading will occur after major tests. In general, TA's create their own quizzes and homework assignments; major tests will be created cooperatively by all TA's with the guidance of the Lab Supervisor. Accurate and up-to-date records of grades and attendance must be kept by the TA's in a location and format determined by the Lab Supervisor. Time required for these duties varies greatly throughout the semester; a broad range is probably between one and six hours per week.

Office Hours

TA's must hold one office hour for each lab session taught (typically this amounts to three office hours per week). These hours are held in the Department's Learning Resource Center (LRC) in 427 Brackett, so as to staff this room throughout the week. This room is dedicated to undergraduate instruction. And, while each TA's office hours are primarily for the benefit of his or her own students, the TA is also responsible for helping, insofar as possible, all students who come to the LRC. This duty requires an additional up-front investment of time by TA’s to familiarize themselves with the resources in the LRC.

Other Required Assistance

From time to time TA's or lecture instructors with will be asked to assist other TA's with activities such as field trips and proctoring examinations. Additionally, because of planned or unplanned absences, a TA may occasionally have to take another TA’s labs or office hours. It is the responsibility of the TA to make coverage arrangements with the approval of the Lab Supervisor. These cases are not common and rarely exceed one to two hours per week.

In addition to these weekly duties, new TA's are required to attend university TA training before the semester begins. This normally lasts several days. The Department also holds a required one-day training session during the first week of the fall semester.

Sources of Research Support

The organizations listed below provide grants to assist with the expenses of thesis research. Students apply directly to the organizations to compete for these awards. The application typically includes a form, abstract of the proposed research, and faculty recommendation letters. Contact the organizations well in advance to obtain application materials and to check on current deadlines. Deadlines may change from year to year.

Geological Society of America (GSA)
GSA awards approximately $350,000 each year to support student research covering a wide range of topics within the earth sciences. The average award amount is approximately $1,600. The deadline for application is usually February 1. Applications are available from Research Grants Administrator, Geological Society of America, P.O. Box 9140, Boulder, CO 80301; or visit the GSA web site at www.geosociety.org.

The Southeastern Section of GSA provides grants to students who are GSA members enrolled in universities in the southeastern U.S. The following types of grants are available from the SE Section: research grants, travel grants for students presenting at the SE section meeting, and travel grants for students presenting at the national GSA meeting. Contact Dr. Harry Stowell, University of Alabama, for information: 205-348-5098 or hstowell@wgs.geo.ua.edu. See www.geo.ua.edu/segsa/segsa.html for more information. GSA also maintains an ongoing list of grant opportunities from sources outside of GSA. This list can be found at: www.geosociety.org/science/grantopps.htm.

American Association of Petroleum Geologists (AAPG)
AAPG supports graduate student research having application to the search for and development of energy resources and to environmental geology issues. AAPG awards approximately $150,000 per year to graduate students for support of their research. The average amount awarded is about $1,200 per student. The deadline is usually near January 15, but check with AAPG for the exact date. Applications are available from AAPG, P.O. Box 979, Tulsa, OK 74101-0979 or call 918-560-2664. AAPG's web site is www.aapg.org.

SEPM -Society for Sedimentary Geology
SEPM annually solicits applications from graduate students seeking financial support for thesis research in the area of sedimentary geology. Awards are in the range from $500 to $1,000. The deadline is usually in January. Contact SEPM at 800-865-9765 or check www.sepm.org for information.

Sigma Xi
Sigma Xi, The Scientific Research Society, administers a Grants-in-Aid of Research program to support scientific investigation in any field. Awards are made in amounts up to a maximum of $1,000. Average size of awards is $600. Closing dates for receipt of applications and supporting letters are March 15 and October 15. Applications may be submitted online. For more information call 800-243-6534 or 919-549-4691, send email to giar@sigmaxi.org, or visit the Sigma Xi web site, www.sigmaxi.org.

Internships
Another opportunity for financial assistance that is often available is an internship. The U.S. Geological Survey and the U.S. Department of Energy are two examples of organizations that commonly sponsor internships. Internship announcements are posted on the board in the back of 322 Brackett.

PROFESSIONAL DEVELOPMENT

There are a number of opportunities for graduate students to develop professionally in addition to their course work and their thesis research. These include presenting talks and/or posters at regional and national scientific meetings, becoming student members of professional organizations, and participating in organized field trips such as the annual Carolina Geological Society Field Trip. All students are expected to attend the annual Snipes Hydrogeology Symposium hosted by Clemson University, and are encouraged to make at least one oral/poster presentation at an appropriate technical meeting (example: Geological Society of America Southeastern section meeting) during their graduate career. Participation in the annual Carolina Geological Society Field Trip is strongly encouraged.

David S. Snipes/Clemson Hydrogeology Symposium

The David S. Snipes/Clemson Hydrogeology Symposium is a day-long conference held annually at the Madren Center on the Clemson University campus, usually in early April. The purpose of the Symposium is to provide a forum for faculty and students to present the results of their current research and to engage speakers from government agencies and private industry to make presentations about pertinent topics. The presentations cover a multitude of subjects from traditional geology to experimental remediation techniques, including subsurface geology and hydrogeology, geochemistry, site characterization, groundwater modeling, and geophysical well logging. The Symposium is an excellent way to highlight Clemson's hydrogeology program and, at the same time, to educate groundwater professionals and state regulators. As a benefit to registered professional geologists, the Hydrogeology Symposium can be used to satisfy up to eight continuing education hours for re-certification.

The first Clemson University Hydrogeology Symposium was organized by Dr. Dave Snipes in 1992, and had approximately 50 attendees. Each year the Symposium has grown in size to a point now that many of the state's groundwater professionals (as well as professionals from around the southeast) look forward to attending it. In 2001, the symposium was named the "David S. Snipes/Clemson Hydrogeology Symposium" in honor of Dr. Snipes.

Carolina Geological Society Field Trip

Every year in the fall the Carolina Geological Society (CGS) organizes a two-day field trip to a geologically important area in the Carolinas or nearby in an adjoining state. The field trip is led by experts who are familiar with the local geology and is usually attended by several hundred persons, including large contingents of students from various universities and colleges. It provides an excellent opportunity to not only learn some fascinating geology, but also to meet and mix with professors and students from other universities and with working professionals.

Notice of the CGS field trip is usually made about two months before the scheduled event and will be announced in the weekly seminar and posted in the department. (Information can also be obtained on the web at www.geo.duke.edu/cgsinfo.htm.) Copies of the preregistration form will be made available to all graduate students. The department and/or Clemson Geology Club normally reserve several vans to

travel to the field trip meeting site. In addition, the department/club will pay for the cost of student registration, lodging, and bus/lunch expense of the actual field trip (all participants travel on chartered buses). Departure from Clemson is usually early Friday afternoon so as to permit attendance at the Friday evening welcoming party (this event affords unparalleled opportunities to be introduced to working geologists and hydrogeologists, many of whom are former Clemson alumni). Saturday is an all-day excursion, and Sunday is half-day, normally ending before 1 PM.

Clemson Geology Club

The Clemson Geology Club is a student organization whose purpose is "to provide an opportunity for student participation in the field of geology and to promote a greater interest in the study of geology through academic and social activities". The Geology Club elects new officers every year and also has a faculty advisor. Graduate students are encouraged to consider joining the Geology Club. To become a member simply requires payment of the dues, which are minimal. The Geology Club holds meetings in 322 Brackett approximately every three weeks (time and day of week determined at the beginning of each semester in consideration of scheduled classes and labs). Guest speakers, summer field camp experiences, planning of field trips or other Club events are some of the activities that occur during the meetings. The Geology Club annually prepares a budget, which is submitted to Student Government for funding approval; most years the Club receives approximately $1,000 for field trips. The Geology Club schedules an annual spring picnic, sponsors a fund-raising event each semester (required by Student Government), and usually participates in the spring "campus sweep".

Professional Organizations and Meetings

Students are encouraged to join professional organizations and to present results of their thesis research at meetings of these organizations. The major organizations hold national meetings, regional and local meetings, and research conferences. Students typically receive substantial discounts on membership and meeting registration fees. Annual student membership fees range from about $7 to $35.

Geological Society of America

Annual National Meeting --every fall
Southeastern Section Meeting --every spring
You can find out more information or join GSA online at www.geosociety.org. Their phone number is 1-888-443-4472. For more information on the Southeastern Section of GSA, visit www.geo.ua.edu/segsa/segsa.html or link through the GSA web site.

American Geophysical Union

Annual National Meetings --every spring and fall.
Contact AGU at 800-966-2481 or see www.agu.org for more information.

National Ground Water Association

Annual National Meeting Students may join the Scientists & Engineers Division of NGWA.
Contact NGWA at 614-898-7791 or at ngwa@ngwa.org. Visit www.ngwa.org for more information.

American Water Resources Association
Annual National Meeting
Contact AWRA at 703-904-1225 or visit their web site at www.awra.org.

American Association of Petroleum Geologists
Annual National Meeting --every spring
Eastern Section --every fall
AAPG has a Division of Environmental Geosciences. Contact AAPG at 918-560-2615 or visit www.aapg.org for more information.

SEPM -Society for Sedimentary Geology
Annual National Meeting
Contact SEPM at 800-865-9765 or visit their web site, www.sepm.org, for more information.

Carolina Geological Society
Weekend field trip somewhere in the Carolinas every fall.
Membership dues and field trip registration are very reasonable. Registration information is available in advance of the trip each fall. Contact Duncan Heron at 919-684-5321 or heron@geo.duke.edu. See www.geo.duke.edu/cgsinfo.htm for more information.

American Institute of Professional Geologists
Annual National Meeting every fall.
Contact AIPG at 303-431-0831 or visit their web site at www.aipg.org.

Association of Engineering Geologists
Annual National Meeting every fall.
The local chapter (AEG Carolina Section) holds quarterly meetings at various sites in the Carolinas. For information about AEG Carolina Section, call 704-628-2119; visit www.aeg.org for information about the national organization.

Sigma Xi
Numerous meetings, including local meetings.
Sigma Xi is an international research society whose programs and activities promote the scientific enterprise and honor scientific achievement. See www.sigmaxi.org for details.

FACILITIES AND EQUIPMENT

The Department of Environmental Engineering and Earth Sciences maintains several laboratories, including a computer room, which is available for graduate student use. In addition, the department owns a wide range of equipment for geologic, hydrologic and geophysical field measurements. Some of these facilities and faculty contacts are described below.

Geochemistry Lab

The departmental geochemistry lab is located in 331 Brackett. A Perkin Elmer Zeeman/5100 PC Atomic Absorption Spectrophotometer is the major piece of equipment housed in the lab. This instrument has both flame and graphite furnace atomic absorption capabilities and is available for analysis of inorganic constituents in ground water. In addition, the room contains a fume hood, an ultrapure water system, and assorted equipment for bench-top analyses of water chemistry and sample preparation. Ask Dr. Warner about the use of this equipment.

Other major pieces of equipment for geochemical analysis owned by the department include an HP 6890 Gas Chromatograph with an FID autosampler. This equipment is used to measure organic compounds in ground water, and is housed in the Rich Lab. An ion chromatograph, also housed in the Rich Lab, is available. Ask Dr. Falta about the use of this equipment.

A wide range of other equipment for chemical analysis is available on campus. Much of the analytical equipment in other departments can be used for thesis research by students in the Hydrogeology program by making arrangements through their advisor.

Petrophysics Lab

The department maintains a petrophysics lab in 428 Brackett. The purpose of this lab is to measure hydraulic properties of aquifer samples and soils. The lab contains a suite of flexible wall permeameters for measuring saturated permeability. In addition, the lab contains a Hassler cell for making permeability measurements under confining pressure and a Boyle's Law helium porosimeter. A capillary pressure vessel is also available. Ask Dr. Castle about using this lab.

Thin Section Preparation Lab

This laboratory is located in the basement of Brackett Hall (Room B04). It contains several rock saws, a trim saw, a thin-section cutoff saw, and a thin-section grinder. Laps are available for final polishing of samples. These instruments allow the complete preparation of standard thin sections for petrographic study, or polished sections for microprobe analysis.

The lab also contains two sieve shakers and associated sieve pans for grain-size distribution analyses. See Dr. Warner about using the saws or polisher or Dr. Castle if you need to use a sieve shaker.

Petrographic microscopes are located next door in Room B05. One microscope has a 35 mm camera for taking photomicrographs, and another has a video camera linked to a TV monitor to display images from the microscope. An automated Swift Model F point-counting stage is also available for obtaining modal analyses. The department also owns a digital camera with a special microscope adapter. Consult Dr. Warner or Dr. Castle before using the microscope equipment.

Computer Resources

The Department maintains a graduate student computer lab in 333 Brackett. This lab contains desktop computers with associated printers and peripherals. The computers are connected to the Internet and can be used to access the university mainframe. You are welcome to use the computers in this lab at any time. Your master key will get you into the lab, but please be sure to lock the lab when you leave. Additional computers are located in the graduate student offices. The availability of these computers is variable, so ask your colleagues if you are interested in using one of them.

Software in the computer lab includes a full suite of word-processing, spreadsheet, database (MS Office), and web-browser programs. CAD (Turbo Cad) and drawing (Canvas) programs are available for preparing figures, and advanced plotting packages (e.g., SigmaPlot, TecPlot) are available for making 2-D or 3-D graphs. SURFER is installed on all the computers; it is used in several courses to prepare maps. Symbolic math packages (MATLAB, MATHCAD, Maple, Scientific Notebook) are also available. FORTRAN, C++, BASIC and PASCAL compilers are installed in the computer lab or are available elsewhere in the department. In addition, a variety of groundwater flow models are on hand, including GWVISTAS for MODFLOW, ASM (Aquifer Simulation Model) and associated programs to analyze single-phase transport, AQUIFERWIN2 and SUPRPUMP to analyze pumping tests, and T2VOC for analyzing multi-phase flow and transport.

There are several campus computer labs where both PC and Unix-based machines are available to all students at Clemson. Some of the labs are operated by DCIT, the university-wide computer support group, whereas others are operated by a group within the College of Engineering and Science. The labs are scattered at various locations across campus, including one on the first floor of Brackett Hall. You need an account and a password to access computers in those labs.

Field Equipment

The department has a variety of field equipment that can be used for geophysical and hydrogeological studies. The equipment is stored at various locations in the department and elsewhere on campus. Some of the equipment is used in the Hydrogeology Summer Field Camp. Ask Dr. Moysey if you are interested in using the geophysical instruments and Dr. Murdoch about the hydrogeology field equipment.

<u>Geophysical instruments</u>

- Pulse Ekko 100 low frequency ground penetrating radar
- Pulse Ekko 1000 high frequency GPR
- GR-110 Exploranium portable gamma ray scintillometer
- EM-34 electromagnetic ground conductivity meter
- Surface electrical resistivity instrument
- Fluxgate magnetometer

<u>Drilling Rig</u>

- CME 45 drill rig
- Augers (4” solid stem; 8” hollow stem)

Diamond bit core barrel
Hydraulic hammer
Geoprobe sampling equipment

Well Pumping Test Equipment
5 Parascientific precision transducers
Druck portable transducer
5 In situ Troll water level data recorders
15 kw Kubota generator, Honda generator
25, 7.5, 5, 3, and 1/3 Hp submersible pumps
2 Campbell Scientific CR10X data acquisition systems
2 Grunfos variable rate sampling pumps

Vadose Zone Equipment
Portable mini-Permeameter
2 Guelph permeameters
7502B time domain reflectometry soil moisture device

Water Chemistry Water quality meters (pH, DO, conductivity, turbidity, temperature, ORP)

Stream Gauging
Swoffer current meter
Ohio current meters
Pygmy meter

Borehole Geophysics
Logging instrument with caliper tool and capabilities for measuring
Single point resistance Gamma ray Temperature

Hydraulic Fracturing Equipment

A specially designed system for creating and monitoring shallow hydraulic fractures is available. This system consists of a slurry mixer and pump with related equipment for controlling the fracturing process and monitoring associated ground deformation. Dr. Murdoch is in charge of this equipment.

DEPARTMENTAL INFORMATION

Graduate Office Space

Desks for graduate students are located in 201 and 333A Brackett Hall. Desk assignments are not made; rather, it is up to the graduate students themselves to decide who sits where. You may continue to use the desk as long as you are registered for graduate credits during the regular semesters and are in residence at Clemson University. A key to the graduate offices may be obtained from Cindy Gravely in the departmental office (340 Brackett). This key also opens the mailroom (340A Brackett), the computer room (333 Brackett), the learning resources center (427 Brackett), and the introductory teaching labs (424 and 425 Brackett). A $2 deposit is required, which is refundable when the key is returned to Ms. Gravely at checkout. A non-refundable charge of $5 per key is levied for lost

keys to cover the cost of replacement. Students may also receive a building key, if needed. (At present, Brackett Hall is open 24 hours a day, 7 days a week, so students may enter the building at any time without a key; this is subject to change, however.) Because of the unlimited access to our building, security is a major concern to all. Always lock the graduate office when leaving after 4:30 PM and on weekends! This applies to the mail room, computer room, etc. as well.

General Office Procedures

A telephone (864-656-6989) is available in both graduate offices (with an extension in 427 Brackett) for student use. These phones are intended primarily for campus or local calls. Graduate students making research-related long distance calls at the request of their research advisor should use the advisor's nine-digit authorization code or make other arrangements with their advisor. Students are authorized to place long distance telephone calls only with the permission of the appropriate advisor. Calling cards must be used for personal long distance calls.

Incoming mail addressed to any graduate student is placed in the mailboxes in the Computer Room. (Personal mail should be directed to the student's home address, not the department's mailing address.) Outgoing mail, both interoffice and off-campus, may be placed in the appropriate tray in the mail sorter by the mailroom door.

The copier machine in the mail room is available for work-related copying. For duplication of lab exercises, class handouts, tests, etc., graduate teaching assistants should enter the appropriate code number. The copying of articles, reports, book excerpts, etc. relevant to project or thesis research being conducted by graduate research assistants requires entry of a specific grant code number. If there is no grant to which the copies can be charged, then the copies must be prepaid at the student's expense. Personal copying is discouraged; if unavoidable, students must prepay for the copies. Prepayment should be made to Cindy Gravely in increments of at least $5 (per 100 copies). If problems are encountered during use of the copier, they should be promptly reported to Cindy Gravely or another member of the office staff.

Students may use the department's facsimile machine (also located in the mail room) for official business purposes only, with authorization from their research advisor. Personal faxes may be sent at the University Union or other locations in downtown Clemson.

Office supplies are kept in the mailroom and are available for use by graduate students only in conjunction with their research or employment as a graduate assistant. The department does not furnish office supplies to graduate students for their coursework or other personal use.

Purchasing

Students must obtain prior approval before ordering supplies, chemicals, or equipment. If the purchase is to be made from a research grant, the permission of the PI who has the grant is required. If a departmental account is to be used, the approval of the Department Chair is necessary. In either case, a vendor information

form should be completed and turned in to Cindy Gravely. On this form, indicate the account number to be charged, the vendor name and address (including telephone number), and the specific item(s) to be purchased, with an approximate cost amount. Based on this information, Cindy will enter the requisition via the on-line purchasing system to obtain a purchase order number. This number must accompany the order. The actual placing of the order may be done either by Cindy or by the student. When purchasing technical supplies it is often advantageous for the student to place the order, because Cindy may be unable to answer questions concerning back orders or substitution of another item. Use of the departmental VISA Card is encouraged to facilitate the process. If the vendor will accept VISA, then the call will need to be transferred to Cindy because only she is allowed to give out the card number to vendors. Also, it is important that the correct departmental mailing address (check with Cindy) be given to the vendor.

Direct purchase vouchers are to be used for orders less than $1500. (This amount includes the shipping cost.) Orders over $1500 require bidding. In this case, provide Cindy with the necessary purchase information (use standard purchase requisition form), and the order will be submitted through proper channels. The process takes a little longer, so allow at least three to four weeks for delivery. If a specific vendor is desired, a sole source justification may be attached to the requisition that (1) describes the technical and performance characteristics of the equipment, (2) explains why these characteristics are essential, and (3) verifies that they cannot be obtained from any other source.

Student Travel

Students planning to take a trip should first read the "Clemson University Pocket Guide to Official Travel" to familiarize themselves with university policies and procedures. This brochure explains which expenses are allowable and which are non-allowable. A copy is kept in the main office (340 Brackett).

A travel request form must be completed and approved by the Department Chair prior to taking the trip. The date(s), destination, mode of travel, purpose of trip, source of funds, and an estimated breakdown of expenses should be indicated. If the travel is to be charged to a research grant, then the form must be signed by the grant PI. If the travel involves use of a motor pool vehicle, then provide the following information to Cindy Gravely:

Account number to be charged
Name of driver
Type of vehicle (car, minivan, 12-or 15-passenger van)
Destination of trip
Purpose of trip
Date and time of pick-up (must be between 7:30 AM and 4:30 PM, Monday-Friday)
Date and time of return

You must give at least three-days notice to request a vehicle. (NOTE: you should request well in advance in order to secure a van.) Should you need to cancel the request, please notify Cindy so that she can cancel the order for you. Otherwise, we

could be charged for the vehicle even if it is not used.

When requesting reimbursement after the travel, a travel worksheet must be filled out. This form can be obtained from Cindy; she can help answer questions concerning the form or relating to any aspect of the travel. The student may wish to review the form prior to the trip and/or take it on the trip to keep up with the expenses as they occur. Any and all receipts from the travel should be retained and turned in with the travel worksheet upon completion of the trip. Filing for reimbursement should be done within 30 days after returning from the travel.

Health and Safety

Exposure to Hazardous Chemicals

A hazardous chemical is defined as any substance that is known to be corrosive, ignitable, reactive, or toxic. A Material Safety Data Sheet (MSDS) is available for almost all hazardous chemicals and should be reviewed prior to handling each chemical. MSDS copies are filed in a notebook kept in the main office.

Most students in the Hydrogeology program will not be exposed to extremely hazardous chemicals. Even if there is not a perceived risk, safe chemical handling practices should always be followed. It is important to minimize one's exposure to all chemicals, even to those with no known risk, as sometimes "harmless" chemicals are later discovered to have adverse health effects.

All students who are exposed to or work with hazardous chemicals should review the applicable parts of the Chemical Hygiene Plan. A copy of this plan is available in the main office or can be obtained from Scott Brame, who is the departmental Health and Safety Officer (Scott's office is in 332 Brackett). It may also be viewed on the web at http://ehs.clemson.edu/chp2000/index.html. The Chemical Hygiene Plan contains general procedures for working with hazardous chemicals as well as specific instructions for handling known carcinogens and flammable or explosive substances.

In the Geological Sciences labs, the most likely areas where exposure to hazardous chemicals may occur are:

1) Geochemistry Lab, 331 Brackett (as a student or as an RA)
2) Introductory Geology/Physical Science Labs, 424/425 Brackett (as a TA)

The geochemistry lab contains concentrated acids and standards used to calibrate the atomic absorption (AA) instrument as well as cylinders of compressed gases, some of which are flammable. Exposure to the acids and standards should be minimized through use of protective gear such as lab coats, eye wear and gloves. The tanks should not be handled without supervision. If a leak in a tank is suspected, leave the lab and seek help.

In the introductory geology labs, dilute Hydrochloric Acid is used to test for carbonate rocks. Although this is a very dilute solution, it is used by all the students and should be treated carefully. The location and accessibility of eyewashes in each

lab should be ascertained. The physical science labs use several chemicals as well; although some are household chemicals, they should not be treated casually.

If you are involved in any research or project that uses hazardous chemicals, consult the MSDS for each chemical. Do not assume that a chemical is safe just because those around you may be treating it casually. Seek advice from the Health and Safety Officer when in doubt. Protect yourself!

Other Hazards

The department maintains several items of laboratory equipment for which safety is a concern with regard to their operation. Most notable are the rock saws and sieve shakers in the thin section preparation lab located in the basement of Brackett Hall (room B04). These should not be operated without prior instruction.

In the field, pumps and generators used in aquifer performance tests constitute a potential hazard. Students may also be in close proximity to drilling rigs. Hard hats are required to be worn at all times when a drill rig is being operated.

The use of geologic hammers is another source of accidents. Protective eyewear and clothing should be worn when attempting to break rocks or to collect samples, as rock chips may fly off and strike the user or other persons standing nearby.

Bob Campbell Geology Museum

The Bob Campbell Geology Museum is located in the South Carolina Botanical Gardens adjacent to the Heritage Corridor Visitor's Center. Dr. Carolyn Rebbert is Director of the Geology Museum (see Appendix A). The museum contains displays of natural mineral and fossil specimens and faceted gemstones with a combined worth exceeding $2,000,000.00. The Bob and Betsy Campbell Geological Collection, which includes a splendid fluorescent mineral display, and the Paul H. Benson, Jr. Collection of gemstones and cabochons, are the two most prominent exhibits.

The chief purpose of the Bob Campbell Geology Museum is to acquire and display geological materials of scientific, historic, aesthetic, and educational value. It serves also to stimulate interest in the study and research of geological materials through providing access to specimens for observation and analysis. The museum contributes to the University's public outreach programs by developing educational exhibits and offering guided tours. Each year thousands of K-12 students visit the museum on class field trips.

Web Site

Information about the graduate program in Hydrogeology and the Department of Environmental Engineering and Earth Sciences can be accessed on the World Wide Web at http://www.ces.clemson.edu/eees/. Ms. Mary Shirley maintains the Web site in collaboration with the program coordinators in the department. Each faculty and staff member is encouraged to maintain a home page with current information. The Web site for the Graduate Program is reviewed periodically by the Graduate Coordinator in consultation with the faculty. Review and update takes place at least

once a year and typically at more frequent intervals throughout the year.

GENERAL UNIVERSITY INFORMATION

Before classes begin, you are advised to call the Graduate Admissions Office for a list of pre-semester requirements. Most are highlighted below. A list of useful reference phone numbers is given in Appendix D. Other general campus information may be obtained from the Visitors Center or via the campus information hotline (see Appendix D).

Registration

Continuing graduate students are advised to take advantage of pre-registration, which occurs near the middle of each regular semester according to a timetable established by the University. In November, students may pre-register for the upcoming spring semester, while pre-registration for both summer sessions and for Fall semester takes place in April. Detailed information on registration procedures, tuition and fees, as well as the course listing, can be found in the "Schedule of Classes," which is published online. To pre-register, the following steps should be followed:

1)	Review the schedule and meet with research advisor (or Graduate Program Coordinator to agree on a projected class schedule.
2)	Follow the instructions from the university for online registration procedures.
3)	Pay all fees in advance of the deadline established by the university (to prevent cancellation of your schedule and payment of additional fees).

NOTE: To register, you will need your computer ID (this is your social security number) and computer password (initially, the last four digits of your social security number -when you enter this number the first time, you will be directed to select a 5-8 digit number, which will serve as your new password). If you forget your password, you can have it reset at the Help Desk in Martin Hall (must present a picture ID).

Payment of Fees

Graduate Assistants qualify for reduced tuition, which is less than the tuition for in-state graduate students without an assistantship. The tuition for Graduate Assistants is the same whether you are from South Carolina or from another state.

Graduate assistants are required to enroll in at least nine (9) credit hours each semester to get the reduced tuition rate; three (3) credit hours are required for each summer session. Although the normal (half-time) workload is 20 hours per week, students are sometimes hired at less than half-time. Students hired less than half-time are still eligible for the reduced tuition benefit. To receive the reduced academic fee rate for a particular semester, a qualified student must be on the departmental payroll prior to the beginning of that semester.

Graduate Assistants may choose to have fees deducted from payroll checks in

installments during the semester. See Cindy Gravely for more information..

General questions regarding billing should be directed to the Office of Student Accounts Receivable (G08 Sikes Hall). Questions about specific fees or financial aid should be directed to the office responsible.

Computing
Upon acceptance to the University, every student is assigned a computer login and password. Your login consists of the first letter of your first name, and the first six letters of your last name. If another student shares your name, the login may vary slightly. To receive the correct login and password, call or stop by the Help Desk located in M2 Martin Hall. Students are available throughout the day to assist you with any computer-related needs or questions. Connection to the Clemson University system is possible from any on-campus terminal or from off-campus.

Sporting Events
Graduate students may purchase season tickets for Clemson football and basketball games. If interested, report to the ticket office at Gate 9 of Memorial Stadium to complete an application. Tickets for individual games may also be purchased roughly two weeks before game day. Prices and availability vary, so be sure to contact the ticket office early. Baseball games are free with a university ID, and soccer tickets may be purchased at the gate for about $3 with a university ID.

Fike Recreation Center
Exercise equipment, gymnasiums, racquetball/handball courts, swimming and diving pools, locker rooms, and other athletic facilities in Fike Recreation Center are available for students with a yearly membership. Graduate assistants may join for an annual fee. Fike is located across the street from the football stadium.

R.M. Cooper Library
Located on campus adjacent to the reflecting pool, the main library is filled with a wide variety of reference books and journals. Periodicals may be checked out by graduate students for a maximum of three days. Books may be checked out for a maximum of six weeks. Late fees of $1/day for periodicals and $.25/day for books apply if the due date is exceeded. The card catalog (LUIS) is located on-line and can be accessed from any computer on campus through the university mainframe. A variety of search options are available to you, as well as the benefit of interlibrary loan, free of charge.

Graduate Student Association (GSA)
The GSA is a university-wide organization of all graduate students for the purpose of promoting graduate student interests. At the beginning of the fall semester, departmental GSA representatives are elected. The bi-weekly senate meetings are open to all graduate students and are posted via e-mail prior to the meeting date. Feel free to contact the GSA office (656-2697) for more information.

Bookstore
The campus bookstore is located on the lower level of the Hendrix Student Center. Books may be purchased at any time before or after the start of classes each

semester. Textbooks are listed by department and course number. If a course is cross-listed between two different departments, the textbook may be located in either department's section. Many books are available in new and in used form. Prices may vary drastically between the two, so be sure you know which you have selected. Supplies are also available in the bookstore, along with a wide variety of Clemson University paraphernalia, computer software, and household items. Purchases can be made using your Tiger Stripe debit account, or any other traditionally accepted form of payment.

Redfern Health Center

Redfern Health Center is open during regular business hours to serve the needs of all students. The health fee you pay each semester will cover the cost of any care you receive at Redfern. However, payment for prescriptions and lab work is extra, and will be expected before you leave the premises. If you should choose to make an appointment, simply call the number listed in Appendix D and speak with a representative. Walk-ins are also accepted, but the wait may be lengthy. When parking in the Redfern lot, it is essential that you obtain a temporary parking permit from the reception desk. If you do not, you will be ticketed and your vehicle will likely be towed. In case of an emergency, notify the front desk and they may be able to assist you. Parking is also available adjacent to Redfern for anyone with a commuter sticker on their vehicle.

Parking Services

Vehicles must be registered and a fee paid immediately upon being brought to campus. Parking permits and further information may be obtained from Parking Services, which is located in the Student Union across from Brackett Hall. Lines get to be long as the August 15 deadline nears, so it is best to register your vehicle as early as possible. You may have already received a notice from Parking Services during the summer regarding vehicle registration. The commuter sticker allows you to park in any orange parking space during regular class hours and in any green parking space (except those marked "24 hour employee parking) after 4:30 PM. If you are parked outside your permit zone during regular hours, be assured you will be towed. However, plenty of commuter parking is available on the sides of roads and near the stadium. Buses shuttle students from all commuter and resident lots through main campus on a regular basis. Maps of their routes and daily schedules are available from the Parking Services office, at many of the bus stops, or on the buses themselves. Because these shuttles are City of Clemson buses, all questions regarding their policies and procedures should be directed to the CATS office at the number listed in Appendix D.

Student ID

Before you begin classes, it is important to obtain a Tiger Stripe card. This card will serve as your student identification card, your library card, your financial debit card, and your access card to all university events. In order to receive your card, you must bring one form of photo identification to the Tiger Stripe office and prepare to have your picture taken. Processing of the card should only take a few minutes.

Security
The campus security office is located behind the football stadium near parking lot C-8. Yellow phone boxes are also located throughout campus for use in case of an emergency.

Campus Post Office
The campus post office is located on the bottom floor of the Student Union. It provides all regular postal services, including the sale of money orders, outgoing registered mail, and incoming and outgoing COD mail. You may also pick up or ship UPS packages. Post office boxes may be rented on an academic year basis, but are usually reserved for undergraduates.

City of Clemson
For all information regarding local issues of any kind, call the Clemson information line or the Chamber of Commerce. The information line is automated and will supply you with anything you want to know about the local area, including "how to" information regarding fishing permits, etc. The Chamber of Commerce is located off of College Avenue. After you cross Tiger Blvd. and pass under the train trestle, make a right and then an immediate left into the parking lot. The office is just inside the front door.

APPENDIX A
GEOLOGICAL SCIENCES FACULTY AND STAFF

Name	Title	Office	Phone
Brame, Scott	Research Associate	332 Brackett	656-7167
***Castle**, Jim	Professor	334 Brackett	656-5015
Dean, Gray	Lecturer	341 Brackett	656-1571
Elzerman, Alan	Professor & Department Chair	156 Rich Lab	656-5568
Falta, Ron	Professor	340C Brackett	656-0125
Gravely, Cindy	Administrative Assistant	340 Brackett	656-3438
Gourdin, Jackie	Administrative Assistant	441A Brackett	656-1560
Hepler, Chris	Research Associate	342 Brackett	656-1051
Kendall, Treavor	Assistant Professor	339 Brackett	656-1897
Krause, Lois	Lecturer	442 Brackett	656-7653
Molz, Fred	Professor Emeritus	158 Rich Lab	656-1003
Moysey, Stephen	Assistant Professor	338 Brackett	656-5019
Murdoch, Larry	Associate Professor	337 Brackett	656-2597
Wagner, John	Professor	448 Brackett	656-5024
Warner, Rich	Professor	336 Brackett	656-5023
*Graduate Coordinator			

8/15/07

APPENDIX B
FACULTY RESEARCH PROFILES

James W. Castle
Professor, Ph.D., University of Illinois (1978)

My research focuses on energy and the environment, with most of my graduate students performing research on wastewater treatment, sediments, or subsurface geology. We collaborate extensively with graduate students and faculty in other departments. In particular, we are working very closely with Dr. John Rodgers, an Environmental Toxicologist and Professor in the Department of Forestry and Natural Resources. Dr. Rodger's students and my students work side-by-side on pilot-scale, demonstration-scale, and full-scale constructed wetland systems for wastewater treatment. The research includes sediment studies, toxicological testing, and investigation of the biogeochemistry of processes occurring in constructed wetland treatment systems. We have pilot-scale systems set-up on campus, in which treatment effectiveness is measured for various organic and inorganic constituents in a variety of simulated and actual wastewaters. Each system is modular and designed with a unique combination of plants and sediments. Results from the pilot-scale studies are being used to design and construct wetland treatment systems in the field. We are working closely with collaborators from the energy and environmental industries and have projects in several states including West Virginia and California. Using results from the pilot-scale research, we recently designed and constructed a demonstration-scale wetland system to treat produced oilfield and natural gas storage produced water at a facility in West Virginia. We are working toward applying results from our studies of constructed wetland treatment systems to gaining a better understanding of sedimentological and biogeochemical processes of analogous environments in the geologic past. The results are applicable to interpreting the origin of buried sediments and ancient sedimentary rocks.

The research of some of my recent graduate students has involved using sedimentology and sequence stratigraphy to gain a better understanding of the vertical variability and lateral continuity of Coastal Plain Tertiary aquifers and confining units in South Carolina and Georgia. In the Piedmont, structural controls on water supply have been investigated through field-mapping projects in collaboration with the Blue Ridge Water Company, the South Carolina Geological Survey, and the U.S. Geological Survey. In the Appalachian basin, my research interests focus on integrating the sedimentology and sequence stratigraphy of Paleozoic foreland-basin strata with the regional tectonic framework.

Selected Publications

Mikhailova, E. A., Post, C. J., Magrini-Bair, K., and Castle, J. W., Pedogenic carbonate concretions in the Russian Chemozem, Soil Science (in press).

Castle, J. W., Molz, F. J., Lu, S., and Dinwiddie, C. L., Sedimentology and fractal-based analysis of permeability data, John Henry Member, Straight Cliffs Formation (Upper Cretaceous), Utah, U.S.A., Journal of Sedimentary Research, v. 74, p. 270-284, 2004.

Castle, J.W., Foreland-basin sequence response to collisional tectonism, Geological Society of America Bulletin, v. 113, p. 801-812, 2001.

Miller, R.B., Castle, J.W., and Temples, T.J., Deterministic and stochastic modeling of aquifer stratigraphy, Ground Water, v. 38, no. 2, p. 284-295, 2000.

Ronald W. Falta, Jr.
Professor, Ph.D., University of California, Berkeley (1990)

My research is in the area of hydrogeology and subsurface environmental remediation. Current research projects involve the development and testing of new methods for restoring sites contaminated with organic chemicals such as hydrocarbon fuels and chlorinated cleaning solvents. I also am generally interested in mathematical analysis of subsurface flow and transport problems including groundwater flow, vadose zone water flow, and vadose zone gas flow.

During the past 8 years I have directed two EPA-funded field demonstrations of alcohol flooding for subsurface NAPL remediation. NAPL stands for "nonaqueous phase liquid", and refers to any organic liquid which does not completely dissolve in water. We performed our first field test of alcohol flooding (the first of its type in the world) at Hill Air Force Base, Utah, in summer 1996. That test was successful, and we are currently performing a similar field experiment for Dover Air Force Base in Delaware. These projects involve large amounts of analytical chemistry, laboratory experimentation, and numerical modeling in addition to the field work.

I have also directed several DOE-funded research projects related to NAPL contamination problems at the Savannah River Site. These mainly involve three-dimensional numerical simulation of the multiphase (air, water, NAPL) contaminant transport and remediation in the M-Area of the site. Other funded projects have mainly involved mathematical analysis of subsurface remediation systems including air sparging, soil vapor extraction, and steam flooding. I currently have research collaborations with Lawrence Berkeley National Laboratory, Purdue University, Michigan Technological University, the USEPA R.S. Kerr Environmental Laboratory, the Savannah River Technology Center, and the University of Stuttgart (Germany).

Selected Publications

Falta, R.W., Steam Flooding for Environmental Remediation, in Groundwater Contamination by Organic Pollutants, Analysis and Remediation, J.J. Kaluarachchi, editor, *ASCE Manuals and Reports on Engineering Practice No. 100*, p. 153-192, 2001.

Roeder, E., and R.W. Falta, Modeling Unstable Alcohol Flooding of DNAPL-Contaminated Columns, *Advances in Water Resources*, 24 (7), pp. 803-819, 2001 Looney, B.B., and R.W. Falta, editors, Vadose Zone Science and Technology Solutions, *Battelle Press*, Columbus, OH, 1540 p., 2000.

Falta, R.W. Numerical Modeling of Kinetic Interphase Mass Transfer During Air Sparging Using a Dual-Media Approach, *Water Resources Research*, Vol. 36, No 12, December, 2000.

Falta, R.W., C.M. Lee, S.E. Brame, E. Roeder, J.T. Coates, and C. Wright, Field Test of High Molecular Weight Alcohol Flushing for Subsurface NAPL Remediation, *Water Resources Research*, Vol. 35, No. 7, July, 1999.

Treavor A. Kendall
Assistant Professor, Ph.D., Virginia Tech (2003)

My research in environmental geochemistry examines the chemical dynamic of mineral surfaces in contact with aqueous solutions, organics, and biological materials. An understanding of the biological-mineral interface is essential for predicting solution conditions, nutrient availability, and the fate of contaminants in hydrogeological systems. At stake is the quality of our water and the sustainability of ecosystems.

A common soil bacterium releases a myriad of gene products with acidic, basic, and redox-active functional groups that have the potential to change the chemistry of a mineral surface and the surrounding solution. Specifically, I am interested in reactions which lead to mineral dissolution and contaminant release.

My approach investigates the biological-mineral interface at multiple scales with a variety of techniques, including our most advanced technologies. Advances in scanning probe microscopy afford remarkable insight into the chemistry, mechanics, and structure of biological-mineral interfaces. The same ultra-high sensitivity that allows the atomic force microscope (AFM) to detect molecular forces also enables imaging with nanometer and possibly atomic resolution, in situ under environmental conditions.

My work has demonstrated the value of understanding and quantifying the molecular level forces that direct biomolecule interaction with a mineral surface. I developed a new technique that allowed linkage of a bacterial siderophore to an AFM tip to ultimately be probed on mineral surfaces under environmentally relevant conditions. Novel, molecular level evidence of biomolecule specificity and reactivity for a mineral surface was provided, and iron removal via ligand contact is now proposed as one pathway for microbial iron acquisition.

Selected Publications

Kendall, T.A. and Hochella, M.F., Jr. (2003). The measurement and interpretation of molecular level forces of interaction between the siderophore azotobactin and mineral surfaces. *Geochimica et Cosmochimica Acta, 67* (19): 3537-3546.

Kendall, T.A. and Martin, S.T. (2005). Mobile ions on carbonate surfaces. *Geochimica et Cosmochimica Acta,* 69 (13): 3257-3263.

Kendall, T.A. and Martin, S.T. (2006). Water-induced reconstruction that affects mobile ions on the surface of calcite (In review).

Fred J. Molz
Professor Emeritus, Ph.D., Hydrology, Stanford University (1970)

I received a Ph.D. in Hydrology from Stanford University in the late Spring of 1970 and joined Auburn University the following fall as an Assistant Professor of Civil Engineering. From 1979 to 1984, I served as Director of the Engineering Experiment Station and Assistant Dean for Research in the College of Engineering. On January 1, 1990, I was appointed to the Huff Eminent Scholar Chair in Civil Engineering and became director of the Geological Engineering Program. Resigning those positions in late 1995, I became professor and SCUREF Distinguished Scientist in the Environmental Engineering & Science and Geological Sciences Departments at Clemson University. At Clemson, I devote approximately 40% of my time to teaching and 60% to research. My research interests include both the experimental and theoretical aspects of transport processes in the groundwater-soil-plant-atmosphere system, and I have been author or co-author of over 150 publications and presentations, mostly in hydrology and soil physics, including a book entitled "Numerical Methods in Subsurface Hydrology". Since 1975, I have directed three relatively large experimental studies of thermal energy storage in confined aquifers and two large field studies devoted to increasing the understanding of contaminant migration in groundwater. I contributed significantly to the development and application of the electromagnetic borehole flowmeter, and the use of stochastic fractals to represent flowmeter and related data. Current research involves surface and subsurface transport processes in wetlands, the use of fractals to represent heterogeneity in natural systems, and measurement of hydraulic conductivity distributions in aquifers using the electromagnetic borehole flowmeter and in oil reservoir rocks using the gas mini-permeameter.

Selected Publications

Molz, F.J., 0. Güven, J.G. Melville and C. Cardone. 1990. Hydraulic Conductivity Measurement at Different Scales and Contaminant Transport Modeling, externally reviewed chapter published in a book entitled *Dynamics of Fluids in Hierarchical Porous Formations*, Academic Press, J.H. Cushman, editor.

Molz, F.J., H.H. Liu and J. Szulga. 1997. Fractional Brownian motion and fractional Gaussian noise in subsurface hydrology: A review, presentation of fundamental properties, and extensions, *Water Resources Research, 33*, 2273-2286.

Feng, K., and F.J. Molz. 1997. A 2-D, diffusion-based, wetland flow model, *Journal of Hydrology, 196*, 230-250 Dinwiddie, C.L., N.A. Foley and F.J. Molz. 1999. In-well hydraulics of the electromagnetic borehole flowmeter, *Ground Water, 37*, 305-315.

Lu, S., F.J. Molz, G.E. Fogg and J.W. Castle. 2002. Combining stochastic fractal and facies models for representing natural heterogeneity, *Hydrogeology Journal.* v. 10, p. 475-482.

Stephen Moysey
Assistant Professor, Ph.D., Stanford University (2005)

Prior to completing a Ph.D. in Geophysics at Stanford University, I obtained a M.S. in Hydrology at the University of Arizona. As a result, I am very interested in problems that lie at the boundary between hydrology and geophysics, i.e., in the field of hydrogeophysics.

My research interests focus on the investigation of techniques for generating models of environmental processes constrained by multiple types of data. Specifically, I am interested in developing practical methods for simultaneously using geophysical surveys with traditional types of data, such as pumping and tracer tests, to calibrate groundwater models. This work spans a variety of problems including understanding relationships between geophysical and hydrologic data (rock physics), the development of methods for measuring and describing heterogeneity in complex environments, and statistical techniques for parameter estimation. Tackling this diversity of topics offers the opportunity to pursue a combination of field, lab and theoretical studies.

The results of my work in hydrogeophysics have led to the development of a systematic method for the estimation of field-scale rock physics relationships and a pattern recognition technique for identifying facies in ground-penetrating radar (GPR) data using neural networks. In the past, I have also been active in research related to natural tracers of hydrologic processes. Future research opportunities are likely to include integrated characterization of aquifers using electromagnetic surveys, natural tracers, and traditional hydraulic tests; theoretical and laboratory based studies in rock physics; and the investigation of geophysical methods for determining aquifer recharge.

Selected Publications

Moysey S., K. Singha, and R. Knight, A framework for inferring field-scale rock physics relationships through numerical simulation, *Geophysical Research Letters*, 32(8), L08304, 2005.

Moysey S. and R.J. Knight, Modeling the field-scale relationship between dielectric constant and water content in heterogeneous systems, *Water Resources Research*, 40, W03510, 2004.

Moysey S., J. Caers, R.J. Knight, and R.M. Allen-King, Stochastic estimation of facies using ground penetrating radar data, *Stochastic Environmental Research and Risk Assessment*, 17, 306-318, 2003.

Moysey S., S.N. Davis, M. Zreda, and L.D. Cecil, The distribution of meteoric $^{36}Cl/Cl$ in the United States: A comparison of models, *Hydrogeology Journal*, 11(6), 615-627, 2003.

Larry Murdoch
Associate Professor, Ph.D. University of Cincinnati (1991)

My research interests are in combining field studies and theoretical analyses to improve our understanding of processes related to hydrogeology. Much of my work falls into three broad categories; (1) Methods to improve the remediation of contaminated sites; (2) Monitoring and characterization of in situ processes and conditions; (3) Analysis of aquifer systems.

In the late 1980s I developed methods for creating hydraulic fractures at shallow depths in poorly cemented sediments or soil, and much of my work since then has been involved with environmental applications for this technology. I spent most of the 1990s developing and demonstrating remedial applications that ranged from simple techniques like using sand-filled hydraulic fractures to increase the flow rate to contaminant recovery wells, to more elaborate schemes where hydraulic fractures were filled with granular graphite and used a sheet-like electrodes to induce contaminant movement by electro-osmosis. My work on hydraulic fractures has continued since coming to Clemson in 1997, and I currently have ongoing projects where graduate students are investigating the effects of fractures on fluid flow in the subsurface, and the mechanics of fracture propagation at shallow depths.

The studies of processes near hydraulic fractures pointed out a need for better methods to monitor in situ processes. In response to this need, I have developed several methods for increasing the accuracy and resolution of in situ monitoring methods. One method involves installing sensors into the sidewall of boreholes. This technique has been used at contaminated sites both in the U.S. and in Denmark. Development of improved monitoring methods is often conducted as a secondary effort in many of the field projects that I work on with graduate students. A Clemson grad student and I recently developed a remarkably simple method for making closely spaced measurements of air pressure during in situ vapor extraction, which the student will use as part of his MS thesis.

I am also interested in characterizing aquifer systems using both theoretical and field methods. This effort includes developing and applying methods for conducting well tests in aquifers. We have recently completed a well field on campus that is used for teaching and research. One MS thesis is currently being completed that describes the basic hydrogeologic conditions of the well field, but there is much more work that could be done in that area. Characterizing interactions between surface water and ground water, and extending these concepts to the watershed scale are also topics that interest me, and that have led to graduate student projects in the past and hold the potential for projects in the future.

Selected Publications

Murdoch, L.C. and others. Remediation of organic chemicals in the vadose zone, in *Vadose Zone, Science and Technology Solutions*. Chapter 7. pp 948-1247. R.Falta and B. Looney eds. Battelle Press, 2000.

Murdoch, L.C. and W.W. Slack. Forms of hydraulic fractures in shallow, fine-grained formations. Journal of Geoenvironmental and Geotechnical Engineering. In press

John R. Wagner
Professor, Ph.D., University of South Carolina (1993)

My current research efforts are concerned primarily with topics in geoscience education, especially the design, development and evaluation of interdisciplinary geoscience curriculum materials at both the college and K-12 levels. I also have research interests in landscape evolution and process geomorphology, and in paleogeography/ paleoclimatology, particularly during the Quaternary.

My work in undergraduate geoscience education has revolved around a sequence of three restructured science courses, required of elementary education majors, which I instituted in 1993 through grant support from the South Carolina Commission on Higher Education. The earth science course, in particular, has provided a wealth of data for assessing the impact of this unique mix of science content and pedagogy on student achievement and attitudes.

My K-12 research has focused primarily on two curriculum projects, SC MAPS (South Carolina Maps and Aerial Photographic Systems) and SE MAPS (SouthEast Maps and Aerial Photo-graphic Systems). Both are interdisciplinary, thematic packages based on geology, which investigate the interrelationships among rocks and minerals, landforms, historical development, economic trends, cultural diversity, land use, conservation of natural resources, and environmental concerns. Student activities in the SC MAPS Teaching Manual focus on local study sites representing major landform regions of the area. The SC MAPS Portfolio contains classroom sets of 29 large-format, laminated cartographic products, including infrared aerial photographs, satellite and SLAR imagery, topographic maps and other special purpose maps. These programs also serve as a framework for researching the effectiveness of a variety of alternative strategies for training teachers.

My interests in landscape evolution and process geomorphology revolve around the interpretation of remotely sensed data to document environmental changes over time. With grant support, I maintain a small custom map printing center, through which I design large format maps and other cartographic products needed by K -12 teachers for special student projects. I also run a variety of teacher workshops and courses using activities and products developed for SC MAPS and SE MAPS.

I have also investigated the genesis, structure and paleogeography of stream terrace deposits in upstate South Carolina. Streams with much higher flow regime and sediment load once passed through the Clemson area. Eventually, I plan to plot the occurrence of all such deposits to determine flow characteristics and drainage basin morphology and relate these features to previous climatic conditions.

Selected Publications

Cain, P.W., Wagner, J.R. and Berry, C., *South Carolina Maps and Aerial Photographic Systems* (3rd ed.), South Carolina Department of Education, Columbia, SC, 1996.

Wagner, J.R., Barbary, S.W. and Astwood, P.M., Full circle partnerships for elementary science education: A collaborative approach to group learning in Earth Science, J. Geol. Education, v. 43, p. 376-380, 1995.

Richard D. Warner
Professor, Ph.D., Stanford University (1971)

My research is primarily concerned with the mineralogy and petrology of mafic and ultramafic rocks. In recent years my efforts have concentrated on three principal topics: (1) mineralogy and petrology of ultramafic bodies in the Blue Ridge and Piedmont of the southern Appalachians; (2) magnetic petrology of the lower continental crust; and (3) geochemistry and petrology of Mesozoic diabase dikes.

Ongoing studies of ultramafic rocks in the Blue Ridge of western North Carolina are focused on the Buck Creek dunite in Clay County and the Webster-Addie complex in Jackson County, two of the largest ultramafic bodies in the southern Appalachians. Mineralogical-petrological studies are aimed at constraining the P-T conditions of metamorphism of the bodies and elucidating their metamorphic history. Bulk rock geochemistry is being analyzed to decipher whether the bodies originated as part of an ophiolite sequence or as a diapiric intrusion of upper mantle material.

Magnetic petrology integrates magnetic property studies with conventional petrology for the purpose of understanding the development and modification of the magnetization in rocks. Satellite measurements reveal a global pattern of long-wavelength magnetic anomalies whose sources are thought to reside in the lower crust. Dr. Peter Wasilewski (NASA, Goddard Space Flight Center) and I seek to characterize the magnetic properties of the lower crust through study of deep crustal rocks transported to the surface as xenoliths or exposed in tectonically uplifted crustal sections.

My diabase research focuses on geochemical analysis of the dikes in order to identify parent magma types and constrain the nature of the diabase source region(s). Detailed petrographic and electron microprobe studies are conducted to characterize the mineralogy of the diabase samples and define magmatic crystallization trends. I am interested in the interrelationships between magma composition, cooling rate/texture and mineral chemistry, particularly mafic and spinel group minerals.

Selected Publications

Warner, R.D., Mineralogy and petrology of metaultramafic rocks at Buck Creek, North Carolina, Southeastern Geology, v. 40, no. 3, p. 183-200, 2001.

Warner, R.D. and Wasilewski, P.J., Magnetic petrology of arc xenoliths from Japan and Aleutian Islands, J. Geophys. Res., v. 102, no. B9, p. 20,225-20,243, 1997.

Warner, R.D. and Wasilewski, P.J., Magnetic petrology of lower crust and upper mantle xenoliths from McMurdo Sound, Antarctica, Tectonophys., v. 249, p. 69-92, 1995.

Warner, R.D., Kidd, N.B., Snipes, D.S. and Steiner, J.C., Mafic mineral crystallization in South Carolina diabase, South Carolina Geology, v. 38, p. 37-52, 1995.

Warner, R.D., Snipes, D.S., Hughes, S.S., Walker, R.J., Schmitt, R.A. and Steiner, J.C., Geochemistry and petrology of Mesozoic dikes in South Carolina, in *Eastern North American Mesozoic Magmatism* (J.H. Puffer and P.C. Ragland, eds.), Geol. Soc. America Special Paper 268, p. 333-346, 1992.

Scott E. Brame
Research Associate, M.S., Clemson University (1993)

My main interests are in spatial modeling of environmental changes and geologic processes. I use Geographic Information Systems (GIS) to facilitate the solving of complex problems that have a spatial bias to their data. Some problems are solved directly using just the spatial analysis tools found within a GIS while others require passing the data onto a numerical simulator that can model fluid flow and material balance interactions between cells. In this latter application, the GIS can be used as pre-and post-processor for the numerical simulator.

Recently, I have been working on integrating a Decision Support System (DSS) into the GIS environment. Given that the learning curve for any complex GIS software is fairly steep, I want to implement the DSS concepts into a user friendly internet based GIS system. This would allow those individuals without any GIS training to access the data, make their own maps, and to make decisions about spatial information using a web based DSS interface.

Selected Publications

S.E. Brame, J.W. Castle, O.K. Fawumi, and R.W. Falta, 2006, History Matching of Heavy Oil Production for Comparing New Approaches to Generating Reservoir Property Distributions, West Coalinga Field, California, SPE Paper 93469, 2006 SPE/DOE Symposium on Improved Oil Recovery, Tulsa, Oklahoma, April 22-26, 2006.

J.W. Castle, D.A. Bruce, S.B. Brame, D.A. Brooks, R.W. Falta, and L.C. Murdoch, 2004, Design and Feasibility of Creating Gas-Storage Caverns by Using Acid to Dissolve Carbonate Rock Formations, SPE 91436, 2004 SPE Eastern Regional Meeting, Charleston, West Virginia, September 15-17, 2004.

Appendix C
Course Descriptions

GEOL 601 Applied Geophysics 3 credits (S)
Introduction to the most important methods of geophysical exploration and their application to the investigation of subsurface groundwater and mineral resources. Emphasis is on the principles, techniques, interpretations and limitations of magnetic, gravimetric, electrical, electromagnetic, well-logging and seismic geophysical surveys.
Prerequisite: GEOL 101 or consent of instructor; PHYS 208 or 221 recommended.
Instructor: Dr. Moysey

GEOL 603 Invertebrate Paleontology 3 credits (F-even years)
Life of past geologic ages, as shown by fossilized remains of ancient animals, with emphasis on the invertebrates.
Prerequisite: GEOL 101 or consent of instructor.
Instructor:

GEOL 605 Geomorphology 3 credits (S)
Surface features of the Earth -their form, nature, origin, development, and the rates and patterns of changes they are undergoing. Laboratory studies emphasize a process approach to terrain analysis stressing complex interactions of geologic, climatic and tectonic forces.
Prerequisite: GEOL 101, 102 or consent of instructor.
Instructor: Dr. Wagner

GEOL 608 Geohydrology 3 credits (F)
Hydrologic cycle, aquifer characteristics, theory of groundwater movement, mechanics of well flow, experimental methods, and subsurface mapping.
Prerequisites: GEOL 101, 102.
Instructor: Dr. Murdoch

GEOL 615 Analysis of Geological Processes 3 credits (F)
Introduction to methods for analyzing geological processes. Mathematical methods will be introduced to solve problems related to stream flow, reaction kinetics, radioactive decay, heat flow, diffusion, fluid flow through geologic media and related processes.
Prerequisite: MTHSC 206 or consent of instructor.
Instructor: Dr. Murdoch

GEOL 621 GIS Applications in Geology 3 credits (S)
Introduction to Geographic Information Systems with applications to current geological and hydrological problems. Topics will cover the use of Global Positioning Systems, spatial analysis and image analysis. Hands-on training with GIS software and techniques will be covered in the lab.
Prerequisite: Graduate standing and strong computer skills.
Instructor: Mr. Brame

GEOL 651 Selected Topics in Hydrogeology 1-4 credits (F,S,SS)
Selected topics in hydrogeology with emphasis on new developments in the field. May be repeated for a maximum of six credits, but only if different topics are covered.
Prerequisite: GEOL 300 or 408/608, or consent of instructor.

GEOL 801 Field Geophysical Techniques 3 credits (S-odd years)
Project oriented field study of basic geophysical methods used for shallow geological investigations and for environmental site characterization. Techniques/interpretation include seismic, electrical and electromagnetic sounding, ground-penetrating radar, magnetics, gravity, self-potentials, and borehole geophysics. Emphasis is on basic principles and physical understanding of the geophysical methods with applications in mind.
Prerequisite: Consent of instructor.
Instructor: Dr. Moysey

GEOL 803 Geostatistics 3 credits (F-odd years)
Numerical and statistical treatment of geological data emphasizing the analysis of spatially and temporally distributed variables and unique aspects of geological variables. Topics include methods of sampling geological data, quantitative procedures for reducing the dimensionality of geological data sets, and techniques for presentation and interpretation of results. *Prerequisite:* EX ST 301 or MTHSC 301. *Instructor:*

GEOL 805 Advanced Stratigraphy 3 credits (F-even years)
Classification, distribution, chronologic succession and correlation of sedimentary rocks; interpretation of features of strata in terms of their origin, depositional environment, paleogeography and relation to organic evolution; Atlantic Coastal Plain stratigraphy.
Prerequisite: GEOL 413/613 or consent of instructor.
Instructor:

GEOL 806 Aquifer Characterization 3 credits (F-even years)
Characterization of aquifers from the microscopic scale to the regional scale. Geological origin of aquifers and modification by diagenetic and deformational processes. Application of subsurface geological techniques to data acquisition and interpretation. Prediction of fluid occurrence and flow by integrating results of subsurface analysis. *Instructor:* Dr. Castle

GEOL 808 Groundwater Modeling 3 credits (F)
Mathematical and computer modeling of groundwater flow and nonreactive solute transport through geological formations; conceptual flow models for geologic systems; formulation of governing mass and energy conservation equations; application of analytical, numerical and stochastic models to real-world problems. *Prerequisite:* GEOL 415/615 or consent of instructor. *Instructor:* Dr. Falta

GEOL 809 Subsurface Remediation Modeling 3 credits (S)
Lectures and computer exercises involving subsurface remediation methods, including groundwater extraction, soil vapor extraction, steam flooding and a variety of other techniques; modeling flow of multiphase and multicomponent mixtures in porous medium.
Prerequisite: GEOL/EE&S 808 or consent of instructor.
Instructor: Dr. Falta

GEOL 810 Analytical Methods for Hydrogeology 3 credits (F-odd years)
Analytical mathematical methods for modeling subsurface fluid flow and transport processes including saturated water flow, unsaturated gas zone flow, chemical transport, and heat transfer, emphasizing the derivation and solution of governing equations for modeling subsurface flow and transport. *Prerequisite:* GEOL/EE&S 808 or a graduate groundwater course or consent of instructor. *Instructor:* Dr. Falta

GEOL 811 Rock Physics 3 credits (S-even years)
Experimental and theoretical rock physics taught at an advanced level. Electrical, fluid-transport, and seismic properties are covered in detail. Special emphasis is placed on the rock/solution interface and how that interface affects electrical, fluid transport, and seismic properties. Other topics such as magnetic, mechanical and thermal responses are discussed briefly. *Prerequisite:* Consent of instructor. *Instructor:*

GEOL 813 Environmental Geochemistry 3 credits (S-odd years)
Inorganic geochemistry, specifically the distribution of trace elements in rocks, regolith, water. Topics include micronutrients and concepts of essentiality; health problems related to natural occurrence of toxic elements; environmental pollution arising from non-ferrous metal mining, coal mining and coal use, gasoline additives; urban and regional geochemistry.
Prerequisite: GEOL 318 or consent of instructor.
Instructor: Dr. Schlautman

GEOL 814 Environmental Sedimentology 3 credits (F-odd years)
Environmental-based applications of sedimentology to developing an understanding of heterogeneity and scale, fluid flow and saturation, sediment-fluid interactions, and modeling approaches; field and laboratory methods; case studies; implications to environmental sustainability. *Prerequisite:* Consent of instructor. *Instructor:* Dr. Castle

GEOL 816 Aquifer Systems 3 credits (S-odd years)
Hydrogeologic characteristics of selected major aquifer systems in the US and elsewhere; conceptual models for the controls of recharge, discharge, and flow through aquifers in different geologic settings; development of numeric models to simulate natural and stressed aquifers.
Prerequisite: GEOL 408/608; GEOL/EE&S 808 or consent of instructor.
Instructor: Dr. Murdoch

GEOL 818 Hydrogeology of Fractured Aquifers 3 credits (S-even years)
Processes and characteristics of fluid flow through naturally and artificially fractured subsurface formations; principles of flow in dual porosity materials, characterizing fractures and fractured aquifers, mechanics of fracture formation, methods of inducing fractures from wells; case studies and applications.
Prerequisite: GEOL408/608; GEOL/EE&S 808 or consent of instructor.
Instructor: Dr. Murdoch

GEOL 850 Selected Topics in Environmental Geology 1-4 credits (F,S)
Selected topics in environmental geology emphasizing subsurface contamination. May be repeated for a maximum of six credits, but only if different topics are covered.
Prerequisite: Consent of instructor.

GEOL 851 Geology Seminar 1 credit (F,S)
Students review current topics in geology and make oral presentations.

GEOL 875 Hydrogeology Summer Field Camp 6 credits (SS)
Groundwater geology field techniques including examination of surface exposures, analysis of cores and geophysical well logs, subsurface mapping, aquifer performance tests and groundwater remediation.
Prerequisite: Consent of instructor.
Instructor: Dr. Murdoch

GEOL 891 Master's Thesis Research (F,S,SS)
Credit to be arranged.

APPENDIX D
REFERENCE PHONE NUMBERS

GRADUATE SCHOOL (Graduate Admissions) 656-3195
CLEMSON AREA TRANSIT SYSTEM (CATS -Bus) 654-CATS (2287)
CITY OF CLEMSON INFORMATION LINE 654-CITY (2489)
REGISTRAR'S OFFICE 656-2171
UNIVERSITY REVENUE & RECEIVABLES (Bursar's Office)..... 656-5592
COMPUTER & INFORMATION TECHNOLOGY (Help Desk) 656-3494
ATHLETIC DEPARTMENT (Ticket Office)..... 656-2118
FINANCIAL AID OFFICE (automated) 656-2280
CALL ASSISTANCE CENTER (Campus Information) 656-3311
PARKING SERVICES 656-2270
BROOKS CENTER 656-3043
POLICE DEPARTMENT (Clemson University)..... 656-2222
VISITOR PROGRAMS (Visitor's Center)..... 656-4789
TIGER 1 CARD OFFICE..... 656-0763
STUDENT HEALTH SERVICES (Redfern Health Center) 656-2233
BOOKSTORE (Hendrix Student Center) 656-2050
GRADUATE STUDENT GOVERNMENT (GSA Office) 656-2697
LIBRARIES (Cooper Library) 656-3027
CLEMSON CHAMBER OF COMMERCE..... 654-1200